PROCEEDINGS

The First International Congress on Postharvest Loss Prevention

Developing Measurement Approaches and Intervention Strategies for Smallholders

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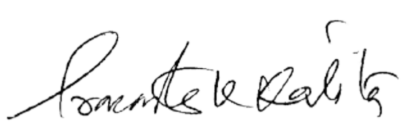
The First International Congress on Postharvest Loss Prevention

Dear Readers,

We are happy to publish the proceedings of the First International Congress on Postharvest Loss Prevention. This is a unique event planned to provide a forum for various stakeholders to share, learn, and work together to develop and plan action items for reducing postharvest loss (PHL). The abstracts represent four themes. The first theme, Postharvest Loss Status & Emerging Issues, highlights losses occurring in various countries, defines specific needs, and identifies technical, social, and policy regulatory factors causing these losses. The abstracts in the second theme, Intervention Strategies for PHL Mitigation, cover topics of innovative/emerging postharvest technologies, farm mechanization and its effect on postharvest quality, economic assessment for sustainability of postharvest technologies, and critical stages in supply chains with a focus on research. The abstracts on Measurement Methods & Metrics of PHL theme address tools and standards/protocols for postharvest quality and quantity loss assessment. As a central theme of the First Congress, the ability to measure PHL using scientific methods is critical for mitigating losses and evaluating the impact of interventions. The abstracts in the final theme of the conference, Education Platform and Decision Support System, focus on the need to develop knowledge platforms and decision support systems, and discuss successful examples where effective tools and community participation proved beneficial.

This publication includes a total of 101 abstracts. The rich contents of this proceedings cover topics related to issues in postharvest loss and approaches for its prevention for many different crops under a variety of climatic conditions. We would like to thank all the authors and their respective organizations. We sincerely thank the Archer Daniels Midland (ADM) Company for establishing the ADM Institute for the Prevention of Postharvest Loss and its support of the First Congress and publication of this proceedings. We would like to thank all members of the Program Committee, including the co-chair Dr. Dirk Maier, for reviewing the abstracts and making useful comments for revisions. I also thank the staff of the ADM Institute for their help in getting all the abstracts in order. Two dedicated people significantly contributed to the publication of this proceedings. Dr. Deepak Kumar of the ADM Institute and Dr. Kathy Partlow of the College of Agricultural, Consumer and Environmental Sciences at the University of Illinois spent many sleepless evenings reviewing and editing the abstracts and finally bringing this proceedings into the current shape. I truly appreciate both of their work and dedication. Without support, guidance, and inspiration from colleagues of the Food and Agriculture Organization (FAO) of the United Nations, the Rockefeller Foundation, the Bill & Melinda Gates Foundation, John Deere, United States Agency for International Development (USAID), University of Illinois at Urbana-Champaign, and the College of Agricultural, Consumer and Environmental Sciences (ACES) at the University of Illinois at Urbana-Champaign, this Congress, Program, and the proceedings would not have come together, and I express my sincere thanks and gratitude to all of them.

Thank you.



Prasanta K. Kalita
Professor and Director, ADM Institute for Postharvest Loss Prevention
University of Illinois at Urbana-Champaign

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Abstract # ADMI001

The Nature of Smallholder Agriculture in Paran State in Brazil and Implications for Alleviating Postharvest Loss

Mary Arends-Kuenning[1], Marcos Garcias[2], Marin Thompson[1]

[1]University of Illinois

[2]University of Sao Paulo/ESALQ

Corresponding Author: marends@illinois.edu

Introduction: The nature of smallholder agriculture in Paran state in Brazil and implications for alleviating postharvest loss Introduction Brazil is a major global agricultural producer. In the past twenty years, it has become the world's second-ranked producer of soy and third-ranked producer of corn (FAO 2014). However, grain is left behind in the field because harvesters are not calibrated optimally, and infrastructure for transporting agricultural goods is inadequate. We examine postharvest loss among smallholders in Paran, a state in the South of Brazil. Farms tend to be small and family-owned, in contrast to the large commercial farms of the Center West. Small family farms are important contributors to the production of subsistence crops, with smallholders in Paran accounting for 10 percent of total corn production, 6 percent of total soybean production, and 10 percent of total wheat production in Brazil. Reducing postharvest loss will help the smallholders increase their incomes and levels of food security.

Objectives: The paper describes smallholder grain producers in Paran and Brazilian government policies towards smallholders, focusing on policies that affect postharvest loss. We describe smallholder farms in Paran with respect to farm farmers in the southwest corner of Paran. The survey focused on the farmer's perception of postharvest loss and their harvesting and marketing of grains. We report the results of an investigation of the supply chain of smallholder grain production, focusing on the implications for postharvest loss. We conclude with a discussion of the implications for future research about postharvest loss.

Approach: The research makes use of literature reviews, Brazilian government data, and original data to describe smallholder grain producers in Paran. The Brazilian government conducted an Agricultural Census in 2006, and we use the results to map smallholder production and produce descriptive statistics. We review and summarize the literature available in Portuguese and English, including journal articles, reports, and academic theses. Interviews with participants in the supply chain including millers, cooperative leaders, traders, and end users are coded and summarized, and the implications for postharvest loss are discussed. Finally, we conducted a pilot survey of 18 smallholders in the southwest of Paran, collecting data about their production, income, marketing of production, and demographic characteristics. The sample was a convenience sample, which was drawn with the assistance of local extension agents.

Findings: The Brazilian government has invested considerable resources in providing credit for smallholders to purchase new harvesting equipment and storage facilities. However, although the smallholders participate in the programs, the credit is not being used in a way that minimizes postharvest loss. On-farm storage is primitive and ineffective at preventing loss from spoilage and rodents. Among the 18 smallholder respondents, 9 reported that postharvest loss was a large problem (level 5 on a 5-point scale) and 9 reported that it was considerable (level 4 on a 5-point scale). Smallholders admitted that they did not have an accurate measure of the extent of postharvest, but estimated that losses affected

5 and 8 percent of their production, a total of 300 kilograms on average per smallholder per year. Based on the smallholders' responses, the main contributors to postharvest loss were suboptimal operation of harvesting equipment, hilly terrain that made it difficult to adjust harvesting equipment, and poor quality transportation on secondary roads. The majority of smallholders did not store their grains, and among those who did, they stored their grain with wholesalers.

Conclusion: Brazil has become a major world agricultural power. Although large farms in the Center West of the country dominate soybean production, most farms that produce grains are smallholder farms. These farms account for a significant share of staple grains, such as black beans (76 percent), colored beans (54 percent), and corn (46 percent). Given the importance of soybean production for Brazil's economy, the smallholder share of 14 percent of production is significant. Studies of postharvest loss in Brazil should include smallholder farms, where there might be great potential to decrease postharvest loss and improve food security. The state of Paran was one of the dominant states for smallholder production, especially in black beans, corn, soybean, and wheat. Future research on postharvest loss among smallholders should include studies of municipalities in this state. In our survey, farmers perceived that postharvest loss was a significant problem, with every farmer rating it at least a 4 on a five-point scale. The Brazilian government has invested considerable resources in providing credit for smallholders to purchase new harvesting equipment and storage facilities. However, although the smallholders participate in the programs, the credit is not being used in a way that minimizes postharvest loss. On-farm storage is primitive and ineffective at preventing loss from spoilage and rodents. Further research might discover why farmers do not invest in storage and whether new effective, cheaper modes of storage might be useful.

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Abstract # ADMI002

Postharvest Loss Assessment of Vegetables in Kenya

Willis Owino[1], Victor Afari-Sefa[2], and Ngoni Nenguwo[2]

[1]Jomo Kenyatta University of Agriculture and Technology, Juja, Kenya,

[2]AVRDC - The World Vegetable Center Eastern and Southern Africa, Arusha, Tanzinia

Corresponding Author: willis@agr.jkuat.ac.ke

Vegetables are highly perishable and if care is not taken during production, harvesting, handling, transport, and storage, they soon decay. Estimates of postharvest losses in developing countries such as Kenya are hard to judge, and most of the data is generally estimated. In order to minimize postharvest losses, there is the need to assess both the traditional and globally important vegetables so as to understand the diversity of crops grown, the different value chains for the target crops, and to quantify the losses along these value chains. The globally important vegetables such as tomato, cabbage and onion may have been well studied in other countries and contexts, but country- specific needs may differ and require intervention to maximize year-round availability and affordability. Traditional vegetables are diverse, under-studied and there may be crop- specific challenges which are currently poorly understood. These globally important and traditional vegetable value chains must be assessed from the field to the consumer to quantify current postharvest losses in terms of both quantity and quality, and to understand where interventions will be appropriate.

The main objectives of this study were:

1. To capture current pre-harvest practices such as varieties of crop cultivated and seed sources for production, postharvest practices and constraints faced by farmers, traders and other actors in the value chain.
2. To quantify losses in vegetable crops at the farm gate, during transportation and storage as well as during marketing.
3. To identify suitable interventions in the vegetable value chain to reduce postharvest losses.

Postharvest loss assessment was carried out for tomato and amaranths value chains in a number of regions in Kenya. These included; Kitengela, Mwea East and West, Subukia, Juja, Lugari, and Bondo. Dependent on the region, vegetable farming was practiced by older generations of farmers while in other areas, farming was carried out by the youth. In Bondo there were more female farmers than men. However, in the other regions the majority of the farmers were male. Majority of the vegetable farmers were found to be either illiterate or semi-illiterate with only few having attained a tertiary level of education. Land size was a limiting factor in vegetable production in some regions, especially in Juja, where the majority of the farm size was less than one acre. However, in other regions farmers had large portions of land that were under-utilized. Among the three amaranth regions that were surveyed only Juja was producing leaf amaranth. Bondo and Lugari farmers are focusing on the production of grain amaranth. It was evident that farmers are growing a wide range of tomato varieties, though Kilele F1, Safari F1 and Rio Grande were the most common varieties. The main contributors of losses for tomatoes were physiological damage and diseases, poor handling during harvesting and transport. For amaranth it was mainly exposure to the sun after harvest and over stuffing in sacks. The postharvest losses of amaranth totalled 34% at harvest mainly due to leaf shredding, insect and pest damage, and harvesting of over mature leaves. In the market, the losses of the leaves were about 43% mainly due to poor handling. For tomatoes, the causes of losses for tomato were dependent on the region. At the farms in

Kitengela, the main cause of losses was physiological damage (blossom end rot) and other diseases which accounted for 31% of fruit losses. In total about 57% of the harvested fruit from Kitengela farms was damaged. In tomatoes from Mwea, the main causes of the losses were insect and pest damage, accounting for 20% damage at harvest.

Transportation and poor handling contributed to about 24% of the fruit losses in the market. A stakeholder's workshop was conducted to present and have a general discussion on the results of Postharvest Loss Assessment, identify and prioritize the necessary interventions on postharvest handling, and develop a researchable activities plan for tomato, amaranth and other vegetable crops in Kenya. From the results of the study and deliberations from the conference, a number of interventions for addressing the challenge of postharvest losses are proposed. These included organization of vegetable growers into Farmers Association/Groups and aggregation to target specific markets; Capacity building of farmers on proper agronomic practices, proper harvesting and handling techniques, access to improved varieties of vegetable seeds/ seedlings for specific market segments and introduction of innovative production technologies; Testing of the introduced/novel vegetable varieties for their specific postharvest quality attributes and consumer acceptance; Develop, test, and promote suitable packaging materials for bulk packaging; Provisions of marketing and input information system, access to better extension services, postharvest handling technique and developing vegetable quality and safety standards will go a long way in mitigating postharvest losses along the vegetable value chains.

Abstract # ADMI003

Perishables postharvest losses in Brazil: a review and a current view of an old problem

Gilmar P. Henz

Embrapa/MAPA, Brasília-DF, Brazil

Corresponding Author: gilmar.henz@agricultura.gov.br

Due to its continental dimensions and agricultural diversity, the problem of postharvest losses of fruits and vegetables in Brazil is recurrent in the national media. The way the subject is usually presented to public is by showing tons of sound food turned into waste, and at the same time exposing vulnerable populations to food insecurity, without access to food. These reports expose the dramatic social and economic changes experienced by Brazil in its recent history, from food importer to a big player in the world food market, along with economic and social progress, rapid urbanization and agricultural development. This paper aims at reviewing critically publications (scientific articles, reports, abstracts and others) on postharvest losses of perishables in Brazil to evaluate the progress on reducing or addressing the subject in the last 50 years. More than 20 papers and reports were found on this theme, almost all published in Portuguese in Brazilian journals, many of them of limited circulation. Many reports were published on the subject, typically belonging to the category of "grey literature", with small number of copies available and not peer reviewed. Most of the publications only estimate percentage of losses, usually by the application of questionnaires. The first publications on postharvest losses in Brazil started from the 1970's, also corresponding to a period of fast growing agricultural, economic and social development. Before 1960, Brazil had an export-based agriculture of commodities such as coffee and sugar, and used to be a net importer of food. Fruits and vegetables were produced in green belts located around the larger cities and rural populations were almost self-sufficient. During this period, postharvest losses of perishables were not considered as a problem, in a situation in which neither the basic production nor distribution of fruits and vegetables had been solved. During the period comprised from 1960 to 1990, Brazilian agriculture experienced rapid development, with the adoption of modern production techniques, investment in research, development and innovation in science, and increase of graduate courses in agricultural sciences, including postharvest and food techonology. As a result, several reports, surveys and estimates of postharvest losses in fruits and vegetables were published. Fourteen papers and report about PHL of perishables were published between 1971 and 1994 in in Ten Brazilian Cities and Minas Gerais state, with losses for tomato ranging from 0% to 50%, and for lettuce from 7.5% to 37%. A survey done at the wholesale state market and street markets of Recife, a city of Northeast Brazil, reported 21.5% and 19.6% of losses, respectively for fruits and vegetables, at the wholesale market, and 16.5% and 16.7% at street markets (SUDENE, 1971). In São Paulo, a similar survey was performed by Ueno (1976), at the supermarkets, perishables retail shops and street markets: banana (33%) and papaya (29%) showed higher average losses for fruits and cabbage (14%) and lettuce (13%) among the vegetables. Several papers published showed distinct loss percentages at wholesale markets, such as 15% and 10% for tomate and sweet pepper in Manaus (Brandt et al., 1974); 10% during the dry season and up to 50% at the rainy season for tomato in Minas Gerais state (Mukay & Kimura, 1976). At the retail market, in Minas Gerais state, postharvest losses of 27% (carrot), 42% (sweet pepper) and 40% (tomato) were recorded (Fundação João Pinheiro, 1992); 34.4% in tomato in São Paulo (SAASP, 1995); and 13% (carrot), 30% (tomato) and 20% (sweet pepper) in the Federal District (Lana et al., 2000). By 2002, IBGE estimated in 20% food waste in households in Brazil (Vilela et al., 2002). These estimates pointed out generic causes, such as poor handling, adverse environmental conditions,

poor product quality, unproper packaging and lack of refrigeration. The main constraints in these reports were poor methodology applied, with lack of standardized, scientific parameters since they were based on observations or interviews. The objective of these surveys were also clearly divided by the author's background into two groups (economists and agronomists), with different approaches and reccomendations. These first attempts to quantify PHL in Brazil were successful in showing the growing importance of the subject to society. After the 1990's, scientific papers and thesis on PHL can be regarded as more science-based, using proper methods to measure or quantify losses, loosing the general characterist and becoming very specific, combining a perishable product (one vegetable crop or fruit species) with subject (postharvest phsiology or pathology, packaging, handling, refrigeration, etc). In 1990, the first book on postharvest of perishables in Portuguese was published in Brazil by Chitarra & Chitarra (1990), with a specific chapter on PHL. Presently, yearly congresses and scientific meetings are held by scientific societies on plant physiology, fruits and vegetables crops, postharvest, food technology, plant pathology and fresh-cut products were held, addressing different aspect and causes of PHL. Many papers proposed changes in the handling system or technologies to reduce PHL but do not take into account key factors for the market such as the additional cost of the technologies. Most of the reccomendatios to reduce PHL were related to replace wooden boxes (known in Brazil as K boxes) by cartoon or plastic crates; better handling systems; transport by refrigerated trucks at an average temperature (15oC) because of mixed products loads and long distances to reach domestic markets; use of refrigeration chain until the produce reach consumers; PVC plastic wrapping. Currently, Brazil has good capacity to produce knowledge and technologies with potential to reduce postharvest losses generated by public institutions (Embrapa, universities) and also by the private sector, such as retailer companies (supermarkets) and exporters of fruits and vegetables. Presently, two sectors of the perishables production are responsible for significant changes in PHL: organic agriculture and small holders farmers production. The expansion of supply and consumption of organic fruits and vegetables has changed the pattern of production, distribution and consumption, with new attributes of quality. Another recent developments in Brazil are governmental projects on Food Banks and the integration of small holders farmers into the market through the Program of Food Acquisition (PAA), in which local agricultural products are bought for school feeding schemes. However, regardless these recent progresses, it is important to raise public awareness of middle-class consumers, a segment of society that has become accustomed to consider food as just another consumption item. Regardless the improvements experienced by Brazilian agriculture in the last decades, reducing postharvest losses of fruits and vegetables as a main goal still need more effective governmental initiatives, combined with the private sector, such as supermarket chains, and other civil society organizations.

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Abstract # ADMI004

GENDER ROLES IN POST- HARVEST MANAGEMENT ALONG THE MAIZE VALUE CHAIN IN SOUTHWESTERN ETHIOPIA

Chemeda Abedeta[a]*, Abera Guluma[a], Margareta Lelea[b], Oliver Hensel[c]

[a] Jimma University, Collage of Agriculture and Veterinary medicine, P. O. Box 307, Jimma, Ethiopia.

[b] German Institute for Tropical and Subtropical Agriculture (DITSL), at the Faculty of Organic Agricultural Sciences, University of Kassel, Germany

[c] Agrartechnik, University of Kassel, Nordbahnhofstr. 1a, 37213 Witzenhausen, Germany

Corresponding author: chemedaa@yahoo.com

Maize is a versatile crop allowing for cultivation in diverse climates. It is used as a source of food and feed, raw materials for industries and as a source of fuel material in rural areas. A leading crop in terms of productivity and coverage area, maize is consumed at different stages of maturity. In Ethiopia, maize is grown in a fragmented smallholder production system, characterized by high post-harvest losses. To address these losses, the social diversity of smallholder farmers, transporters, processors and retailers need to be considered. Of these social factors, gender plays a significant role but has heretofore not received adequate attention. Specifically in our research, the gendered division of labor for post-harvest management of maize is analyzed with regard to its potential contribution for informing strategies to reduce maize post-harvest losses. The study was conducted in the southwest region of Ethiopia, in three districts of Jimma zone, each with distinct agro–ecologies. A multi-stage sampling technique was employed to select the zones, districts, kebeles (the lowest administration region in the country) and different respondents from each actor category along the value chain. In total, 311 respondents including farmers, traders and service providers were interviewed using a structured questionnaire including a few open-ended questions. Qualitative data was coded for quantification so that both could be analyzed with SPSS software (version 20). The Harvard framework was employed to analyze the gendered division of labor. The results revealed that in maize activities, 24.65% of productive maize-related activities were done by women and girls; 26.23% were done by men and boys; and 40.11% were done by both. Reproductive household activities were done predominantly by women and girls 47.86%; men and boys were responsible for 17.03% of reproductive activities; and 30.1% were performed by both. Everyday household decision making was also predominantly done by women and girls 68.94%; men and boys were responsible for 11.04% of everyday household decisions; and 20.02 % were done by both. The variables which show significant differences between the sexes are education level, productivity of maize cultivation for farmers, distance from processing facility and age of traders. The profit margins calculating the costs of inputs against the sale cost of the maize products, not including labor costs are distributed as follows among actors: producers 74%, retailer/collectors 13% and wholesalers 13% for grain and producer 20%, retailer 18% and road side retail 62% for green consumption of maize.

Generally, post-harvest activities are deemed to be the responsibility of women in this region of Ethiopia. Consideration of the gendered division of labor and development of efficient maize processing technologies for industrial corn wet milling and corn dry milling would reduce the overall workload of time-consuming and tedious tasks for women and with the added benefit of improving the nutritional quality for the consumer. There is also need to develop and demonstrate improved storage structures for different actors along the chain to reduce losses. Typical recommendations to reduce maize post-harvest losses include encouraging market orientation among farmers, building processing centers, introducing wet milling technologies, and improving linkages among actors to formalize the maize value chain. As

such formalization efforts would likely increase the participation of men in the maize supply chain, if such recommendations are enacted, care must be taken in order to continue to include women in the benefits of such formalization, rather than to displace them.

Abstract # ADMI005

Postharvest losses along the citrus value chain: A case study of Benue State, Nigeria

Sarem Ugoh, Michele Clarke, Sarah Jewitt

University of Nottingham

Corresponding Author: lgxsau@exmail.nottingham.ac.uk

Sweet orange is the most common citrus fruit grown around the world. This is as a result of its sweet taste, importance in nutrition and medicinal attributes (Ezejiofor et al., 2011). Nigeria is the world's 9th highest producer of citrus, providing 3% of the world's total production (UNCTAD, 2010). Global production of citrus in Nigeria was 3.9 million metric tonnes in 2012 (FAO, 2012). In Nigeria, sweet orange is cultivated in 15 states: Benue, Nassarawa, Osun, Anambra, Ekiti, Imo, Kogi, Ebonyi, Edo, Delta, Oyo, Kwara, Ogun, Taraba and Kaduna (Olife et al., 2015). Benue state is the largest producer in the country (Avav and Uza, 2002).

The major sweet orange varieties produced in Benue are – Valencia, Washington navel, Ibadan sweet, Tangelo, King and Tangerine. These varieties are harvested at different times of the year; therefore oranges are available all year round. Production of citrus in Nigeria is mainly for direct local consumption (Ezejiofor et al., 2011; Bamise & Oziegbe, 2013): 45% of citrus is consumed fresh and 25% is processed (NIHORT, 2000). Direct consumption has been attributed to the lack of citrus processing facilities (Hon et al., 2009). The demand for fruit juice in Nigeria is increasing by 10% every year. Fruit juice consumption in 2012 was estimated at 550 million litres (FMARD, 2013). In 2002 over 90% of consumed fruit juice was imported. As a result, the Nigerian Government placed a ban on the importation of fruit juice in 2002. This was to reduce the amount of foreign exchange expended on importing fruit juice and concentrates that can be produced locally in the country, to improve and encourage local production and processing in the horticultural sector (Olife et al., 2015). However, Nigeria is still importing over 98% of citrus concentrates today (FMARD 2015).

The level of postharvest losses (PHLs) in Nigeria cannot be ignored when viewed against the backdrop of incomparable statistics of food insecurity and poverty levels. The Food and Agriculture Organization in 2014 revealed that 9.4 million Nigerians were undernourished; this represents about 6% of the Nigerian population. The effects of PHLs are not circumscribed to food insecurity but also the protection of natural resources and human wellbeing (Hodges et al., 2012). The externalities of food production – the waste of land, water, energy, fertilizers, finite and infinite resources when postharvest losses occur have negative impacts on the environment (BCFN, 2012). Despite the magnitude of citrus produced in Benue, enormous losses are recorded. While postharvest statistics are lacking and inconclusive due to the dearth of research; FMARD (2013) reports that citrus is one of the crops affected most by PHLs in Nigeria, recording about 40 – 50% losses. According to Jolaoso (2011) over 50% of citrus fruits are lost in transit between farm and market in Nigeria. The National Horticultural Research Institute (NIHORT, 2000) estimates that 30% of citrus is lost due to postharvest handling.

This paper forms part of a series of papers that adopts the commodity centred approach as a methodological framework to give an account of an orange; follow it from farm to glass; highlight entry points of postharvest losses; various actors and institutions involved along the value chain; and the impact on small-scale farmers. This paper brings the context of postharvest losses along the citrus value chain in Benue State, Nigeria to the forefront. It first of all analyses the functional citrus value chain in Benue State and then addresses the challenges faced by small-scale local citrus farmers.

This study is based on primary data gathered over a 7-month period in Benue state, Nigeria. The results identify major factors exacerbating citrus postharvest losses. These include the lack of market – the absence of adequate processing industries, a unified value chain and saturation of open local markets; the absence of good road networks; the impact of middlemen; low income of smallholder farmers; microbial damage due to improper handling and harvesting techniques; absence of political willpower and the lack of research and development in the agricultural sector.

In developing countries, as well as Nigeria, the study of postharvest losses is still at its infancy. It is evident that postharvest losses are a problem but adequate crop and region specific research and political willpower is lacking. Investment in the citrus industry will not only reduce the amount of postharvest losses (Olife et al., 2015) but also increase the income of small-scale citrus farmers and boost the economy.

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Abstract # ADMI006

Postharvest Losses in Vegetable Value Chain in Bangladesh, Cambodia and Nepal

Shriniwas Gautam[1], Antonio Acedo Jr[2], Yoonpyo Hong[3], Pepijn Schreinemachers[3], Ngoni Nenguwo[4], Fenton Beed[1], and Jacqueline d'Arros Hughes[3]

[1]AVRDC - The World Vegetable Center East and Southeast Asia, Thailand,

[2]AVRDC - The World Vegetable Center South Asia, Hyderabad, India,

[3]AVRDC - The World Vegetable Center, Taiwan,

[4]AVRDC - The World Vegetable Center Eastern and Southern Africa, Arusha, Tanzinia

Corresponding Author: shrlnlwu.gautam@worldveg.org

Postharvest loss of vegetables, especially in developing countries, reduces the economic benefit derived from vegetable production (Weinberger and Acedo,2011).Most vegetables are vulnerable to postharvest loss due to their high water content, soft texture and high respiration rate. The percentage of postharvest loss is higher for vegetables compared to staple food crops, both in quantity and Impact on quality. Because the causes and extent of losses in vegetables vary across location, crop, season, value chains, and consumer demand, a detailed understanding of the entire value chain is needed to develop practical and effective solutions. AVRDC - The World Vegetable Center (AVRDC) activities are built around four interrelated global themes: Germplasm, Breeding, Production and Consumption. The postharvest program works across these four themes and takes a value chain approach to design and implement postharvest activities with the participation of value chain stakeholders. AVRDC is currently implementing a United States Agency for International Development (USAID)-funded Postharvest Project that includes three Feed the future countries in Asia: Nepal, Bangladesh, and Cambodia. These countries are among the worlds poorest and are extremely vulnerable to food insecurity and malnutrition. Postharvest loss reduction can help improve food and nutrition security and reduce poverty. Our study was conducted to understand the current postharvest value chains for priority vegetables in the three countries, quantify postharvest losses along the value chain nodes, and identify appropriate interventions to minimize postharvest losses as a way to augment farm income and improve the quality of vegetables supplied to consumers. Surveys using pretested questionnaires and focus group discussions were conducted between July 2013 and January 2015 in two sites in each country (Jessore and Barisal districts in Bangladesh; Battambang and Siem Reap provinces in Cambodia; Kapilvastu and Banke districts in Nepal) (Ahmed,2013; ANSAB,2015;RUA,201&) Two major vegetable crops were covered in each country: tomato (Solanum lycopersicum) in all three countries, eggplant (S.melongena)In Bangladesh, leaf mustard (Brassica Juncea) in Cambodia, and cauliflower (Brassica oleracea var. botrytis) in Nepal. Additionally, in Nepal and Cambodia, a quality assessment worksheet was used to determine the magnitude and cause of losses at four stages along the value chain (farm, collection, wholesale, and retail levels) using replicated random samples. Overall, more than 1,100 value chain stakeholders (about 700 farmers and 400 collectors, wholesalers and retailers) were surveyed or participated in the focus groups. The survey and focus group discussions showed that vegetables are an important source of family income for farmers and traders in the study areas of all three countries. The value chains studied were either regional or national in nature, with most of the volume used to meet domestic demand, making contributions to the national economy through import substitution alone. The value chains were traditional, with no major postharvest technology (i.e., no cold storage or cold chain; no packaging innovation). Value addition activities were limited.

Extent of postharvest loss

Losses differed with the crop, location, and the value chain actor. In Cambodia, the total outright losses were 26% and 23% of the total harvested quantity for tomatoes and leafy mustard respectively.

In addition, about 12% of tomatoes and 18% of the leafy mustard were sold at reduced prices due to quality loss (losses due to reduced freshness, colour, maturity, and physical damage in the postharvest stage).In Nepal, quantitative losses were 26% and 19% of the total harvest for tomatoes and cauliflower respectively. The qualitative loss of cauliflower resulted in a 7% price drop (equivalent to NRs 3/kg; NRs 98 = US $ 1) for retailers, 6% for farmers (equivalent to NRs 2/kg) ,4% for wholesaler (equivalent to NRs 1.5/kg),and 2% for collectors (equivalent to NR& 1/kg)compared to those without postharvest damage. The price reductions were about 4% for both farmers and wholesalers due to qualitative loss in tomato. In Bangladesh, quantitative postharvest loss of tomato and eggplant was around 26% and 20% of the total harvested quantity respectively. The qualitative loss occurred in 7.S°k and 6.5% of the harvested tomato along the postharvest chain for tomato and eggplant respectively, with the highest loss at the farmers level. In Bangladesh, farmers incurred the highest postharvest loss, followed by wholesalers, while retailers and collectors had the lowest postharvest loss. However, in Nepal and Cambodia, farmers incurred lower losses among the value chain actors.

Causes of postharvest losses

Farmers in Nepal and Cambodia expressed concern over preharvest losses from disease and insect damage, while traders' losses were mainly related to transportation and storage deficiencies. In Bangladesh, the losses immediately after harvest and during transportation were the highest, due to harvesting at the wrong time and the use of inadequate handling methods. Most of the farmers lacked access to markets (e.g., good roads, places to sell produce) and storage facilities, which are essential to reduce postharvest losses. The lack of storage is particularly problematic for traders. Participation of women in the vegetable value chains in addition to handling household chores, women also contribute to vegetable production activities in Cambodia and Nepal. Here, contribution is defined as the percentage of the total time required by the women surveyed in farm and trader families to complete the activities. In Cambodia, women in farm families surpass men in terms of their contribution in purchasing inputs, selling produce, and other exchanges of money for goods. In Nepal, women participated far less than man in vegetable postharvest activities such as grading, cleaning and packaging, and their contribution was the lowest (less than 5%) in vegetable marketing activities (transportation and selling).At the tradens level, women's contribution was the highest for selling vegetables (88%) in Cambodia, while In Nepal it accounted for less than 10%.Women's highest participation in Nepal was in packaging activities (25%). Potential interventions and capacity development to address farmers concerns regarding postharvest losses, improved varieties with high yields, good quality characteristics, and resistance to handling hazards during packaging and transport seem appropriate. At the trader's level, however, cost effective storage technology could help reduce postharvest loss in all three countries. The value chains studied used traditional low-technology practices; many of the postharvest losses in quantity and quality can be minimized by providing knowledge and skills to assess produce maturity, and improving harvesting and handling techniques, including the use of improved packaging materials. Capacity development opportunities for women farmers and traders, especially in Nepal and Bangladesh are essential to increase their access to resources and ability to participate in financial matters and decision making. AVRDC's value chain approach identified country-specific issues related to postharvest losses, value chain constraints, technological interventions, and capacity development needs. Involving value chain stakeholders from planning to validation of results of value chain surveys is especially effective in identifying the real needs for value chain improvement. Smallholder farmers in the three countries would benefit from value chain upgrades similar to those that have been undertaken in more developed Asian countries such as Thailand, where investments in postharvest infrastructure and knowledge have transformed smallholder farmers into economically progressive producers serving national and international markets.

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Abstract # ADMI007

Cross-Country Evidence of Postharvest Loss in Sub-Saharan Africa: Insights from Purdue Improved Crop Storage (PICS)

Tahirou Abdoulaye[1], Corinne Alexander[2], John Herbert Ainembabazi[3], Dieudonne Baributsa[2], Didier Kadjo[2], Bokar Moussa[4], Oluwatoba Omotilewa[2], Jacob Ricker-Gilbert[2], Feleke Shiferaw[5]

[1]IITA Nigeria

[2] Purdue University

[3] IITA Uganda

[4] INRAN Niger

[5] IITA Tanzania

Corresponding Author: cealexan@purdue.edu

Introduction: Improving staple crop production is widely viewed as crucial for increasing food security and reducing poverty in Sub-Saharan Africa (SSA). However, it is essential to recognize that food security challenges do not simply end at harvest (Affognon et al. 2015). Smallholder farmers in SSA face numerous challenges after their grain leaves the field. Farmers who store grain may experience significant quantity losses due to damage from rodents, insect pest and mold and subsequent price discounts for damaged grain (Kaminski and Christiaensen 2014; Kadjo et al. 2015; Kadjo et al. 2016). Part of the reason quantity loss occurs is that many farmers lack access to effective storage technology, such as airtight (hermetic) storage bags or metal silos. These technologies have the potential to positively impact household welfare but are currently not available in many rural settings (Jones et al. 2011; Gitonga, et al. 2013). In addition, households may be have their food safety and health jeopardized when they store grain if they apply storage chemicals inappropriately or consume grain that has been infected with mold and aflatoxins (Hoffman and Gatobu 2014). All of these storage challenges undermine household income, food security and nutrition, food safety, and health.

Objectives: The objective of this presentation is to share results on Postharvest Loss (PHL) in maize from five countries in sub-Saharan Africa (SSA). Data was collected from smallholder farmers as part of the Purdue Improved Crop Storage (PICS) project funded by the Bill & Melinda Gates Foundation, US Department of Agriculture Economic Research Service, and USAID Borlaug LEAP program. Households surveys were conducted in Benin (360 households), Nigeria (2,010 households), Uganda (1,193 households), Tanzania (309 households), and Ethiopia (300 households). In addition to household characteristics, maize storage practices were assessed including use of storage technology, maize marketing practices, PHL and sources of PHL. We measure PHL as the percent postharvest loss of the quantity stored by the household.

Results: Table 1 presents some country-level descriptive statistics of the status of PHL in each country, as well as data on farmers' postharvest management practices for maize. PHL in each country is the outcome of farmer behavior (use of storage technology, length of storage period and household savings/liquidity) and the local environment (how many seasons, whether there is rain at harvest, and pest pressure). We find that the average percent PHL varies by country from a low of 3.7% in Uganda to a high of 6.9% in Tanzania. Comparing average PHL in West Africa, Benin has much higher PHL at 6.2% than Nigeria at 4.7%, which may be explained by the lower use of storage protectants in Benin at 26% compared to 37% in Nigeria. Furthermore, the majority of storage protectants used in Benin are not approved for postharvest use with only 3% of farmers using a certified storage chemical in 2013 (Kadjo et al. 2015). Comparing average PHL in East Africa, Tanzania has the highest average PHL at 6.9% while Uganda has the lowest at 3.7% and Ethiopia has 4.7%. Tanzania is the epicenter of the larger grain borer (Prostephanus truncatus) distribution which explains the large PHL even though 51% of farmers use storage protectants. By comparison, 77% of farmers in Ethiopia applied storage protectants to their maize which may explain their lower losses. Farmers in Uganda have the lowest use of storage protectants on maize at only 12%. Instead the very low PHL in Uganda can be explained farmers decisions to sell their maize before insect damage accumulates and thus only storing a very short time. Farmers in Uganda store on average about 8 weeks for market sale and 17 weeks for home consumption much shorter than the farmers in Ethiopia and Tanzania store over 23 weeks for market sale and 35 weeks for home consumption. These results highlight that farmers take actions to reduce PHL, either by applying protectants or selling early to avoid losses. The early sales in Uganda mean that farmers cannot take advantage of higher prices later in the storage period and thus their actions to reduce PHL also reduce their income.

Table 1: Country-level descriptive statistics on PHL and postharvest management for maize

	Benin 2013	Nigeria Season 1, 2014	Ethiopia Season 1, 2014	Uganda Season 1 2014	Tanzania Season 1 2014
Average Percent PHL (Quantity Lost/Quantity Stored)	6.2%	4.7%	4.7%	3.7%	6.9%
Percent Applied Storage Protectant	26%	37%	77%	12%	51%
Average weeks stored for sale			24.5	7.9	23.8
Average weeks stored for consumption			35	17.3	35
Percent using Woven bags	37%	76%	63%	71%	70%
Percent using Traditional Granaries	52%	16%	14%	7%	12%
Percent using Hermetic Storage	0%	2.3%	0.8%	0.9%	0.7%

For Benin, we have a panel households surveyed in 2011 and again in 2013. Kadjo et al. (2015) analysed the factors affecting the household storage decision at harvest including expected PHL, use of storage protectants, expected price increases and household savings. Households that have access to storage chemicals also store more maize than households that do not and expect lower PHL, but this was not statistically significant. We found that the single most important determinant of a household's ability to store is savings at harvest. Households that have access to storage chemicals also store more maize than households that do not and expect lower PHL, but this was not statistically significant.

In conclusion, these findings highlight the need to increase smallholder farmer access to effective storage technologies to improve income and food security. The goal of reducing PHL should be an outcome of increasing smallholder farmers' incomes and food security through access to more effective storage technologies where access means both physical availability and financial capacity to purchase these technologies.

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Abstract # ADMI008

POSTPRODUCTION LOSSES IN SIERRA LEONE: THE CASE OF AGRICULTURAL BUSINESS CENTERS (ABC)

Parameswaran Kumar Mallikarjunan, Keith Moore

Virginia Tech, Blacksburg, VA 24061

Corresponding Author: kumar@vt.edu

Food shortage has long been a primary cause of hunger in most malnourished countries and Sub-Saharan African countries are the ones that suffer the most from poverty and hunger. Despite having fertile soils, favorable climate and sufficient rain among other conditions that favor high agricultural productivity, these countries lack access to available markets, resources, and technology to achieve productivity and food security. Not only in sub-Saharan Africa, but also in most of the developing countries postharvest losses are due to insufficient storage, inappropriate handling practices and poor transportation conditions. There is an urgent need for solutions to extend the shelf life of high nutritive value food products to promote food security. Among perishable products, animal products (meat, poultry, and seafood) are essential to have a well-balanced nutritious diet. They not only deliver high-value protein but also provide essential micronutrients in daily diet, especially minerals such as iron, zinc, potassium, calcium and vitamins such as vitamin A and B12. However, meat perishables require improvements in infrastructure, including cold chains to permit storage and transportation adequately, which is not available satisfactorily in sub-Saharan Africa. Proven food processing technologies makes it clearer that if there are acceptable carry-over stocks available, perishable food product loss can be minimized and they may become reachable by poorer community. Thus, the motivation of this presentation is to find opportunities to improve food security, increase access to the nutritious food, and assure a healthy and active lifestyle through implementation of appropriate food processing technologies with potential partners in the region.

In addition to perishable protein rich foods, non-perishable protein rich foods like groundnuts have unique issues with mold and associated mycotoxins, especially Aspergillus spp. and aflatoxin. The presentation will also provide overview of efforts by Virginia Tech researchers to manage and mitigate this threat in sub-Saharan Africa.

Appropriate technologies that have a potential for implementation include thermal processing methods and packaging innovations. This presentation will give an overview of benefits from such technologies to inactivate spoilage and pathogenic microorganisms for specific food preparation practices (local recipes) and provide shelf-stable, pathogen-free, safe protein rich products. A thermally processed food in appropriate packing will provide an effective solution for shelf-stable storage and distribution of nutritious and high protein food products without a need for refrigeration. This simple and easily adaptable technology will serve as a major contribution of to the regional food security woes and will aim to strengthen the value chain for animal products.

The project must be carried out in three phases. In Phase I, the study will focus on needs analysis to assess available resources in the host countries. In this phase specific involvements will be explored to participate with academic institutions, private and public organizations. In Phase II, proven thermal processing technologies and packaging systems will be designed to construct a pilot scale processing plant in participating academic institutions. In phase III, the developed technologies will be implemented and impact from such implementation will be assessed.

The presented solution will ensure storing; transporting and delivering perishable foods and eliminate the need for refrigeration. While training participants from the sub-Saharan Africa with latest food processing technologies for long term, implementation of GMPs and HACCPs as appropriate for food products, processing methods and packaging applications will allow food security to be built into the emerging process industry. An integrated systems approach will demonstrate how gender, socioeconomic background, market accessibility, technology, governance and globalization factors are engaged. Profitability and food safety issues will not only encourage the governmental agencies to approve the process and pave the way with regulative arrangements but also increase the attainability to credit. This will return as a new possibility for women agriculture producers and small scale entrepreneurs to earn a better market place and improve their livelihood in long term.

Abstract # ADMI009

Postproduction Losses in Sierra Leon: The Case of Agricultural Business Centers (ABC)

Joseph Sherman Kamara, Bashiru Mansaray, Alhassan Kamara, Joseph Mattia, Mohamed Sankoh, Ansley Fomba, Nancy Iye Tommy, Osman Kargbo, Sahr Marvin Bockari-Gevao

Njala University, Freetown, Sierra Leone

Corresponding Author: jshermankamara@njala.edu.sl

Introduction: The attainment of self-sufficiency in rice is a major priority of the government of the Republic of Sierra Leone. Under the Smallholder Commercialization Programme (SCP), community-based Agricultural Business Centers (ABC) are being established across the country and supported with various facilities to boost smallholder rice production. This approach is expected to pave the way towards commercial farming. The shift from subsistence to commercial agriculture in a smallholder setting is likely to present key technical challenges. For example, as farm sizes increase, larger farms will require more careful planning to minimize field and postharvest losses. Currently, the rice postharvest system is very weak, and is typified by high postharvest losses, very poor grain quality and seasonal supplies. This has led to greater national consumer preference for imported rice (Kamara et al., 2014). The ABCs are expected to change this situation.

In the quest for rice self-sufficiency in Sierra Leone, a comprehensive understanding of the root causes of qualitative and quantitative losses will be extremely useful (Prusky, 2011). As a transition to modernized agriculture the ABC system represents a good model to facilitate the identification of the root causes of postproduction losses in order to address them in a comprehensive manner. OBJECTIVE: The objective of this study was to generate quantitative estimates of the rice post production loss profile as well as qualitative information on how these come about at Agricultural Business Centers (ABC) in Sierra Leone. METHOD: Data was collected through a national survey in which 60 ABCs selected from 12 districts were interviewed using structured questionnaires and checklists. Frequencies of responses to how specific operations were being conducted and estimates of postproduction losses were determined from for all 60 ABCs, as applicable. FINDINGS: Quantitative losses during rice post-production operations The ABCs show interest in many crops but rice (96.3 and 98.3 %) and cassava (60.0 and 41.7 %) were the most commonly grown and processed crops, respectively. More than 80 % of ABC were conducting basic operations like threshing, pre-cleaning, parboiling, drying, milling, transportation, storage and marketing at the time of visit. However, a smaller proportion (less than 35 %) indicated that they also conduct advance operations like grading, branding, grain moisture control, insect pest control and temperature control during storage. Whereas 96 % claim they plan ahead for postproduction operations, only 52 % follow the plan. Estimates of quantitative losses compiled for 60 ABCs in a postproduction loss profile (Figure 1) suggests that farmers at ABCs incur losses from harvesting through marketing. The data showed that whereas parboiling, pre-cleaning, cleaning, milling, marketing and packaging were minimal (less than 3.6 %), losses from harvesting, threshing, transportation and drying operations were appreciably high (4.4 to 9.9 %). Addressing these challenges requires a good understanding of their root causes (Prusky, 2011). Details of postproduction operations Harvesting, transportation and cleaning. Despite available machinery at most ABCs for harvesting most 79 % of them harvest their rice crop manually and 21 % of them do not complete harvesting, due to the extensive size of their rice fields. The problems of prolonged and incomplete harvesting will require mechanized harvesting, which in turn requires a great deal of planning and competence. Shattering (61 %) and transportation losses (25 %) were the main sources of harvesting losses identified. High shattering losses is due to late harvesting or use of shattering varieties. Harvested grains are either threshed in the field or the center. Field threshing is done manually, by beating the straws or trampling on them.

Alternatively, the harvest may be transported to the center and threshed mechanically using the available motorized thresher. Threshed grains normally contain many contaminants. Farmers use manual winnowing and our hand-picking to remove foreign materials. Both light and heavy contaminants were manually removed from grains using traditional winnowing and direct hand-picking. Parboiling, drying and milling. Processed rice is normally sold by ABCs either as raw-milled or parboiled rice grains. Parboiling improves various aspects grain quality, including cooking, nutritional, glyceamic, milling and storage qualities (Fofana et al., 2011). Parboiling is practiced by almost all ABCs (90 %) using either the traditional immersion (46 %) or direct steam methods (54 %). Parboiling losses are minimal (Figure 1). The Parboiled or raw milled rice is dried on concrete drying floors drying losses are caused by pests, over-drying, uneven drying, delayed drying, pest contamination, dust and grain fissuring. Milling at the centers is mainly mechanical (85 %) but also manual (52 %) Packaging and storage Most ABCs (58%) use standard packaging materials (nylon or plant fibre bags) and 80 % of these used nylon fiber bags and bag storage was the preferred for storing all rice products. Storage duration varied between 1 and 6 months. Weevils and rats were the most common pests and the most important sources of storage losses reported. Homemade mechanical traps (47 %) and chemical poisons (46 %) were used for rats while insecticides (61 %) and pepper (35 %) were used for weevil control. CONCLUSION: Despite access to improved facilities farming practices at ABCs are still basically traditional, except for milling. They therefore continue to face challenges of high quantitative and qualitative postproduction losses, which typifies inefficient systems. The study concludes that access to postharvest facilities alone did not seem to reflect enhanced postharvest capability among ABC farmers. We recommend that the SCP considers a

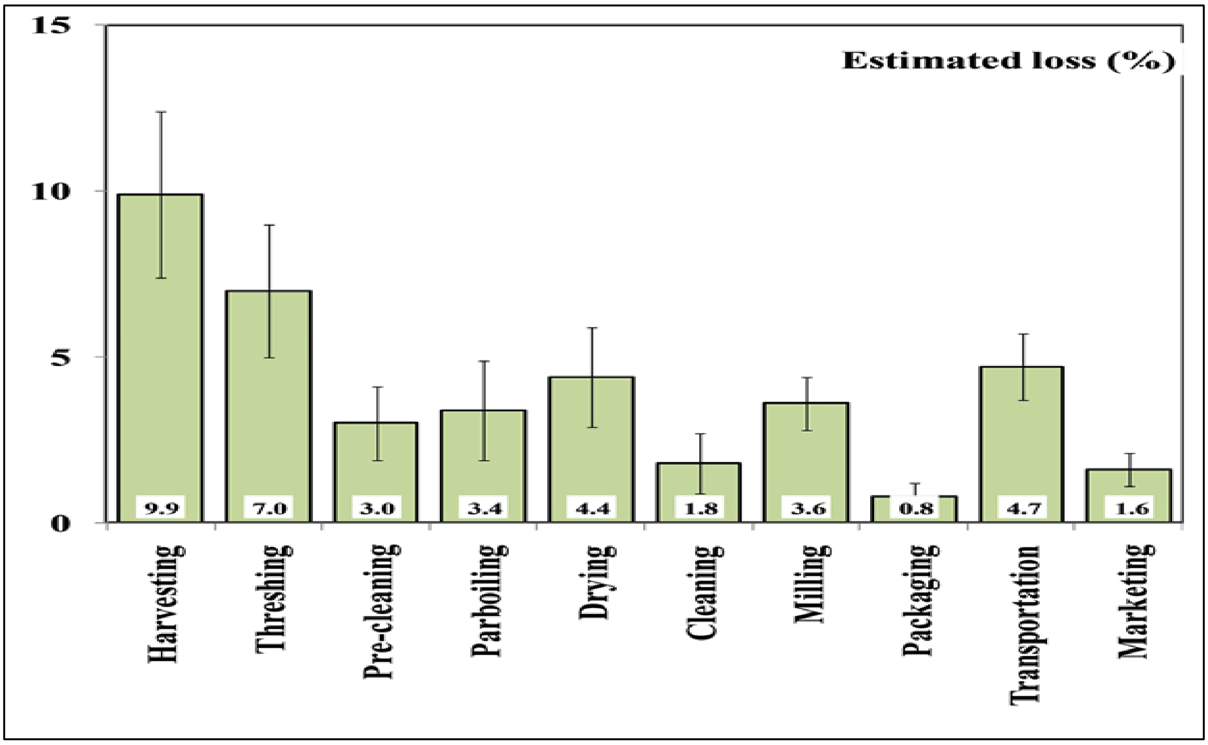

Fig. 1 Estimated rice postproduction loss profile for ABCs in Sierra Leone. Columns represent mean losses and error bars represent standard errors of mean (SEM) determine from estimates given by managers and operators from 60 ABCs

community-based approach to competence building in planning, operation, maintenance and management of the facility as necessary accompaniments for efficient utilization.

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Abstract # ADMI010

Assessment of Maize Grain Damage and Weight Losses Caused by Storage Insect Pests in Ethiopia

Girma Demissie1, Solomon Admasu2, Belay Garoma1, Tadele Tefera3, Stephen Mugo3

1Ethiopian Institute of Agricultural Research, Bako Natioanl Maize Research Coordinating Centre, P.O.Box 2003, Addis Ababa, Ethiopia; 2Hawassa National Maize Research Project, Hawassa, Ethiopia

3International Maize and Wheat Improvement Center (CIMMYT), ICRAF House, UN Avenue, Gigiri, P.O.Box 1041, 00621 Village Market, Nairobi, Kenya

Corresponding Author: gdemissie2009@gmail.com

Maize is one of the major food staples in sub-Saharan Africa (Mellor et al., 1987), with 57 million tons produced on about 30 million ha in the year 2010 (FAOSTAT, 2010). In Ethiopia it is second largest grain crop after tef in terms of area coverage and ranks first in total production and yield per hectare (CSA, 2010). It is a staple food for most households and is grown in almost all agro-ecological zones, including marginal areas, on both large and small-scale farms. The national food security is often pegged to availability of adequate supplies of maize to meet domestic demands. One of the key constraints to improving food security in Ethiopia is the negligence and poor post-harvest handling and insect pest management systems. Stored grain insect pests are the major constraints to maize storage in Ethiopia. The primary aims of storing food commodities are to effect a uniform supply of food throughout the year, to make available reserves for contingencies and to speculate on higher prices whether it is for local or export markets. For one or more of the above reasons, maize grain is often stored in Ethiopia for more than eight months (Demissie et al., 2008), but the lack of quality storage structures for grain storage and the absence of storage management technologies force many maize growers to sell their produce immediately after harvest. Consequently, farmers receive low market prices for the surplus grain they produce (Beyene et al., 1996). Estimation based on some limited observations indicated that grain losses in maize due to storage insect pests alone are about 30 - 40% and up to 100% was recorded in on-farm store of unprotected grains after 6 to 8 months of storage where hot and humid environments allow insects to reproduce rapidly and poor storage system (Tadesse, 2003; Demissie et al., 2008). Even though the production of maize is going on advancing, postharvest losses caused by storage pests are one of the major constraints in Africa in general and Ethiopia in particular. The importance of a pest is determined by the extent of the losses it causes. Grain-loss assessments provide the basis of programmes for reducing postharvest losses. In food security and postharvest pest management policy, availability of reliable postharvest losses data is essential for good decision making. However, updated information on major arthropods involved, damage and losses caused, and management practices followed on stored maize is scanty in Ethiopia. Knowledge on the presence and distribution of stored grain insect species is essential for application of effective management. It is, therefore, timely to identify dominant species, quantify the losses and consider how to minimizing postharvest grain losses, can help conserve resources and improve human well-being. Therefore, the present study was carried out with the objectives to: i, determine the dominant species of insect pests associated with stored maize; ii, quantify the extent of damage and losses inflicted to the maize grain on farmers' condition and iii, investigate possible control options used by farmers in the major maize growing agro-ecologies of Ethiopia.

Survey was conducted during 2009 and 2010, which covered major maize growing agro-ecologies in Ethiopia to assess the dominant species of storage insect pests, farmers' storage structure and prevention method used, grain damage and losses in farm-stored maize. Multi-stage sampling procedures were

applied to select the study sites and farms that represent diverse ecological and socio-economic environment and varying maize production systems. One hundred ninety three farm-stores in 2009 and four hundred fourteen farm-stores in 2010 were surveyed around Bako, Ambo, Melkassa and Hawassa areas of Ethiopia. Besides, 150 and 200 farmers in 2009 and 2010 were interviewed, respectively. The results revealed that the maize weevil Sitophilus zeamais is one of the most dominant pests that caused heavy grain losses in maize followed by Sitotroga cerealella. Gombissa among storage structures and insecticides among control methods were used by majority of farmers. The results of grain damage and weight losses showed that the highest and lowest grain damage and weight losses percentage were recorded from Melkassa and Hawassa, respectively. The average grain damage and weight loss were 28.39% and 4.57%, respectively. The majority of interviewed farmers estimated grain losses ranging from 35 to 50%. With such high levels of damage and losses caused by insect pests, vulnerability of the subsistence farm households to food insecurity was inevitable. The poor state of available post-harvest technologies and farmers' inadequate knowledge on proper postharvest handling methods seems to further aggravate the already fragile food insecurity. Any strategies to help smallholders to simultaneously improve their capability to use modern farming tools, and improve their ability to use suitable processing and storage methods could be the pathway out of hunger and poverty. Therefore, devising a better storage insect pest management systems, including development of resistant maize varieties to S. zeamais and S. cerealella, that would reduce tremendous grain losses and training of the smallholders is necessary in order to achieve food security and improved nutrition.

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Abstract # ADMI011

Cost-Effective Measurement of the Economic Value of Post-Harvest Losses in Africa

J. Lowenberg-DeBoer

International Programs in Agriculture, Purdue University

Corresponding Author: bjd@purdue.edu

Introduction: Post-harvest loss is often thought of in physical terms as the percentage of food produced that is no long available for consumption and the value lost estimated as the value of that food that has disappeared from the food chain. For example, the World Bank estimates that about $4 billion in grain is lost in Sub-Saharan Africa annual mainly based on the grain that is no longer available (World Bank, 2011). But the loss in value may be much larger than the value of the absolute quantity that is eaten by insects and rodents, that is no longer useable because of contamination with mycotoxins, or that spoils because of poor handling and storage conditions. Post-harvest lost includes the reduced value of grains and other food that is damaged post- harvest. Insect excrement and body parts left in the food may affect the taste and food safety, and consequently reduced the price consumers are willing to pay. Moldy grain may still be saleable, but only at a reduced price. Rotten spots on fruits, roots, tubers and vegetables, and other post- harvest damage may increase the labor required for processing or cooking, also reducing the price. The damaged grain or other food maybe be less appealing to consumers and therefore attract a lower price in the market. Farmers and traders may not be able to access certain high value markets if their products are damaged or contaminated, and thus they realize lower sales prices. This presentation will summarize cost-effective approaches to determining the effect of post-harvest damage on the value of foods and provide some examples from cereals and grain legumes. This presentation will be of interest to post-harvest researchers and everyone concerned with food security.

Objectives: The general objective of this presentation is to summarize cost effective approaches to measurement of the economic value of post-harvest damage. Specific objectives include:

1. Outlining the main methods for estimation of the value of post-harvest damage to food quality.
2. Provide examples from studies in Africa that have effectively measured loss in post- harvest value of cowpea, beans and maize.

Methods: The approach will be to review the literature on post-harvest value loss assessment to identify unique methodologies used and good examples.

Results: Estimating the value of post-harvest damage to food quality requires eliciting consumer preferences. Most preference elicitation methods fall in a range that goes from estimating preferences based on actual consumer purchases to stated preference methods that depend on what consumer say. In estimating the value of post-harvest food quality damage the most common methodology for using consumer purchase information is “hedonic pricing” which uses links measured attributes statistically with price variation. Since each purchase in a traditional Africa market is a separate negotiation with a different price depending on the exact characteristics of the product being purchases, hedonic pricing works well. It has been widely used for estimating the value of storage damage in cowpea (Faye et al., 2004 & 2006; Mishili et al, 2007; Langyintuo et al, 2003; Langyintuo et al, 2004; Ibro, 2011). It has also been used for common bean (Mishili et al, 2011). Those studies all simulate consumer purchases by asking a researcher or technician to buy cowpea or beans in a traditional market as if they were buying for themselves. These studies indicate that for both cowpea and common beans the price discount is somewhere in the range of 0.17% to 2.3% of the average annual price for each bruchid hole in a sample

of 100 grains. Gathering hedonic pricing data is not expensive. The cowpea studies in the 1990s and early years of this century were typically funded with $5000-$10,000 per year per country with three to five markets covered. Because hedonic pricing data is usually collected on actual purchases the results typically have credibility beyond the economics research community. The main disadvantage of hedonic pricing is that several years of data are usually required to sort out seasonal effects from underlying preferences for product characteristics. A hedonic pricing study for grains, grain legumes or oil seeds does not usually fit into the typical masters or doctoral research program period. If results are required quickly some kind of choice experiment is typically used. Those choice experiments can range from actually selling various lots of grain with different damage levels to determine selling prices to show people samples with different damage levels and asking what price they would be willing to pay. For example, Compton et al (1998) used focus groups of grain traders in Ghana to estimate price discounts based on samples of insect damaged maize. They found a 0.60% to 0.97% price reduction for every 1% of insect-damaged maize kernels beyond a threshold of 5% to 7% damage. Jones (2012) asked grain traders in Malawi to choose between samples of maize labeled with different price levels. In the 10% to 30% damaged kernel range, they found that a 1% increase in percent of damaged kernels resulted in a price discount of 2.8% to 3.6% depending on the total damage level, but little evidence of a discount below 10% damage. Choice experiments can typically be completed in a matter of weeks. They fit very well into the usual masters or doctoral research program. The statistical analysis of choice experiments is complicated and the choice experiment community is wary of biases introduced by how the experiment is designed and conducted. In most cases the closer the choice experiment is to actual purchases the more credibility the choice experiment results have.

One of the reasons why the Purdue Improved Crop Storage (PICS) program was able to achieve rapid scale up was that the cowpea hedonic price studies had shown substantial price discounts for damaged cowpea. Based on that information the PICS team was able to help farmers and traders understand the profit opportunity in improved storage. Adoption of improved storage for maize in Africa is likely to be slower than for cowpea because the price discounts are smaller and the market typically allows a threshold of 5% to 10% damaged kernels before any discount is applied. This difference is linked to how cowpeas and maize are consumed. Cowpeas are often boiled whole and the consumer can see the storage damage on the plate. Maize is usually milled before cooking and storage damage usually is noticeable by the consumer only if it affects taste or color of the cooked food.

Conclusions: Researchers in Africa have used hedonic pricing and choice experiments to estimate the loss in value due to post-harvest damage. Hedonic pricing is relatively inexpensive, the data analysis is straight forward and non-economists often find the results credible because they are based on actual purchases. The main disadvantage of hedonic pricing is that several years of data are usually required to sort out seasonal effects. Choice experiments can be implemented more quickly than hedonic pricing. Data can be obtained in a matter of weeks. But the statistical analysis is complicated and credibility of the results is sometimes questioned because of concerns about experimental design and implementation.

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Abstract # ADMI012

EXPERIENCE WITH REGARD TO APPLICATION OF EXPLORATORY AND QUANTITATIVE FISH LOSS ASSESSMENT METHODOLOGIES IN AFRICA

Yahya Ibrahim Mgawe

Fisheries Education and Training Agency, Bagamoyo, TANZANIA

Corresponding Author: ymgawe@yahoo.com

The global demand for food fish is increasing unprecedentedly triggered by population growth and voracious appetite for fish all over the world. Unfortunately, this is happening at the time when fish supply, especially from capture fisheries, seems to have reached an optimal level. Given the situation, there is an urgent need for promoting sustainable resource management regimes and aquaculture development, coupled with reduction of post-harvest losses. Probably, reduction of losses has more to offer, as a quick-fix, than the other two potential intervention measures.

Total global food losses have been estimated at 1.3 billion tons per year, which is about one-third of the total world food production for human consumption. This figure includes post-harvest fish losses, which are reductions in the quantity, quality or monetary value of fish in the supply chain (FAO- 2014). Although it is widely acknowledged that high post-harvest fish losses occur in many fisheries but there is lack of sufficient understanding of how significant the losses are, who is being affected and how and what could be done to reduce losses?

In view of this situation, studies have been conducted in sub-Saharan Africa which involved several countries including; Ghana, Kenya, Mali, United Republic of Tanzania and Uganda. The main objective was to consolidate post-harvest fish loss assessment methods and generate basic data with regard to quality and physical losses in Small-Scale Fisheries (SSFs). Also, attempts were made to investigate the interplay between marketing environment and post-harvest fish losses.

The complexities in assessing fish losses under small-scale scenario compelled the use of a mixed methods approach consisting of review of historical data, exploratory and quantitative assessment techniques including extensive interviews with focus groups. Generally, the process included thorough review of research reports, fishery sector reviews, development plans and policy framework for information on post-harvest fish losses including how losses are considered in national policies of respective countries. The findings helped in developing check-lists to guide qualitative data collection in the field. Thereafter, pilot studies were conducted in order to familiarize with field scenario, conduct stakeholders' analysis and field-testing checklists as well as to validate secondary data. Detailed fish loss assessment activities were then conducted by using exploratory research techniques including; observation, Semi-Structured Interviews (SSI) and focus group interviews before applying quantitative methods; Load Tracking (LT) and Questionnaire Loss Assessment Method (QLAM).

The result indicates that post-harvest fish losses (PHFL) in SSFs occur at all stages in the fish supply chain from capture to consumer. Huge physical and quality losses were found to occur in some supply chains assessed in all the countries, with quality loss reported to account for more than 70 percent of total loss. Concurring data are that physical losses seldom exceed 5 percent of total fish landed.

Furthermore, the studies indicated limitations to a purely technical approach to reducing fish losses, namely the assumption that maintaining quality will increase the value of the fish and income of the operator, rather something more has to be done. Notably, the findings express explicitly existence of an invincible interplay between market accessibility and post-harvest fish losses. Unfortunately, the linkage

between marketing forces and post-harvest fish losses has never been analysed adequately limiting ability to address the problem effectively. Hence, there is an urgent need to analyze the marketing environment surrounding SSFs as an important way of reducing losses.

The essence is that increased returns to the fishermen or trader are dependent upon macro and micro-marketing environmental variables including; political, economic, social cultural and technological forces as well as forces impacting suppliers, intermediaries, customers and competition. These variables are actually related to market access issues given that if the sellers had access to different buyers in domestic, regional and international fish markets they would be able to sell out their produce before much spoilage and thus reduce losses.

In conclusion, the studies propose a conceptual framework re-orientation, extending traditional theoretical outlook of limiting ourselves to primary drivers of studying post-harvest fish losses; microorganisms, autolysis and rancidity, to also consider marketing environmental forces as other major causes of the losses.

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Abstract # ADMI013

Rice post-harvest losses in sub-Saharan Africa: Advances by the Africa-wide Processing and Value-Addition Task Force

Sai Atanga Ndindeng, Sali Atanga Ndindeng, Benin John Manful, Benin Koichi Futakuchi, Benin Jean Moreira, Benin Seth Graham-Acquaah, Benin Paul Houssou, Delphine Lamare Mapiemfu[2], Paa-Nii Torgbor Johnson[3], Ousman M. Jarju[4], Salimata S. Coulibaly[5], Nahemiah Danbaba[6], Fallou Sarr[7], Jean G. Nemlin[8], d'Ivoire Alphonse Candia[9]

[1]Africa Rice Center (AfricaRice)

[2]IRAD-Cameroon

[3]CSIR-IFR, Ghana

[4]NARI-The Gambia

[5]LTA-Mali

[6]NCRI-Nigeria

[7]ITA-Senegal

[8]CNRA-Cote

[9] NARO-Uganda

Corresponding Author: S.Ndindeng@cgiar.org

Introduction: Paddy rice production in sub-Sahara Africa (SSA) in 2013 is estimated at 20.5 million tones (IRRI, 2015) but this quantity does not reach the table of consumers due to post-harvest losses that can be subdivided into physical grain loss (PGL) and grain quality loss (GQL). Efforts at identifying and resolving the critical issues along the rice value chain in many SSA countries is impeded by the lack of a simple, adoptable and well- defined practical methodology on how to estimate PGL and GQL after harvest. This makes it impossible to have credible data during the various operations along the rice value-chain.

Objectives: In order to resolve this issue, Africa Rice Center (AfricaRice) and its partner [(National Agricultural Research Institutes (NARIS)] operating within the context of the Africa-wide Processing and Value-Addition Task (APVATF), have developed a protocol to assess PGL and GQL from harvest to storage.

Methods: The protocol identifies nine and six critical points for PGL and GQL respectively and describes how to quantify these losses at each point while taking into consideration the grain moisture content, equipment used, rice variety and ecology. The protocol is being used to quantify the potential losses (when improved practices are used) and the actual loss (when farmerâ##s practices are used) in 14 African countries in at least 2 hubs per country. The sample size is 10 farmers per hub (for harvesting, threshing, cleaning and drying), 9 parboilers per hub (for parboiling), 3 mills per mill type per hub (for milling) 3 locations per hub (for storage). For PGL, the percentage losses will be summed and used to calculate the actual losses based on the latest production estimates for each country. For GQL, the proportion of impurities, broken and chalky grains will be evaluated. The monetary value of PGL in US dollars will be determined based on the current price of paddy in the market. Likewise, the monetary value of GQL will be expressed as the difference in the market price of the benchmark rice (inferior quality) and different alternative rice (superior quality) in the market place or under experimental conditions (Demont et al. 2012, Akoa-Etoa et al. 2015). Results/ Findings: Preliminary data for PGL and GQL have been collected from 4 and 11 countries respectively. Averagely the proportion of PGL for

shattering, stacking, in-field transportation, manual threshing, drying on cemented floors or tarpaulin, parboiling, milling and storage are 1.9, 3.1, 4.9, 5.8, 6.8, 6.9, 5.9, and 10.5% respectively giving an overall % PGL of 30. Check experiments with different varieties at AfricaRice showed that shattering losses averagely doubles from 2.75 to 5.46% when grain moisture at harvest drops from 20 to 15% after a period of 3.5 days. Field stacking losses was 8.72 and 8.36% for harvesting at 20 and 15% grain moisture respectively. In-field transportation losses were very low (0.23%) but the proportion of grains left on the panicle after manual threshing was much higher (20.87%) at 20 % grain moisture content than when a mechanical thresher (ASI-thresher) was used (0.22%). Manual and mechanical cleaning of the paddy resulted in 2.2 and 0.1% losses respectively. For GQL the average proportion of impurities, broken and chalky grains were 2.1, 40.6 and 16.8% respectively. Proportions of PGL and GQL from different countries should a high degree of variability. Conclusion: A protocol has been developed and tested for the quantification of PGL and GQL in SSA. Harvesting at 20 % moisture is critical but this must be accompanied by threshing with a mechanical thresher. Stacking after harvest increases PGL irrespective of the grain moisture content at harvest if precautionary measures are not taken to collect grains that may drop. The expression of PGL and GQL in monetary value will be done once all data is collected. This will allow for the validation and comparability of losses across SSA countries.

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Abstract # ADMI014

Research contributions to estimation of tomato postharvest losses in Brazil

Augusto Hauber Gameiro, José Vicente Caixeta-Filho, Thiago Guilherme Péra

University of Sao Paulo, Brazil.

Corresponding Author: gameiro@usp.br

Introduction: The supply of tomatoes for consumption or processing is a relatively complex activity, especially given the perishability of the fruit. Large-scale plants require large volumes of raw material. Evidence confirms that there are significant logistics losses (Gameiro et al., 2007). In 2013 the Brazilian production of tomatoes was 4.187 million tons, in an area of 62,690 hectares, generating a gross value of agricultural production estimated at R$ 5.220 billion or US$ 2.420 billion (IBGE, 2015). Part of that volume is destined for industrial processing of foods such as sauce, extracts, pulps, catchups, juices etc. The proper management of the raw material is a key point for the competitiveness in the sector. It is known that the tomato fruits are highly perishable with a very thin peel, becoming a fragile material for handling and transporting. The fruit has in its composition approximately 93% to 95% water. Empirical evidence report high values of existing losses in supply, therefore efforts to optimize the supply logistics are required.

Objectives: The objective of this paper is to present some progress made in recent years related to methods of estimation of post-harvest losses of tomato for both fresh consumption and for industrial processing in Brazil.

Methods: We will discuss three research results developed by ESALQ-LOG Group: Costa & Caixeta-Filho (1996), Gameiro et al. (2007) and Gameiro et al. (2008). Henceforth we refer to these results as P1 (from "paper 1"), P2 and P3, respectively. We will highlight the progress and discuss the difficulties and limitations met. Thus, we aim to contribute to the discussion of a research and development agenda regarding the tomato PHL issue for the coming years. P1 intended to analyze the economic effects of post-harvesting losses for tomato for fresh consumption, specifically during its transport and commercialization, since the producing area of Apiaí city to the "Mercado Municipal of Piracicaba", in Piracicaba city (both in Sao Paulo State). Three agents were identified in this commercialization channel: the producer, the middle-man and the retailer. It was analyzed, through non-linear programming techniques, the variations of prices, quantities, revenues and margins in relation to the increase of the transportation and retail market losses, as well the changes in the supply and demand price elasticities. In P2 and P3, we followed closely the whole process of harvesting and industrial supply of tomatoes in a facility located in the Brazilian Midwest region. In P2, the data collected in the field were harvest fruit weights, waiting times, load disposal on trucks and losses involved. For the estimation of tomato PHL, we carried out an experiment in which we measured the weight difference of samples arranged in loads of 8 trucks that had waiting times properly controlled. The fruit waiting times inside the boxes in the field after manual harvest were found (waiting to load the trucks) and the fruit waiting time in the truck body (during traveling and waiting to unload at the facility). We obtained the weights by appropriate scales both in the field and in factory. Samples of 30 kg fruits were prepared, placed in polypropylene bags and placed at three different heights in the buckets. For each time two samples were prepared. Thus, in total, we outlined an experiment with 48 samples obtained from eight trucks in three heights and two samples per time. We used the data of percentage weight loss to adjust econometric models (multiple linear regression models) of losses for different waiting times (in the box and bucket) and load height inside the truck. The model considers manual harvest. In P3 a deterministic simulation mathematical model was developed with the objective of allow better knowledge of the whole process of tomato harvest, from the field to the facility, and to estimate possibilities of optimization. The simulation using the model generated different scenarios that, when compared with the real performance in field, show the importance of the accurate management, with evident potential of expressive financial gains in the supply chain process due the reduction of time, losses and costs.

Results: Through P1, we surprisingly noticed that any kind of losses in post-harvest channel was beneficial for the producer, because there was an increase of prices followed by an increase in the demanded quantity. On the other hand, the middle-men were indifferent to increases in losses, either at the retail or at the middle-man level, because they sell in volume (number of boxes) and the losses are accounted in weight (kg). For the retailers, the losses in any market level were not interesting, because they buy in volume and sell in weight, incorporating their own losses as well the middle-men's ones. It was also confirmed that the consumer was always in prejudice with the increase of losses, because there is an increase in price related to a reduction in the quantity demanded.

The experiment for measuring losses described in P2 generated the data that we used to estimate the loss equations. We tested different models with and without constant, with simple variables, square and cross ones. The models showed regression coefficients (R2) between 56.9% and 66.6%. In most of them, the estimated coefficients were significant for the "t" test at 5% significance. As expected, the signs of the variables related to time (time in the boxes and time in the back of trucks) showed positive signs indicating that the higher this time, higher product losses. For the height variable, the signal found (in models 1 and 2) were negative, also going to meet expectations. Thus, the greater portion of the height of the product is determined, the lower the weight pressure on the fruit and thus the losses are smaller. Comparing the seven tested models, we elected the #6. In addition to submitting the highest regression coefficient, t-tests were significant for two of the three variables and the signs are consistent with the expected from the literature. Thus, the model indicates that losses are influenced by the waiting time in the boxes and in trucks (where the pressure on the fruit is higher), and this has its effect on losses potentiated by the time the fruits were inside the boxes, in the field, waiting for the loading (cross variable). If we consider, for example, that the product has to wait 12 hours in the boxes at the field before being loaded into the truck and another 12 hours between the trip and the wait for unloading at the factory (these times were fairly representative of the Brazilian reality), the weight loss would be of the order 2.39%. Two assumptions and limitations should be considered from P2: i) due to the expansion of mechanical harvesting, new models should be proposed for this technology; and ii) new experiments should consider the variety of fruits, since it is known that some are more resistant than others.

The simulation model of supply logistics developed in P3 allowed us to conclude that the losses of product could be reduced from the current more than 2% for less than 1%. The reduction of production capacity idleness could be reduced to lower opportunity cost and higher total revenue. To a factory with a processing volume of more than 330 thousand tons per season, the improvements of the supply process by PHL could result in gains estimated of approximately of US$ 2.3 million/season.

Conclusions: Our general conclusions are that the developed researches - both for tomatoes for fresh consumption and for processing - with a focus on detailed mapping of the supply chain contributed to a better understanding and measuring of product losses. We conclude that the proposed methods for the estimation of tomato PHL are suitable, allowing quantifying the losses and thus signaling the importance of proper management of the process. The main limitations - that consequently motivate new ideas - are:

the need to consider different varieties of tomatoes; to develop similar research considering mechanical harvesting (whose use has increased significantly in recent years in Brazil); to develop new supply chain optimization models and, not only deterministic simulation ones.

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Abstract # ADMI015

Mapping Food Insecurity

Craig Gundersen, Elaine Waxman2

1University of Illinois

2Feeding America Amy Satoh, Feeding America

Corresponding Author: cggunder@illinois.edu

Introduction: Addressing food insecurity across the world requires understanding the geographic distribution of the problem. This understanding is especially important for our efforts to reduce post-harvest loss a thorough portrayal of where food insecurity is concentrated, enables these efforts to be directed where (a) food insecurity is most prevalent and (b) where post-harvest losses may be especially large. While the magnitude, depth, and consequences associated with food insecurity in the United States are less severe than in other parts of the world and, in many cases, far less severe, alleviating food insecurity in the U.S. has captured a great deal of attention from policymakers and program administrators. In 2013, almost 50 million persons lived in households classified as food insecure (Coleman-Jensen, Nord, and Singh 2014). These rates have at the highest they have been since measurement began in 1996. The prevalence of food insecurity is of great concern, a concern heightened by its many demonstrated negative health consequences. (See Gundersen, Kreider, and Pepper (2011) and Gundersen and Ziliak (2014) for discussions of relevant studies.) The alleviation of food insecurity is the central goal of the Supplemental Nutrition Assistance Program (SNAP, formerly known as the Food Stamp Program), the largest food assistance program in the United States and it is a key goal of other programs such as the National School Lunch Program and the School Breakfast Program. Along with SNAP and school meal programs, critical informal food benefits are provided through Feeding Americas network of member food banks and other federal programs. While many programs in the U.S. seek to address food insecurity independent of where it occurs (for example, SNAP), there are other programs that seek to direct resources towards areas most in need. In order to effectively direct resources, information at sub-national and even sub-state levels are needed. This information at, for example, the county-level, however, is not available in nationally representative data sets except for the largest areas due to confidentiality concerns. In other countries, especially low and low-to-middle income countries, information about food insecurity is needed at the sub-national level since many food assistance benefits are distributed based on geographical criteria.

Methods: In response to the need for sub-national level estimates, Feeding America began releasing estimates of food insecurity at the county level for all counties in the United States in 2010 through a large-scale effort titled Map the Meal Gap. In this paper, we begin with a discussion of how these county-level food insecurity estimates are derived. Briefly, these estimates were derived using a two-step process. First, the relationships between various factors (the unemployment rate, the poverty rate, median income, percent African-American, percent Hispanic, homeownership rates, state fixed effects, year fixed effects) and food insecurity were estimated at the state level. These relationships were developed using data primarily from post-

2001 December Supplements from the Current Population Survey (CPS). Second, using the coefficients estimated in the first step and the same variables defined at the county level, estimates of the extent of food insecurity for all counties were established. This imputation method primarily used county-level information from the American Community Survey (ACS). (Other variables, of course, also influence food insecurity rates but only those available in both the CPS and ACS can be included under these methods.) A slightly modified approach was then repeated for income categories, which parallel eligibility criteria for SNAP, for the full population. We also estimate food insecurity rates for children, a category of particular interest in the U.S. insofar as many food assistance programs are geared towards this population.

Results: We concentrate on three key questions that are central to the development of Map the Meal Gap: What are the state-level determinants of food insecurity (full population, households with children, income breakdowns within each)? What is the distribution of estimated food insecurity rates across counties in the United States? How do the county-level food insecurity estimates generated in Map the Meal Gap compare with those from other sources? In answering each of these questions, we will use the most up-to-date information available from the CPS and ACS up through 2013. Conclusions We conclude with, first, suggestions for future research directions on mapping the geography of food insecurity in the United States. This is followed by coverage of current applications for Map the Meal Gap and potential future applications. Second, we provide some preliminary thoughts on how the methods from this work might be applied in other countries. As part of this, we will discuss how our methods can be implemented alongside the numerous other mappings of food insecurity that currently exist, especially those in low- and low-to-middle income countries. Without a doubt, what we use in Map the Meal Gap wouldnt replace these other mappings but they will offer some alternative approaches, especially when these other mappings might not be as feasible and/or data is available in locations that would be amendable to the Map the Meal Gap methods. Third, we consider various ways that our methods and other methods to describe the geography of food insecurity in low-income countries can be used in conjunction with information on the geography of post-harvest losses. This is an underexplored area and so is worthy of further consideration.

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Abstract # ADMI016

Food losses and their ecological footprint in rice value chains in Nigeria

Tanja Pickardt

Rural Development and Agriculture, GIZ

Corresponding Author: tanja.pickardt@giz.de

Food losses do not only have effects on a social and economic scale, but also represent a waste of resources used in production such as land, water, energy and other inputs. Reducing food losses is thus one of the most important reactions to global warming in the agribusiness sector. To evaluate and quantify food losses is conceptually challenging. The German Federal Ministry for Economic Cooperation and Development (BMZ) has therefore commissioned GIZ to undertake a couple of studies on various products in Africa, with the aim to quantify post-harvest losses and to develop recommendations for reducing those losses. The presented study considers the multifaceted impacts of food losses and thus has a twofold objective. First, it offers a sound analysis of the losses occurring along the rice value chain in Nigeria. Second, it highlights and assesses the consequential environmental impacts of these losses, a dimension often missing in classical studies on post-harvest losses. The study compares two rice value chains which are predominant in Nigeria: the traditional value chain of small-scale farmers producing rice in the form of rain- fed agriculture on small fields followed by parboiling and milling, and the industrial value chain with integrated processing. A Life Cycle Assessment in accordance with ISO 14040/44 was used to evaluate the environmental impacts of losses along the value chains. The study is mainly based on primary data from field surveys analysing the production, processing and trading of rice in Kogi and Niger State. The following environmental impact categories are assessed: global warming potential, water scarcity footprint and land occupation. The final results show an estimated post-harvest loss of 25 per cent, resulting in a substantial loss of revenue for farmers. The lack of good processing, storage and transport facilities contributes, as well as diseases and pests, to the losses in the post-harvest sector. The combined post-harvest losses along the value chain of rice account for emissions of 0.65 million tonnes of CO2 eq. into the atmosphere, carry a water scarcity footprint of 2.1 million m' and cause land occupation of more than half a million ha per year. The cultivation phase is the key contributor to the assessed environmental impact categories along the rice value chain, followed by the traditional parboiling process, whereas the industrial value chain is characterized by both less losses and less CO2 emissions. Based on those results, conclusions and technical and organizational measures for the reduction of losses for the promotion of food security as well as for the mitigation of negative environmental effects are discussed. As a follow up and in order to be able to meet the counselling requirements of value chain support projects, GIZ has commissioned the design and pilot testing of a rapid appraisal tool for losses with the objective to develop a lean and easily manageable methodology providing strategic orientation for developing measures aimed at reducing food losses along agribusiness value chains. The methodology is designed to serve as a pre-screening for further in-depth-studies and identify leverage points for reducing losses at the various value chain stages from farming, through handling and processing up to retail trade.

Abstract # ADMI017

An overview of the state-of-the-art post-harvest losses in Brazil

Thiago Pera, Augusto Hauber Gameiro, Daniela Bartholomeu Bacchi, Fernando Vinicius da Rocha , Jose Vicente Caixeta-Filho

Group of Research and Extension in Agro-industrial Logistics (ESALQ-LOG)

Corresponding Author: chikoyem@gmail.com

Introduction: Food security is gaining importance due to population increase and scarcity of natural resources. Bourne (1977) recommends three ways to achieve food security: (i) increase in arable land; (ii) increase in productivity through intensive use of technology; and (iii) increase in growing seasons per year. However, another important alternative focus should be on reduction of post-harvest losses within operations between rural producer and consumer (WRI, 2013). Brazil has been an important food supplier through agricultural expansion. Thus, it is important to understand the state of the art of post-harvest losses (PHL) to strengthen the efficiency of food distribution.

Objectives: The objective of this study is to perform a meta-analysis of the main items of post-harvest losses in Brazil, involving the following indicators: products, types of losses, losses of resources, methodologies, metrics losses and year of publication. The contribution of this study is to identify opportunities for future studies involving the theme of PHL.

Methodology: This study was divided into three phases: (i) identification of sixty major articles published in national / international journals and conferences that evaluate issues of PHL in Brazil from 2000 and on; (ii) development of indicators for meta-analysis, according to definition of PHL categories, methodologies and metrics proposed by Caixeta-Filho (1999); and, (iii) classification of articles based on (ii) criteria. The indicators for meta-analysis of the articles are:

Group of agricultural products: subdivided into vegetables, grains, seeds, flowers and fruits.

Type of loss: (i) Quantitative - direct damage to products, handling, packaging, storage and transport (usually considered as ways for spread of diseases and physiological disorders); and (ii) Qualitative - involves losses related to biological, microbiological and chemical activities (usually affects organoleptic and nutritional properties of products).

Cause of loss: related to causes of loss such as packaging and handling, storage, transport, and physiological disorders, diseases and pests.

Methodology: approaches used to assess PHL, involving: survey, sampling, field and laboratory experiments, and literature review, among others.

Metrics of PHL: metrics related to the magnitude of losses such as weight loss, physical chemistry, economic, nutritional, among others.

Year of publication: the following databases were searched: Web of Science, Scopus and Google Scholar. Results The most studied groups of agricultural products are fruits (45.9%), vegetables (27.9%), grains (23%), seed (1.6%) and flower (1.6%). Regarding the type of loss, it was found that 83.8% of the studies focused on quantitative losses and 16.2% on quality loss. As the cause of loss, it was found that 43.2% of the studies focused on storage activity, 23% in handling and packaging activity, 17.6% in transport, and 16.2% in biological activities (physiological disorders, diseases and pests). The methodologies employed are: experiments conducted in field and laboratory (55.7%), in-site sampling

(23%), literature review (9.8%), interviews / surveys (8.2%), and review of measurement methods (3.3%). The most used PHL metrics are: weight loss (40.6%), biological infestation (26.4%), physic-chemical (22.6%), nutritional (9.4%) and economic (0.9%). As regards year of publication, 63.1% of the articles were published between 2000 and 2008, while 36.9% were between 2009 and 2014.

The main take-home messages are: 1) During the 2000 decade, most studies of PHL were related to vegetables and fruits with focus on losses during storage with experiments using controlled atmosphere and waxes / hormones to increase the shelf life and development of appropriate packaging technology applications; 2) Studies of PHL in grains can be divided into two stages. In the first stage, during the 2000 decade, studies were related to qualitative and quantitative losses of grains in storage to establish appropriate procedures in the various storage operations. The second stage has recent studies, published since 2010, involving physical losses during transportation of the product, especially in road transport; 3) Methodologies for assessment of losses caused by biological activities, storage and packaging were replicated on several studies, whereas for losses caused by transportation, the methodologies used were found in different studies evaluated, even with a questionnaire application dependency.

Conclusions: The objective of this study was to perform a meta-analysis of the main items of post-harvest losses in Brazil, identifying opportunities for future studies. The subject of post-harvest losses follows a multidisciplinary approach, involving agricultural fields of study, agricultural engineering, economics, physiological, biology, among others. Recently, studies of post- harvest have been related to transportation, mainly in road. For future studies, the following recommendations are made: 1) Development of studies approach in supply chain of agricultural products to establish loss on all links; 2) Recommendations from specific analysis of regional public policies to minimize PHL; 3) Establishment of standardized methodologies for agricultural products / PHL assessment, especially in emerging areas of studies, mainly related to transportation - including multimodal; 4) Inclusion of other types of losses, such as economic, environmental and social; 5) Identification of equipment used and recommendations of technologies for minimization of PHL.

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Abstract # ADMI018

USAID Post Harvest Loss Reduction Innovation Lab (PHLIL): Bangladesh Component

Md. Monjurul Alam[1,*], Md. Ayub Ali[2], Md. Abdul Awal[1], Chayan Kumer Saha[1], Md. Rostom Ali[1] and Md. Abdul Momin[1]

[1]Department of Farm Power and Machinery, Bangladesh Agricultural University (BAU), Mymensingh-2202, Bangladesh

[2]Department of Plant Pathology, Bangladesh Agricultural University (BAU), Mymensingh-2202, Bangladesh

Corresponding Author: mmalam.bau@gmail.com

Background: Paddy is the main staple crop of Bangladesh accounting for 76% of total cropped area and 95% of cereal production. Since independence in 1971, the production of paddy has increased over three-fold to 55.5 million tons, compared to double the population of 160 million, and attains self-sufficiency against shrinking of agricultural land by 0.5% per year (FAO, 2014). Over time, the production activities of paddy have been partially mechanized; however, harvesting, transporting, drying, cleaning and storage mostly remain traditional and the responsibility of the farmers, especially of the women. The estimated total post-harvest loss of paddy at farm level is about 14% that includes harvesting (1.06 – 6.5%), handling and transporting (0.63 – 6.0%), threshing (1.65 – 2.0%), drying (1.56 – 5%) and storage (3.05 – 7.5%) (Bala et al., 2010). After processing, a portion of the paddy is traditionally stored at farmers' houses for consumption, for future sale, and as seed. The rest of the paddy end up in the warehouses of rice mills, different organizations and seed companies for use as food grain or as seed through local paddy traders (Farias and Beparies) and commission agents (Aratdars). The price fixing of paddy at all levels depends on the quality. Farmers do not get fair price for their paddy as it develops molds and discolors due to storage at high moisture content, and sustains insect and pest damage in open air storage. The farmers usually dry their paddy under sunshine. They do not have any moisture meter and rely on biting grains to gauge the moisture. They believe that paddy is dried enough for storage; however, in most cases, it remains beyond the safe moisture limit. Moreover, the open air traditional storage of paddy ends up with absorption of moisture from the humid ambient air during the monsoon, which further complicates the situation. Hot and humid weather associated with frequent rainfall during Boro paddy harvest (April-May) makes the ecology favorable for the invasion of storage fungi that causes development of mycotoxins. Invasion of storage fungi is also favored by stored insect. Some mycotoxins are carcinogenic, toxic to humans and domesticated animals, and heat stable in most food stuffs. The post-harvest losses of paddy not only pose a threat to the sustainable food security in the country, but to the nutritional status of the population, especially to the children and women. Therefore, innovative efforts that result in reduced post-harvest losses are urgently needed in Bangladesh.

The Feed the Future (FtF) Postharvest Loss Reduction Innovation Lab (PHLIL) program, USA, aims to provide global leadership to reduce post-harvest loss (PHL) and food waste of durable staple food crops and their processed value-added products with an initial focus on four FtF countries, Bangladesh, Ethiopia, Ghana and Guatemala. The PHLIL Bangladesh component includes mycotoxin, drying and storage components along with gender and cross-cutting issues. The project is in its second year of five years duration. The component is financed by the ADM Institute, University of Illinois and USAID, USA.

Objective: The PHLIL–Bangladesh component intends to build capacity in the areas of awareness of Mycotoxin development, drying and storage technologies of paddy for farmers (men and women), and of farmers' groups and agribusiness entrepreneurs to reduce post-harvest loss and improve grain quality.

Approach: The interventions under the Bangladesh project will integrate farmers (men and women), farmers' groups and agribusiness enterprises with market-based value chain actors by:

- Enhancing their capacity to improve awareness on micotoxin development, drying, storage and marketing of paddy, and thus improving the quantity and quality of paddy;
- Pilot testing of promising "on the shelf" and "in the field elsewhere" best practices and technologies that need further refinements and input for end–users for scale up and commercial uptake;
- Using local artisans, business people and workers to create and develop locally-produced tools and technology to aid in sustainability of resources and practices;
- Investigating cultural, social and economic factors, with specific attention to gender issues, that affect local stakeholders and their interactions with post-harvest practices/technologies and utilizing this information to structure recommended changes/technologies to help ensure their adoption;
- Employing advanced information technology-based systems to more rapidly evaluate and disseminate promising PHL innovations for application; and
- Increasing the quantity and quality of stored food staples and dietary diversity, along with country specific nutrition education, thus increasing access to nutritious food and reducing under-nutrition and food insecurity.

Outputs: The PHLIL–Bangladesh component intends to achieve the following outputs through appropriate innovative efforts:

- A post-harvest loss reduction target of 5% at the household or farm level. This loss reduction could mean a corresponding reduction in household food expenditure for rice (or more rice to sell) roughly equaling 5–10% more household income;
- A national database for mycotoxin infestation in paddy will be developed, the information could be useful for national nutrition policy formulation;
- Appropriate drying and storage technologies will be identified and disseminated among farmers, farmers' groups and agribusiness entrepreneurs;
- Capacity building of the project team to address the gender dimension of agricultural research and extension, and integrate gender approaches into all stages of the project cycle; and
- Three PhD fellows will be trained in mycotoxin, drying and storage sub-projects.

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Abstract # ADMI019

Constraints and Opportunities for Increasing Adoption of Technologies for Preventing Postharvest Maize Losses in Africa

Mungule Daudi Chikoye

Zambian Centre for Lifelong learning

Corresponding Author: chikoyem@gmail.com

In a bid to reduce poverty and improve food security, most governments in the Southern African Development Community (SADC) region have given priority to agriculture. However, this sector faces a lot of challenges such as low productivity and production and postharvest grain losses. Stored grain losses in the SADC region excluding South Africa range from 15-20% annually, leaving approximately 1.3 million tons of products damaged and unsuitable for human consumption or the market. At current market values this equates to $270 million in lost value every year (Southern Africa Trade Hub 2012). In order to address the challenge of postharvest grain losses, the United States Agency for International Development (USAID), through its Southern Africa Trade Hub, partnered with regional training and capacity building institutions in Malawi, Mozambique and Zambia to host a series of training courses in grain management during the period 2013-2014.

The overall objective of the training was to address postharvest grain losses through strengthening the knowledge and skills of actors in the grain supply chain. The residential training covered grain grading and standards, storage management, disease and pest prevention. The training targeted technical and middle management employees from certified warehouse receipt facilities, government, private traders, feed and grain mills, and other grain processors. The training was conducted by Sierk Ybema Grain Services, certified grain trading consultants based in South Africa. The host institutions were Bvumbwe College and ACE in Malawi, CLUSA and Unilurio University in Mozambique and In - Service Training Trust (ISTT) in Zambia. Approximately 360 people were trained in the three countries from over 100 different storage operators, reaching a majority of formal grain storage in the countries. The workshops were highly interactive and the lectures were supported by intensive practical work. The half-day session in which the large scale grain traders joined the course participants provided an opportunity for the two parties to share ideas on how they could improve business relations. This session addressed the challenges faced by small scale grain traders during the delivery of grain to warehouses owned by the large scale grain operators. The evaluation of the understanding learning materials involved participants taking a series of tests. The participants that passed the tests were awarded a certificate which certified them as grain graders throughout the SADC region. At the end of the training participants developed plans on how they intended to apply the knowledge and skills acquired from the training. The results from post training follow up showed a reduction in the losses incurred by the graders traders and this subsequently increased the volume of grain traded. This finding was similar to results of a similar training of grain traders conducted by the In - Service Training Trust in collaboration with SADC Food Security Training Programme in the early 2000s. The results of the training confirmed that capacity

strengthening of Actors along the food supply chain can contribute to the prevention of postharvest losses. The outcomes of these trainings underscored the importance of equipping Actors in the food value chain with knowledge and skills for preventing postharvest food losses. In the absence of information about postharvest loss management, it is no wonder that there is a low uptake of innovations and technologies for preventing postharvest food losses among the actors in the food supply chain in the SADC region. The results underscore the need to have postharvest loss prevention incorporated in the extension service delivered by the ministries responsible for agriculture in the region. In order to increase the human resource trained in prevention of postharvest food losses, there is a need for training and capacity building institutions, colleges and universities of agriculture to reform their curricula to include postharvest management. The training of extension staff and inclusion of postharvest management in the extension programme can contribute to the provision of information on postharvest losses to smallholder farmers and grain traders.

Abstract # ADMI020

Postharvest Loss- A Case Study of Sweet Cherry in Kashmir

Mohmad Arief Zargar

Department of Botany, University of Kashmir, Srinagar-190006, J&K, India

Corresponding Author: arifk11@yahoo.co.in

Introduction: Sweet cherries (*Prunus avium* L.) are one of the most popular temperate fruits; but are highly perishable, having a shelf life of only about 2 weeks even under cold chain management[1]. Short shelf-life and postharvest quality loss is mainly due to high respiratory activity, high susceptibility to mechanical damage (pitting and bruising), softening, minimal reserve carbohydrate (starch), changes in sugar-acid balance, desiccation and browning of stem, fungal spoilage, weight loss, color changes and high transpiration rate[2-5]. Sweet cherries are extremely difficult to handle after harvest because of short postharvest life. However, shelf life can be prolonged through proper handling and management. Sweet cherries being non-climacteric, ethylene antagonists have little effect on their shelf life[6]. Temperature management is one of the most important factors affecting shelf-life of sweet cherries[1]. The principal means of prolonging their shelf-life are rapid elimination of field heat and strict temperature control during storage[1]. After harvest, both field heat and heat from respiration of fruit contribute to heat loading of cherries, while lowering fruit temperatures immediately after harvest results in firmer fruit with reduced decay and greener stems[1,7]. That is, rapid control of heat loading through pre-cooling drastically increases their shelf-life & quality. To achieve a rapid decrease in product temperature, use of fast cooling systems is particularly important. Hydrocooling, being highly efficient, is a typical postharvest treatment for sweet cherry[5]. Cherries should be cooled to 0ºC within 4 to 6 hours after harvest and handled between 10-20 ºC to prevent pitting[8]. Temperatures near 0 ºC and high relative humidity (90–95%) are recommended as storage conditions to keep stems green and fruit fresher[8]. In fact, more quality is lost in one hour at 20°C than in 24 hours at 0°C. In cherry, temperature slightly higher than 4-5 °C has been found to be detrimental. Controlled and modified atmospheres have also been recommended for improving cherry marketability-shelflife & quality[4-5]. Combination of controlled atmosphere with low temperature could be used to further extend storage and shipping life of sweet cherries[9].

India produces only around 15300 tonnes of cherry, a negligible proportion (0.73%) of world production[10]. In India, Jammu & Kashmir is the largest producer of cherry, with annual production of 11429 metric tons (74.7% of Indian production); and occupies more than 90% of Indian area under cherry cultivation[11]. But, production of sweet cherry in Kashmir is decreasing rapidly as the area under cultivation decreases year by year since growers are abandoning its cultivation, because of huge pre and postharvest losses.

Objectives: The objectives of the present study are:

- to analyze the postharvest handling techniques followed (for cherry) in Kashmir.
- to identify the causes of postharvest losses of cherry in Kashmir.

- to suggest the remedial measures so as to reduce postharvest losses.

Methods/Approach: About 150 different cherry growers, farmers, traders, and marketers in three different districts of Kashmir were interviewed repeatedly through well-structured questionnaires. The questions asked pertained to variety cultivated; method, stage & time of harvest; maturity indices; postharvest handling- field heat, cooling, washing, pest control, storage, transport, packing and packaging. The responses were noted and statistically analyzed by computing mean, mode and standard deviation.

Results/Findings: Four varieties of sweet cherry are cultivated in Kashmir: (a) Cherry Misri (Bigarreau Noir Grossa), (b) Cherry Awwal Number (Guigne Pourpera Pecoce), (c) Cherry Double (Bigarreau Napoleon) and (d) Cherry Makhmali. More than 60% of produce is either lost or loses its quality after harvest.

Causes: The causes and factors responsible for huge postharvest losses are:

Improper Harvesting: In Kashmir, maturity indices include only skin color, size and luster. Growers usually handle cherry improperly under ambient conditions, at high temperatures, which are disastrous for this fruit. Fruits are manually harvested at any time of the day from dawn to dusk. The harvested produce is kept either in shade or under sunlight (most often in direct sunlight) under ambient conditions, without caring about temperature of fruits, incident sunlight and field heat.

No pre-cooling: Produce is not cooled at all, since farmers are totally unaware of the effects of temperature, requirement of optimal temperature and benefits of pre-cooling. Field heat is not removed by any means.

Lack of Postharvest treatments: None of the postharvest treatments (such as curing practices, cleaning, trimming, hot water dips, cooling, spraying, irradiation) are used.

Pests and diseases: A variety of insects, fungi and bacteria affect postharvest quality of produce. But proper identification and treatment of these is lacking.

Improper grading, sorting and packing. Though infested fruits are graded out from healthy ones to some extent, table fruits are not separated from processable ones. Local, regional or national standards do not exist for inspection. Fruits are packed while warm in sun-warmed boxes.

Improper Packaging: Produce is manually packed in cardboard boxes, replacing wooden boxes. During storage and transportation, these boxes fail to withstand pressure exerted by weight of overlying boxes, thereby leading to mechanical damage (pitting and bruising). No CA/MA is used.

Improper Storage: Produce is stored for 3-12 hours at orchard itself or at make-shift sheds that are covered by polythene or tin sheets, with very poor physical setting and hygiene. Produce is stored there in packed or unpacked form under ambient environmental conditions (around 15°C, either in shade or light). Cold storage or CA/MA is not available.

Slow and Ordinary Transport: Produce is transported from orchards to roads by laborers and then onwards by ordinary trucks at average temperature of 30°C. A truck takes 30-40 hours to reach national capital, Delhi where temperature is around 40°C. Roads (to orchards, if any) are very bad, making rapid and efficient transport of this delicate fruit difficult. Nearest railway station is 300km away from Srinagar, taking 12-15 hrs by truck. Inadequate, insufficient and improper arrangements are in vogue for transportation of cherry by trains from Jammu onwards.

Delays/waiting: There are delays during handling between different steps- usually a waiting/delay period of three days under ambient conditions (20-40°C).

Suggested Remedies:

At Harvest

- Maturity indices should definitely include sweetness (SSC), tartness (TA), SSC:TA ratio, flesh firmness and flavor in addition to skin color.
- Harvest at dawn, in plastic padded baskets, and keep under shade.
- Trained pickers, appropriate picking containers & careful transport of containers can help reduce the losses.

Post harvest

- Precool immediately, preferably by shower type hydrocooling or simple dipping in cold water[4].
- Use proper chemicals/biopesticides/radiation to control pests and diseases.
- Grade/sort out infested fruits, table fruits and processable ones.
- Use plastic boxes and MA/CA packaging.
- Use refrigeration and MA/CA during storage and transport[4]. Being too perishable, cherry needs to be transported as rapidly as possible in refrigerated carriers.
- Shorten the delays during handling between different steps.

Conclusion: Improper harvesting, obsolete practices, mishandling and mismanagement (especially of temperature) are responsible for huge post harvest losses of cherry in Kashmir. The remedy lies in following modern technologies that efficiently control environmental variables, especially temperature. Cherries should be cooled to 0ºC within 4-6 hours after harvest, handled between 0-5ºC, and stored near 0 ºC at 90–95% relative humidity[4,8].

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Abstract # ADMI021

Addressing climate change impacts through postharvest loss reduction: building capacity for creating action at scale

Tanya Stathers[1], Richard Lamboll[1], Brighton Mvumi[2]

[1]Natural Resources Institute (NRI), University of Greenwich, UK

[2]University of Zimbabwe, PO Box MP 167, Mt. Pleasant, Harare, Zimbabwe

Corresponding Author: t.e.stathers@gre.ac.uk

The earth's climate is warming; warmer air holds more moisture leading to changes in rainfall patterns and shifts in weather systems. These climatic changes induce changes in natural and human systems; such as glacial retreat, coral reef decline, reduced water availability, and reduced soil moisture. Climatic impacts on human systems are complex and intertwine with other dynamic, context specific socio-economic drivers of change, such as increasing population density, urbanisation, changing food choices, equity, input subsidy programmes, communication technologies, policies, markets, globalisation, disease and conflict.

Most studies of the agricultural impacts of climate change have focused on assessing the potential yield impacts on major food or cash crops. They suggest that to date climatic changes such as increasing temperatures and changes in the timing and amount of rainfall have had and will continue to have a negative impact on maize and wheat yields in low latitude areas. Across Africa and southern Asia, maize, wheat, sorghum and millet yields are expected to be more negatively affected than rice or cassava by 2050. The nutritional qualities of food crops are likely to be affected. Potential crop land and land suitable for double and triple cropping is anticipated to decrease in developing countries.

With the human population of Sub-Saharan Africa (SSA) projected to double to 2.1 billion people between 2015 and 2050, and rapid urbanisation leading to more than half of them being urban- based, food demand will surge. Globally, estimates suggest that sustainable food production will need to increase by at least 70% by 2050. However, despite sufficient food currently being produced, 870 million people across the world still remain hungry; 24% of SSA's population are undernourished. This highlights the all too frequent disconnect between food production and food security, with stable access to sufficient, safe and nutritious food being as important as overall availability.

While agricultural communities have been adapting to climatic changes since they first began cultivating crops, the anticipated rate and scale of climatic change combined with the outcomes of other complex and difficult to predict drivers of change are expected to make autonomous adaptation very difficult in the future.

It is not only the crop production stages that are affected by climatic changes. Warmer temperatures may: enable earlier harvesting of crops; facilitate crop drying; increase heat stress during harvesting, transport and threshing; lead to more rapid reproduction of insect pests and diseases on stored produce and higher carry-over of pests from field to store and between years; accelerate the degradation of some

grain storage pesticides resulting in reduced efficacy; increase the risk of mycotoxin contamination; affect microbial fermentation processes; reduce storage and shelf-life periods of crops and food products etc. Many of these factors are also directly affected by changes in rainfall and humidity patterns. As climate change exacerbates the challenge and cost of producing crops, our responsibility to reduce unnecessary loss and waste of the increasingly valuable harvest and the resources (land, labour, water and agricultural inputs) used to produce it grows.

Postharvest losses of cereal grains in SSA are estimated at 13.5%, equivalent to the annual caloric requirement of at least 48 million people, or an annual loss of US$4 billion. Climate change-related crop yield decreases and variability are likely to lead to an increase in food prices, which has been associated with food riots in the past. Many agricultural producers in low income countries are already net food buyers, which means increased food prices will affect them and other poor consumers who spend a high proportion of their income on food. In addition to increasing domestic food production through intensification of existing farming systems and by bringing more land into agricultural use, the SSA region is likely to see increased food imports, food aid and use of social protection packages, changing food consumption patterns, and an urgent need to reduce the amount of food that is lost after harvest.

Significant knowledge and technologies already exist to reduce postharvest losses during harvest, transport, drying, threshing, sorting, storing, processing, and trading. Whilst climate change is affecting the relevance and reliability of these knowledge sets and the efficacy of various technologies, it also increases the need to coordinate our resources and efforts in reducing crop losses after harvest.

Given the distinct seasonality of crop harvests, as well as their variability, privately and publically managed food stocks at all levels (household, community, national and international) play a crucial role in ensuring food is available and accessible throughout the year. Smallholder farming households consider their ability to manage household food stocks (quantity and quality) as a vital aspect of their adaptive capacity for coping with climate change and other shocks. Food stocks help to reduce their vulnerability when harvests are low as a result of climate-related dry spells, heavy rainfall events, or pest or disease attack etc. Food stocks act as a buffer against shocks, a resource that can be converted to cash, as well as providing households with the energy and nutrients needed for supplying manual labour on their own or others' land or in building their human capacity. Therefore, ensuring that sufficient quantity and quality of these food stocks is maintained between increasingly variable harvests is vital, and involves strong management skills and appropriate equipment at every activity stage from harvest to consumption or sale. Many 'no-regrets' style postharvest adaptation practices exist (which provide benefits even without climate change), such as growing and/or storing varieties less susceptible to postharvest pest attack; prompt harvesting, adequate drying, good store maintenance, cleaning and hygiene, protection and monitoring of food stocks, dietary diversification as production of the main food crop becomes increasingly risky; farmer access to market information and transport options, ensuring crop breeders evaluate postharvest as well as pre-harvest crop characteristics.

However, in most countries the mechanisms for agricultural service providers and smallholder farmers to acquire postharvest knowledge, skills, technologies and understanding are weak. While there has been renewed interest by donors, governments, the private sector and development organisations in reducing postharvest losses following the warning signs illuminated by the 2007/8 food price rise, most activities have stopped at pilot-scale technology-driven projects. A much more coordinated, long-term and systemic approach to postharvest capacity building is needed in order to bring about postharvest loss reduction at the scale required to help meet the spiralling challenges of food security during the next 50 years and beyond. This means going beyond the promotion of single technologies as silver-bullet style solutions; reality is much more complex and diverse and requires the acknowledgement that change and adaptation to change are embedded within a larger, much more complex innovation system. Non-linear learning processes, feedback loops and iterative interactions characterise and sustain the continuous adaptation and empowerment of diverse actors in agricultural innovation systems.

Different types of support are required by the different players and parts of the innovation system. For example: extension officers and farmers require hands-on experiences to learn how to reduce and to train others in reducing postharvest losses. Technologies need collective evaluation by farmers, independent researchers as well as the companies producing the technology to help discover what range of options are needed to meet the diverse socio-ecological needs of end-users. Financial service providers need support in understanding postharvest risk factors and their clients' profit opportunities in order to design products that help increase their clients' and their own returns. The media, primary to tertiary level educational institutions, and knowledge networks need support in understanding postharvest issues so they can develop effective approaches for influencing and supporting wide-scale behavioural change. Traders as well as farmers and regulatory agencies need to be involved in developing meaningful price-related quality standards. Conducive policy and institutional arrangements are needed to drive the scaling-up of postharvest loss reduction skills and technologies, and there needs to be effective coordination and alignment of the numerous policies and processes which impact on postharvest losses.

Reducing postharvest losses at scale requires a more systemic approach to strengthening the adaptive capacity of postharvest innovation systems. The complex nature of postharvest innovation, loss reduction, and the dynamic nature of factors such as climatic and other changes which influence innovation and loss and the options for improving them, requires a more holistic understanding of the complexity of postharvest systems by key actors. Building this capacity will entail major investments in trans-disciplinary co-learning processes with diverse players at different scales of operation. Such investments may be less visible than, for example, physical equipment to donors, governments and other actors, but they are crucial for building the capacity for locally owned, driven and sustained postharvest loss reduction at scale.

Abstract # ADMI022

Commodity Systems Assessment Methodology (CSAM) – A Potential Methodology for Post Harvest Losses Analysis

Vijay Yadav T.

Punjab Agricultural University, Ludhiana, Punjab, India

Corresponding Author: vijayyadav.t@hotmail.com

Introduction: Commodity Systems Assessment Methodology (CSAM) is a methodology developed by Jerry La Gra (1990) for facilitating professionals in the agriculture sector to identify and solve problems throughout the commodity system. It is a systematic approach, from planning to product distribution, and it helps to ensure that all factors affecting a given commodity are considered in development programs, whether related to pre-production, production, harvest, postharvest, or marketing. It is an appropriate method for identifying and measuring factors affecting postharvest losses, identifying bottlenecks leading to quality problems and immediate research needs for a specific commodity in a specific location. The methodology includes a questionnaire with set of questions related to different aspects viz., governmental policies, facilitating services, farmer's general cultivation practices, harvesting methods, packaging facilities, storage and marketing. A systematic and interdisciplinary application of the methodology will permit a rapid appraisal of a commodity system.

Objective: A survey was conducted for vegetable and fruit crops using Commodity Systems Assessment Methodology (CSAM) in rural areas of Rajasthan, India to find out different factors responsible for causing variation between the expected production, yield produced and quantity of produce reaching consumers.

Methods/Design/Approach: The methodology involves an inter-disciplinary approach and mostly includes a team of people working together to refer to data in government documents, extension publications, and written reports and also to gather information by interviewing the local growers, handlers, traders and marketers of the commodity. The information is gathered according to the prior prepared questionnaire suited to a specific area and a specific crop, which is then followed by thorough analysis of the data collected in order to find out the potential technical problems. Analysis of the data collected is then utilized for identification of sources of postharvest losses and then they are prioritized in terms of importance (by quantity of losses or by value of losses). By prioritizing the factors one can judge the immediate necessary action and also the actions of greatest benefit.

Findings: From the survey it was found that several factors are responsible for the remarkable gap between the expected production, yield produced and quantity of quality produce reaching consumers. They include practice of traditional farming techniques, lack of enough knowledge about pre-cooling, cultivation, storage and pre & post harvest handling techniques. While the major postharvest losses in the crops were due to improper harvesting practices, lack of suitable packaging, in-availability of appropriate storage facilities and lack of ideal transport facilities. Improper harvest practices include

harvesting of crops without proper knowledge about maturity indices, time of harvest, modern harvesting techniques and pre-cooling. Suitable packing materials are not in use and mostly bamboo baskets, jute bags are overloaded while packing, which constitute a major cause for postharvest losses. Lack of proper cooling facilities during storage and transit, also causes heavy loss to produce. Through the survey using Commodity Systems Assessment Methodology (CSAM), it was realized that major postharvest losses were caused due to inappropriate packing and transport followed by improper harvest practices.

Conclusion: Hence it can be concluded that Commodity Systems Assessment Methodology (CSAM) can be widely utilized in order to conduct postharvest loss analysis of different crops, to know the reasons of loss, extent of loss (both physically and financially) and to act appropriately after suitable prioritization in order to overcome the losses.

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Abstract # ADMI023

FAO Study on Postharvest Losses in Trinidad and Tobago, Guyana and St. Lucia: Marketing and Economics

Kelvin Craig[1], Majeed Mohammed[1], Joseph Mpagalile[2] and Vyjayanthi Lopez[3]

[1]Project Consultants (FAO Project TCP-SLC-3404)

[2]Agro-industries Officer, AGS, FAO Headquarters, Rome

[3]Plant Production and Protection Officer, FAO-SLC, Barbados

Corresponding Author: kelvin_craig@yahoo.com

An assessment of the postharvest losses (PHLs) for cassava, mango and tomato was conducted in Trinidad and Tobago, Guyana and St Lucia using the FAO methodology.

In Trinidad and Tobago, the assessment revealed a PHL of 20.0% for farmers who retailed cassava at the public, roadside or mobile markets. Three Critical Loss Points (CLPs) were identified in the cassava supply chain namely harvesting (CLP1); packinghouse operations (CLP2) and retail markets (CLP3). The corresponding PHLs for cassava at those CLPs were 3.5%, 3.5% and 13% at CLP1, CLP2 and CLP3 respectively with a total economic loss estimated at US$500,000. In the case of Guyana, postharvest losses of cassava were 23.0% for farmers who retailed at the public, roadside or mobile markets. The same CLPs were identified in Trinidad and Tobago and the estimated postharvest losses were 6.5% at CLP1, 2% at CLP2 and 14.5% at CLP3. This was equivalent to a total economic loss estimate of US$839,619.

Postharvest losses of fresh table ripe mangoes in Trinidad and Tobago were 5% at harvesting (CLP1) and 12% at display and sale of ripe fruits at retail markets (CLP4). Thus total postharvest losses for fresh ripe mangoes amounted to 17%. This was equivalent to an estimated total economic loss of US$13,286. Postharvest losses of fresh table ripe mangoes in Guyana at harvesting (CLP1) were 15% whereas at display and sale of ripe fruits at retail markets (CLP4) postharvest losses were 17% making total losses for fresh mango to be 32%. The total economic loss was therefore estimated at US$901,798. Postharvest losses of mangoes in St. Lucia were 23%. At CLP1, CLP2 and CLP3, losses were 8.0%, 13.0% and 2.0% respectively. Total economic loss for mangoes in St. Lucia was therefore estimated at US$82,483.

Postharvest losses of tomatoes measured at the end of the postharvest handling system in Trinidad and Tobago were 27%. Three key CLPs for tomatoes were at harvest (CLP1), at packhouse (CLP2) and during retail marketing (CLP3). In Trinidad and Tobago, the observed losses were 7%, 8% and 12% at CLP1, CLP2 and CLP3 respectively. In the case of Trinidad, the total economic loss was estimated at US$1.9 million. In the case of Guyana, the postharvest losses of tomatoes were 34%. At CLP1, CLP2 and CLP3, losses were 11%, 10.5% and 12.5% respectively. Hence the total economic loss was estimated at US$7.9 million. Postharvest losses of tomatoes in St. Lucia were 20%. At CLP1, CLP2 and CLP3, postharvest losses averaged 7.0%, 8.0% and 5.0% respectively. The total economic loss for tomatoes in St. Lucia was therefore calculated at US$166,579.

The studies were conducted under a project (TCP-SLC-3404) titled Reduction of Postharvest Losses along the Food Chain in the CARICOM Sub-region funded by the Food and Agriculture Organization's Technical Cooperation Programme.

Abstract # ADMI024

Conclusions from 30 Years of Practical Post-harvest Loss Prevention Work

Jürgen Böye & Otto Mück

BM Seminar & Consulting, Germany

Corresponding Author: juergen.boeye@bm-seminar.de

Introduction: Thirty years of practical post-harvest loss prevention work of both authors has provided deep insight into persisting opportunities and challenges. In the period between 1985 and 2000 there was a strong focus on the support of small-scale farmers in developing countries funded by international cooperation programs. After changes in policy priorities the authors extended work towards reducing post-harvest losses on an industry scale mainly in Central and Eastern Europe starting in 2001. Working experiences repeatedly proved that enormous savings are possible at moderate cost. For example, grain storage losses of as much as 30 % in African farmers' stores could be reduced to a level of about 5 % while the cost-benefit ratio was favourable on micro- and macroeconomic scales (Bell & al., 1999). Likewise, in big food facilities of industrialised countries, losses can be substantially minimized by introducing simple and low-cost measures such as improved building design and good sanitation.

Objective: The objective of this contribution is to demonstrate that decades of experience in practical post- harvest loss prevention in small-scale and large scale facilities has resulted in a sound methodological framework to reduce substantially post-harvest losses in storage and processing activities of durable agricultural commodities in an economically and environmentally sound way. This framework is particularly flexible and can be applied under different climatic, economic and social conditions.

Approaches: Post-harvest loss prevention work of the authors in developing countries was carried out in a supportive framework including different donors, cooperation agencies, research institutes, partner countries and non-governmental organisations (NGOs). It included dissemination of knowledge, in the beginning mainly via publications (see the references) and later also on the web (cf. www.fao.org/inpho, for example), training courses and workshops, and targeted research and development projects such as the Larger Grainborer Biocontrol Project of the German agency GTZ (now GIZ). Due to changes in political priorities most of these activities were discontinued towards the end of the 1990s. From this time on the authors contributed to work related to the substitution of methyl bromide, a major ozone-depleting substance that was widespread for post-harvest treatments before its phase out (Bell & al., 1998). In addition, they supported environmentally sound post-harvest practices in big storage and processing facilities all over Europe. The main approaches used were individually designed training events based on thorough case analysis and sharing of knowledge in international conferences such as the 7th Fumigants and Pheromones Technical Conference co-organized by the authors in 2007 in Bremen.

Findings: In order to illustrate major findings three successful projects to which the authors contributed are highlighted:

Larger Grainborer biocontrol - R&D for the wellbeing of smallholders in Africa

In 1981 the Larger Grainborer (Prostephanus truncatus) which was previously only known in Central America was first recorded in Tanzania. While it was only a minor maize pest in its area of origin it spread quickly throughout Africa and caused losses of over 30 % after an on-farm storage period of

about 8 months. Research in Costa Rica conducted by the author J Böye identified the predatory beetle Teretriosoma nigrescens as the most promising natural enemy which was transferred to Africa and released during a GTZ R&D project. Its successful establishment continues to be the most important element of Larger Grainborer containment and still saves millions of dollars every year.

Root and tuber crops: Added value through processing

After several years of post-harvest grain loss prevention work (Gwinner & al. 1996), the limited value of food reserve and cereal bank approaches for rural development became more and more obvious. Root and tubers such as cassava and yam were identified as very promising crops for adding value through processing and selling in rural and urban markets. The authors contributed to a series of training events in Africa. A comprehensive publication (Bell & al., 2000) documents their role in the promotion of income generating activities for women along the product value chains.

Methyl bromide substitution: Post-harvest technology protects our environment

For more than sixty years, methyl bromide has been widely used as a fumigant for storage and processing units, commodities and other purposes. Since it was discovered in the early 1990s that methyl bromide is a serious ozone depleting substance, many activities to phase out methyl bromide and identify suitable alternatives took place (Bell & al., 1998). The authors designed and executed a training program to facilitate phase out of methyl bromide in Eastern European countries and assisted in the evaluation of the Montreal Protocol. Today we can state that methyl bromide emission by man has been drastically reduced and the growth of the Antarctic ozone hole has been stopped.

Conclusions and Perspectives: Implementing sustainable post-harvest loss prevention requires a series of preconditions including reliable funding over extended periods of time, continuity in science-based programs and project approaches, consideration of technical and socio-economic factors, in particular generating income of farmers by adding value along the respective supply chains, introduction of well-defined quality standards and application of loss-prevention methods characterized by environmental sustainability (i.e. contributing to Millennium Development Goal 7 of the United Nations). It has become obvious that a focus on subsistence farming as in the 1980s is definitely too narrow and does not really help rural populations to move forward. Access to markets, adding value and increasing incomes are important steps to improve their living conditions.

Working experience with large-scale industries shows that a short term profit perspective prevails that makes it sometimes difficult to achieve real breakthroughs. Operating profitably at a given moment in time and investing in medium and long-term post-harvest loss prevention often seem to be conflicting objectives.

The main conclusion from previous work is that addressing decision makers and stakeholders in the supply chains has to be considered as the biggest challenge - and not technical issues, for example, stored-product pests. There are indeed sound solutions for many technical questions and a lot of information on reducing post-harvest losses has been published. The major challenge for the future consists in collecting, reviewing, completing, adapting and passing this knowledge to all actors in the supply chain environment: farmers, processors, traders, consumers, and most importantly, political and economic decision makers and enabling them to contribute in their very specific roles to a sustainable reduction of post-harvest losses.

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Abstract # ADMI025

Post Hravest Losses Transportation: Confront and Win Tomorrow Today

Vivek Agarwal, Ravi Dhingra

Annakshetra, India

Corresponding Author: ravi.dhingra@cdcindia.org

Introduction: Transportation of agriculture produce is an important stage of post-harvest loss. In India, transportation of perishable commodities is in the most precarious stage. For local market, the produce is brought either by bullock cart or tractor trollies. The long distance transportation is mainly by rails and trucks which is costly. The basic reason for road transportation is that it takes short transit period. Efficient transport system can go a long way in not only in reducing the post-harvest loss of horticulture produce but also in stabilizing price fluctuations of the same commodity available in different markets of the country. Effective management during the postharvest period, rather than the level of sophistication of any given technology, is the key in reaching the desired objectives. While large scale operations may benefit from investing in costly handling machinery and high-tech postharvest treatments, often these options are not practical for small-scale handlers.

Objective: Quick transportation of agriculture products to maintain quality with minimum damage during transportation for successful marketing of produce.

Methods/ Design/ Approach: Loses in transportation occur due to physical and mechanical injury and uncontrolled conditions, mainly humidity and temperature. Mechanical damage, water and temperature losses, decay during transport and storage are major issues affecting post-harvest. The risk of deterioration of produce during transport can be reduced in several ways-

1. Condition of Roads
    a. To ensure fewer losses, adequate long distance facilities especially by rails should be developed. All national highways to be made one way to make road transport faster.
    b. The surface of roads and their maintenance should be improved in order to have smooth transportation without severe jerks and vibration. Vibration, compression, and impact cause physical damage to produce. It has been found that compression damage occurs when the weight of the load is supported by the produce, rather than the produce container.
2. Packaging
    a. The produce should be properly packed and stacked in well ventilated carriages. Refrigeration and relative humidity control in carriages is of vital significance.
    b. Strong packages to be used to reduce mechanical damages. Also rough handling should be avoided during loading and unloading.
    c. Doors and Walls- Door seals should be kept in good condition to prevent air leakage. Doors should be kept closed whenever the refrigeration system is operating. Opened doors are very detrimental to temperature uniformity maintenance.
3. Loading of Vehicles
    a. Temperature management is critical during long distance transport, so loads must be

stacked to enable proper air circulation to carry away heat from produce itself as well as incoming heat from atmosphere and off the road.

   b. The vehicles should not be overloaded. The vehicle should also have adequate ventilation to prevent heat gain during transport.

   c. During stacking of containers, alignment should be proper (most of the strength of the corrugated box is in the corners). It has been found that a 3cm overhang will decrease the stacking strength by 15 to 34%.

4. Equipment and Containers

   a. Selection of Transport Equipment - A semi-trailer for produce transportation should be in good physical condition, equipped with a duct floor, an air delivery duct and a solid bulkhead. It is also important to ask for a trailer equipped with an air ride suspension system, which will absorb the shock and reduce vibration damage to the produce.

   b. High quality vented containers and load produce should be used to ensure adequate air movement through the load to remove heat generated by produce

   c. For transporting of open loads a thick layer of insulation and cushioning may be provided for bulk loads. Packed produce should be loaded in uniform stacks and braced securely to prevent damage. Other loads should not be placed on top of bulk loaded commodity.

5. Cooling and Refrigeration

   a. The technique of evaporation cooling should be adopted with a slight modification in the existing road trucks and wagons.

   b. In case of refrigerated transportation, ensure that the vehicles are well insulated and have doors that seal tightly and securely. The refrigeration unit should not turn off during delays in transportation.

   c. The refrigeration system used in a transport vehicle must have adequate cooling capacity. With properly cooled produce, most of the heat input is from air infiltration and heat conducted across the walls of the vehicle. Therefore, it is important to consider extreme high or low temperature conditions when calculating the cooling capacity.

   d. Mechanical refrigeration is the most commonly used and effective temperature control method in refrigerated transport vehicles. New designs and materials have resulted in lighter, more flexible systems.

Results / Findings:

1. Loading - During the loading of transport vehicles, the following handling practices should be followed to prevent an excessive loss of quality during the transportation step-

   a. Avoid bumping pallets during handling;

   b. Load produce that is compatible together;

   c. Load produce in centerline loading pattern;

   d. Apply bracing between the pallets and both side walls

e. Do not load produce sensitive to vibration damage directly above steel-spring, suspended axles.

2. Trucks used to transport fresh produce- Most fresh produce is now moved in road vehicles, with lesser amounts by sea, air or inland waterways. The vehicles in most common use are open pick-ups or bigger trucks, either open or enclosed. The use of road vehicles is likely to increase, so users should give attention to the following-
   a. Closed vehicles without refrigeration should not be used to carry fresh produce except on very short journeys, such as local deliveries from farmers or wholesalers to nearby retailers;
   b. Open-sided or half-boarded trucks can be fitted with a roof on a frame. The open sides can be fitted with canvas curtains which can be rolled up or moved aside in sections to allow loading or unloading at any point around the vehicle. Such curtains can protect the produce from the elements but still allow for ventilation. Where pilfering is a problem, the sides and rear of the truck must be enclosed in wire mesh.
3. A second, white-painted roof can be fixed as a radiation shield 8 or 10 cm above the main roof; this will reflect the sun's heat and help to keep produce cool.
4. For the ventilation of long-distance vehicles, more elaborate air intakes can be fitted in conjunction with louvres, to ensure a positive air flow through the load; Refrigerated trucks or road, rail or sea containers may be used for long journeys, but the cost of such transport makes it uneconomical for small-scale operations.
5. Vibration damage is the greatest in locations over steel-spring-suspended axles. Air ride suspension should be used as it dramatically reduces vibration damage. The vibration damage can be prevented by using air compression suspension systems. This provides a gentle ride during transportation.
6. Handling and stowage practices requires to be re-drafted. Although the shape and condition of trucks are important factors in fresh produce transportation, the loading and stowing methods in vehicles are pertinent to damage and loss-
   a. The best loading factor must be achieved, that is the maximum load that can be carried economically under satisfactory technical conditions- a stable and well-ventilated load;
   b. The size and design of packages should give adequate levels of ventilation of contents with the minimum of wasted space, and the packages should be strong enough to protect the contents.
   c. Loading and unloading of vehicles should be properly supervised to prevent careless handling of packages; loading aids such as trolleys, roller conveyors, pallet or forklift trucks should be used where possible to reduce the handling of individual packages.
   d. Stowage should be carefully done to avoid collapse of the stow during transport; packages should not be stacked higher than the maximum recommended by the maker, otherwise the bottom layers may collapse under the weight of those above.
   e. Packed produce should be protected from sun and rain at all times including during loading and unloading.

    f. Packages should be loaded on pieces of lumber or slatted racks on the beds of vehicles, or on pallets in order to allow the circulation of air around stacks during transport.

7. Employment of Drivers is another critical issue. Although every care may be taken to observe all the above precautions, the standards of driving remain a difficult problem to overcome.

Conclusion: Transporters care little about food loss and worry more about getting products to the buyer on time. The market orientation is still such that transporters feel their job is to transport and nothing else. Produce lost in India is greater than other countries in the region. Until public transport conditions - including railways, roads and government-owned trucks - and delivery systems improve, private companies will be the only ones able to afford cutting post-harvest food losses. There are significant inefficiencies in the way that the government supply chains work in India. Much of the infrastructure, such as goods handling and railway systems owned by government facilities, are old and result in significant damage to perishable food.

Abstract # ADMI026

Food Losses and Waste in Tajikistan, Country Report

Umeda Nabieva

ISD Consulting

Corresponding Author: unabieva@gmail.com

Introduction: Food losses refer to the decrease in edible food mass throughout the different segments of the food supply chains; namely, production, post-harvest handling, agro-processing, distribution (wholesale and retail) and consumption. By 2050 the world will need 60 percentage more food, therefore prevention of food losses has a positive impact on the environment, food security, the livelihoods of poor people, food safety and quality and economic development. The exact causes of food losses vary throughout the world and are dependent on specific conditions, consumer behavior, available technology and other factors in any given country.

Objectives: The objective of this study is to identify critical points and patterns of food losses and waste (FLW) along selected food supply chains in Tajikistan, which have the largest impact on food security and food supply in the country. For that purpose the country study aims to provide an overall assessment of food losses and waste and its impact on food security and food supply, as well as identifying and analyzing critical points for food losses and waste along selected agri-food chains.

Methodology: This study had been conducted within framework of FAO Regional Officer for Europe and Central Asia Strategic the Food losses and wastes in Tajikistan and covered five agri-food products and the methodology established by the FAO and the Swedish Institute for Food and Biotechnology (SIFB) was used. For preliminary analysis commodity groups that have high impact on food security were included (cereals, root and tubers, pulses and oilseeds, fruit and vegetables, fish and seafood, milk and eggs). Five priority agri-food chains were identified for detailed analysis after preliminary analysis of each commodity group based on their:

a. economic importance
b. employment generation
c. contribution to foreign exchange
d. contribution to food security.

Findings: A summary assessment of overall losses and waste in the priority food chains is shown in Table 1.

The stages that have the most FLW across all FSCs is agricultural production ranging from 4.9 -20 percent. High FLW in the agricultural production stage is mainly the result of a lack of advanced agronomic knowledge, a lack of innovative skills, a shortage of agronomists, an unwillingness to use agriculture extension specialists, insufficient pest and disease control, traditional methods of harvesting, and outdated agricultural tools and technology in all commodity groups. The highest percentage is reported in dried

apricots (20 percent) and lowest in potatoes (4.9 percent). High FLW and low quality of dried apricots is associated with their perishability, outdated harvesting methods, scarcity of machinery and bad weather conditions.

Table 1: The percentages of food losses and waste

	Agricultural Production %	Postharvest Handling and Storage %	Processing and Packaging %	Distribution %	Consumption %
Cereals (wheat)	7.3	1.3	1.8	2.2	1.6
Roots and tubers (potato)	4.9	5.2	0.2	6.4	4.3
Vegetables (onions)	5.3	7.1	0.3	6.0	4.08
Fruit (dried apricots)	20	15	3.3	4.1	0.1
Milk	7.2	0.4	0.7	4.6	2.0

FLW cereal and milk ranked second in the agricultural production stage constituting 7.3 percent and 7.2 percent respectively. This is due to the fact that during harvesting, cereal farmers still use obsolete and outdated combines such as the Niva, which leave grain in the field. For milk and milk products FLW is mainly due to the absence of feed and grass during winter, leading to disease and premature deaths. Onion and potato losses are comparatively low among commodity groups at 5.3 percent and 4.9 percent respective FLW in this stage. Losses that occur in the other stages are relatively smaller than those that occur in the agricultural production stage. In the post-harvesting and storage stage the highest FLW can be seen again in dried apricots and onions (15 percent and 7.1 percent respectively). This is due to natural drying of apricots, a lack of storage facilities and/or poor condition of storage facilities. The lowest percentage FLW in this stage is 0. 4 percent, which was reported for milk and milk products. In the processing and packaging stage FLW ranges from 0.2 percent (potatoes) to 3.3 percent (dried apricots). In the distribution stage FLW ranges from 2.2 percent (wheat) to 6.4 percent (potatoes). During the consumption stage potatoes (4.3 percent) and onions (4.08 percent) suffer the most FLW due to the purchase of damaged, old or unusable produce. The lowest FLW is 0.1 percent for dried apricot. Causes of food losses and waste are grouped into key factors given below:

a. Resources and Technologies
b. Management, Marketing and Product Development
c. Food Safety and Quality Standards

Recommendation: The following recommendation can be applied for all commodity groups entire FSC:

- Introducing monitoring, reporting and quantification of losses and waste into financial terms at dehkan farms and in processing companies. Although this is a difficult task, it is a good mechanism to prevent losses and waste.
- Promote awareness and build capacity for implementation of private voluntary standards on

food hygiene and safety in the Tajik food industry as self-control and due diligence. The well - known practices are GlobalGAP, HACCP, ISO 9001, ISO 22000.

- Conduct capacity building of farmers on a regular basis by National Associations and Chamber of Commerce and Industry.
- Need to concentrate and undertake more tailored approaches to prevent food losses in the agricultural production, post harvesting and handling stages compared to other stages of food supply chains in analyzed agriculture products.

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Abstract # ADMI027

Survey of Deffects of Orange in Egypt That Affect Its Acceptability for Exportation

Abdel-Moeti Salama, M. Elansary, A. El-Morsy and M. El-Hammady

University of Kafrelsheikh, Egypt

Corresponding Author: Ask002047@yahoo.com

Background and objective: The Mediterranean climate in Egypt creates perfect conditions for oranges (*Citrus sinensis* L.), which makes Egypt an important world leader for orange production and exportation. However, besides high competition there are some defects that affect orange exportation in Egypt. Thus, the objective of this investigation was to determine the different types of defects of Washington navel and Valencia oranges produced for export to identify the root causes of low quality oranges at the field during harvesting as well as at the packing house.

Approach: This experiment was carried out during the 2002/2003 and 2003/2004 seasons. The fruits were examined and separated into exportable and non-exportable according to European Commission standards for grading of oranges in field as well as in three packing houses one in Kafrelsheikh Governorate and two in Gharbia Governorate.

Findings: Defects which made the fruits non-exportable were: visual spray residue, misshape, lack of color, mechanical injuries, without calyx, soft skin, decay, insect damage, creasing, splitting, plugging, sun burn, blemishes, oil spot, chilling injury, bruising, stem-end breakdown, under and over size (Fig. 1).

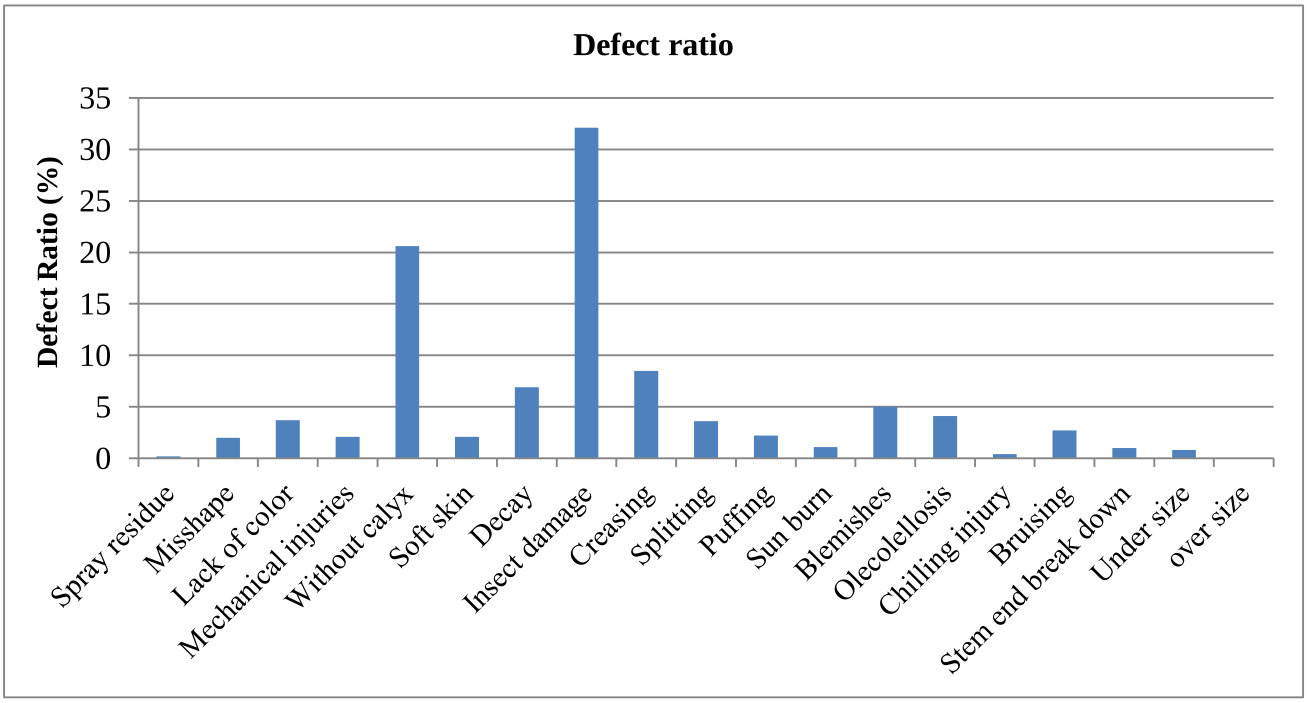

Fig.1 Average of different defect ratios of 'Washington navel' and 'Valencia' oranges in packing houses. Ratios are calculated from means of defects for three packing houses ± SD

The most important defects found in the field experiment in both seasons were: insect damage (33-61%) and creasing (13.5-23.5%). In packing houses, main defects were insect damage (32.1%), without calyx (20.6%), creasing (8.5%), decay (6.9%) and blemishes (5%). Some defects such as chilling injury, bruises, stem end breakdown, under and over size were negligible especially in the 2nd season. Export ratio of Washington navel orange was 21.5 to 26% in the first season, while it was 13 to 46.5% during the second season. Export ratio of Valencia orange was 16 to 50% in the 1st season while it was 35 to 60% in the 2nd season.

Conclusion: The main reasons for fruit rejection for export are as follows in decreasing order: insect damage, fruits without calyx, creasing, decay and blemishes. The conclusion was reached that quality of citrus (Washington navel and Valencia oranges) could be improved by several horticultural practices such as good insect and disease control, avoiding fruit damage at harvesting and harvesting at an early date in the season.

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Abstract # ADMI028

Assessment of critical points for postharvest losses in the maize food supply chain and potential mitigation measures in Uganda

Harriet Muyinza1, M. Otim2. , N. W. Nanyenya3., R. Namugga1.and M. Totobesolla.4

1Food Biosciences programme, National Agricultural Research Laboratories, Kawanda

2 National crop Resources Research Institute Namulonge

3National Livestock Resources Research Institute

4 Food and Agricultural Research Organisation Rome

Corresponding Author: Hmuyinza14@gmail.com

Introduction: Total quantitative food losses and waste globally have been estimated to be as high as one-third of the world food production for human consumption or 1.3 billion tonnes per year (FAO, 2011). This means that increasing food production without improving the systems would equally increase the production of food that nobody is going to eat. Accurate estimates of the magnitude of losses and waste are however still lacking, particularly in developing countries. In Uganda maize is an important staple and commercial crop and important non-traditional export. The crop contributed export earnings of above USD 42.3 million to Uganda's GDP in 2013 (UBOS, 2014). However, postharvest loss along the maize food supply chain are still lacking. There was thus need to identify the critical Loss points in the maize, this could enable focused efforts to address loss causative factors to be identified and deployed for postharvest loss reduction at small scale farmer level.

Objectives:

I. The specific objectives of this study were to analyse the status of the maize Food supply chain,
II. Give an analysis of past and on-going efforts and policy frameworks supporting the maize food supply chains and a Situation Analyses of the supply chain,
III. Analyse the losses and asses prospects for loss reduction interventions in the maize supply chains and
IV. Provide an economic analysis of the current losses and cost benefit analysis of some available and potential solutions to the losses and
V. Provide recommendations for maize loss reduction strategies that are economically feasible, socially acceptable, gender sensitive and ecologically friendly

Methods/Design/Approach: In this study a methodology developed by The Food and Agricultural Organisation of the United Nations was used to identify the critical loss points in the maize food supply chain. The study was conducted in Apac and Lira districts in Northern Uganda with respondents drawn from the sub-counties of Ibuje and Akokoro for Apac and Amach and Barr parishes in Lira district. The methodology involved preliminary screening of food losses ('Screening'). Under this secondary data, documentation and reports, and expert consultations formal surveys, focus group discussions, expert opinion interviews, secondary data and information and direct observation were made along the food supply chain. Then load tracking and sampling assessment was done for quantitative and qualitative analyses at all the steps in the supply chain. This included collection of samples along the critical loss points and evaluating the losses which occured with time as the gain moved along the key points. The load tracking (Sampling) was done together with the semi-structured survey. It involved detailing of forms and levels of losses at the three critical loss points which were identified. These stages included harvesting, storage and its associated practices and milling stages along the maize supply chain in

northern Uganda. The final stage of the methodology was solution Finding (‘Synthesis’) which was used to develop an intervention programme for food losses, based on the assessment results. This was the final stage after assessing the extent, forms, causes, strengths, weaknesses and opportunities characterising the value chain core actors. It thus enabled identification of appropriate technologies that can be used to address the loss causes thus lowering food losses along the maize food supply chain.

Thus implementation of the methodology involved selection of 70 farmer households from each district. A semi-structured questionnaire was used to collect data on level of losses at the harvest, storage and milling stages of the FSC. In addition direct measurements were made at twenty households in the two districts with at least 5 homes per sub-county, where losses during harvesting of maize were assessed by direct observation of left over and split grain at harvesting. Storage losses were evaluated by collecting 500g samples three times from month one to three month of storage from known farmers in the study areas. These were brought on-station at National Agricultural Research Laboratories at Kawanda. They were then analysed mean percent mechanical damage, discoloration and moisture content. In addition samples were tested for aflatoxinB1 presence using rapid Aflatoxin kits. In addition a batch of grain was passed through the existing milling process to evaluate how much losses occurred during this process. This was done by using the known conversion factor and determining how much of the grain was lost in the process. Then following this the potential technologies for loss reduction were analysed for profitability following their cost effectiveness, environmental acceptability and cost effectiveness for use at smallholder level.

Results: In this study three critical loss points harvesting, storage and milling were identified. The main causes of harvesting losses was due to farmers’ careless harvesting of crop and thus leaving some and spilling it in the field. Mean storage losses were found at 4% of farmers’ harvest. At farmer storage level, mean losses were at 20% at 3 months of maize grain storage. The mean percentage loss causative factors included insect damage estimated to result in 16.4%…damage on grain, breakage accounted for 1.0% loss, discoloration was also found at 2.6% levels in and foreign matter at 1.9%. Results showed 40% of the samples evaluated were positive with Aflatoxin B1. The mean moisture content was 12.3%. These losses were caused mainly by storage pest damage and improper on-ground maize drying. Also poor threshing using sticks caused grain damage which resulted in mechanical damage. It is possible that the grain molded before it was dried thus lower levels of moisture did not necessarily correspond to good quality grain.

There was need to promote proper drying on stabilized floors and cribs or tarpaulins to reduce contamination and aflatoxin incidence in maize. Improved threshers were needed at farmer level to reduce grain damage at farmer level. Milling losses were found at 5% of the milled grain. This was caused by poor and inadequately maintained machines calling for improved milling processes to reduce loss at this point.

To address these losses it was recommended that harvesting losses could be addressed by engaging farmers in capacity building events to encourage reduction in harvesting losses caused by careless grain harvesting. Improved drying, threshing and storage needed to be promoted to farmers and grain aggregators. This was to include promotion of improved dryers such as maize cribs, tarpaulins for maize drying. Indeed the analysis of the profitability of using a maize crib and metal silo adoption showed that these would result in enhanced profitability at sub-county level. Thus Storage technologies including metal silos of sizes ranging between 500 to 1.25 tonnes, storage in super grain bags for small scale farmers, and in grain safe containers of capacity of 2 metric tonnes were recommended for adoption by the different scales of farmers. It was also noted that with better storage safety of maize consumers will result in better consumer protection since dangers due to aflatoxin poisoning was to be reduced. Milling on the other hand was to be improved by building the capacity of millers and improving status of maize mills. It was recommended that millers would also be informed about the dangers of contamination of the grain as it passes through the milling stage. Addressing of these critical loss points would ensure enhanced food and income security at small scale farmer level in Uganda.

Conclusion: In conclusion, food losses as assessed through this methodology were still high at three critical loss points of harvesting, storage and milling with highest losses occurring during grain storage. There is thus need for farmer capacity building at the three critical stages, dissemination and availability of technologies to reduce losses thus ensuring that grain quality is uncompromised, food losses abated and attain enhanced food security and incomes.

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Abstract # ADMI029

Causes for post harvest loss in olive and olive oil production in High Atlas-Morocco

Malika Bounfour

Plant Protection-national office for Food safety (ONSSA)-Rabat-Morocco

Corresponding Author: mbounfour@hotmail.com

Introduction: Olive and olive oil make up important food and income sources for small holders in Eastern High Atlas Mountains in Morocco. Olive production is made of scattered olive grooves less than 0.5 ha with minimal inputs. Some families may be living with production from 1 to 5 trees. The olive oil processing sector is characterized by small units that process about 100% of local olive oil. Even though they use minimal technology and their production is for subsistence market, the quality and taste of the oil produced with these mills is successful with local consumers and has the potential to be developed into a source of income. Olive and olive production benefited from funding from the new Moroccan agricultural strategy "Plan Maroc Vert" (PMV), the objective of which is modernizing and giving new dynamics to agriculture.

Causes for Post harvest losses: Access to technology for preventing losses is very limited at all the supply chain stages in olive and olive oil production in mountainous areas. Preventing olive loss for small holders in these areas will contribute to stabilizing families' income and may be a mean to increase food availability. Olives that escaped fruit fly infestation are harvested by beating the branches. These beatings injure the fruits, which makes them vulnerable to mold attack during transport and storage. Losses due to injury from beating, fruit flies and mold may be as much as 30%. In addition these increase oil acidity thus reducing its nutrition quality. In addition to injury, the following year production is reduced due to loss of flowering parts during the beating. These losses may be as much as 100% in some areas. This causes olive trees to produce on alternate years.

Approach: From these arguments, it appears that the best approach is to improve harvesting and storage methods, which could help reduce losses due to mold during storage and also help increase production. Tools, that are cost effective, have been developed for control of olive pest and also for effective harvesting. These include calculating degree days for pest control and mechanical harvesting based on a manual shaker that is more efficient than the traditional method.

Conclusion: These examples should be part of a system where a market environment is developed. Thus the shakers should be developed locally with affordable equipment. Workers should be trained to make these shakers and also training should be developed on farm to use them efficiently. The talk will be built around the idea of Addressing Causes Rather than Symptoms for mitigating post harvest loss (Sonka 2015). Solutions for all the supply chain stages will be discussed to help improve olive and olive oil production and storage in order to minimize post harvest losses.

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Abstract # ADMI030

Micro-nutrient loss in food losses and waste in Norway and Kenya - implications on the prevention of micro-nutrient deficiencies and better data collection and measurement protocols

Warren T K Lee1, Mauro Serafini1,2, Elisabetta Toti2, Camelia Bucatariu3, Jorge M Fonseca3,

Robert van Otterdijk3 and Divine Njie3.

1Nutrition Division, Food and Agriculture Organization of the United Nations. 00155 Rome, Italy.

2Functional Foods and Metabolic Stress Prevention Laboratory, Research Council on Agriculture, Center of Nutrition (CRA-NUT), 00178 Rome, Italy.

3Rural Infrastructure and Ago-Industries Division, Food and Agriculture Organization of the United Nations, 00155 Rome, Italy

Corresponding Author: Jorge.fonseca@fao.org

Introduction: Vitamin A (VitA) deficiency is one of the major deficient micro-nutrients in poor developing countries affecting more than one billion people. Annually, up to 500,000 VitA deficient children become blind and half of them died within 12 months after losing their eye-sight. Concomitantly, about 33% global food production is lost and wasted [1]. Food loss and waste (FLW) from fruit and vegetables are as high as 50%. There is a lack of information on micro-nutrient losses in food supply chains. Given the large scale of micro-nutrient deficiencies and the need of diversified diets to prevent and control micro-nutrient deficiencies worldwide, there is a real need for nutrient loss data to assess the causes and scale of the problem. It would also help inform data-driven food systems policies and programs to reduce nutrient losses and FLW, and to encourage sustainable food production and food consumption patterns.

Objectives: To determine VitA losses, including β-carotene and retinol, in selected food supply chains in Norway and Kenya, and to estimate the scale of VitA losses that could be made available to feed VitA deficient children under 5-year old.

Methods: The Norwegian 'ForMat' food waste database [2] (2011-12) and the FAO food balance sheets (FAOSTAT) [3] with data on fruit and vegetables availability in Norway were used to estimate VitA losses under the 'Fruit and vegetables' categories along the food supply chains. A stepwise approach was used to determine FLW in the food supply chains, while the rates of FLW at different steps of the fruit and vegetables supply chains were: food production (14.1%), wholesale (0.48%), retail (4.5%) and consumption (18.5%) based on the 'ForMat' report.

In Kenya, post-harvest losses (PHL) of VitA from four food items: banana (including plantain), maize, milk (all animals) and fish (all fish caught on land) in selected counties of Kenya were estimated based on the SAVE FOOD Kenya case study (2012-13) [4]. A stepwise approach was also used to determine VitA losses in PHL with specific percentages of PHL along different steps of the food supply chains.

VitA and β-carotene contents in foods from Norway and Kenya were determined using the Norwegian Food Composition Database [5]. Since the fruit and vegetable loss data in Norway are expressed in food categories and sub-categories, such as other fruits and lemons, limes and products rather than in individual food items, assumptions needed to be made in data analysis in order to determine average VitA value in each food category and sub-category.

The number of vitamin A deficient (VDA) children under 5-yr old in Kenya and India were obtained from the Global Nutrition Report [6] (GNP) (2014). The average recommended intake of dietary VitA to be consumed by children under 5-y old to maintain normal serum retinol level and free from clinical signs of VitA deficiency was 425 µg RE/day. This figure was determined based on the Recommended Nutrient Intake [7] (RNI) of VitA for children aged 7-mo to 5-yr.

Results: In Norway (2011-12), the annual volumetric loss of fruit and vegetables in supply chain was estimated to be 354,824 tons/yr (fruit: 227,667 tons/yr and vegetables: 127,157 tons/yr) which corresponds to an overall 280.33 kg RE/yr loss of VitA. If this level of VitD loss (280.33 kg RE/yr) were available to feed VDA children under 5-yr old, approximately 1,807,123 VDA children would have met their VitA needs (i.e 425 ugRE/head/d). Since the percentage and number of VAD children under 5-y old in Kenya (2009) and India (2001-03) was 84% (n=5,843,040) and 62% (n=74,760,220) respectively according to the GNP (2014). Therefore, approximately 30.9% and 2.4% of VAD children under 5-y old in Kenya and India respectively would have benefited from the reduction of VitA loss in Norway.

In Kenya (2009-11), the annual volumetric loss of the four food items in the selected counties was 1,835,468 tons/yr (bananas: 451,842 tons/yr; maize: 879, 789 tons/yr; milk 462,453 tons/yr and fish: 41,284 tons/yr) that corresponds to an overall 338.8 kg RE/yr loss of VitA. Again, if such a quantity of VitA losses (338.8 kg RE/yr) were made available to feed VDA children aged under 5-year, about 2,183,723 children would have met their VitA needs (425 ugRE/head/d). Since the number of VAD children under 5-y old was estimated to be 84% of the total children population under 5-y old (n=5,843,040). Therefore, about 37.4% of VAD children under 5-y old in Kenya would have benefited from the reduction of VitA loss from these four food items in those selected counties.

Discussions and Conclusions: VitA losses from the food supply chains in Norway and Kenya were phenomenal that has not been reported before. In Norway, given the data analysis was focused on the fruit and vegetables among other supply chains; while in Kenya, data were collected from four food supply chains and based on a few counties of the country, the actual scale of VitA losses upon FLW in these countries would be even higher. The present study fills in data gaps on nutrient losses attributable to FLW at country level.

Governments and stakeholders in the food supply chains must act to implement concrete measures to reduce FLW in order to achieve global food security and nutrition while protecting natural resources and improving the sustainability of the food systems. Nutrient losses recovered from FLW could be redistributed to feed vulnerable people with micro-nutrient deficiencies.

The present study provides two models of different methodologies in data collection. In Norway, food items were aggregated into food groups in the database that made estimation of nutrient losses difficult because assumptions had to be made to speculate individual food items included in each category for nutrient calculation. Furthermore, assumption was made on the corresponding rates of FLW within each food category at different steps of the food supply chain. On the other hand, the Kenya study presents a better model to determine PHL and nutrient losses. Because data on individual food items with corresponding rates of PHL across each supply chain were available that allowed more efficient and precise estimation of PHL and nutrient losses. As a result, estimation of vitA losses in the Kenya model is more reliable than that of the Norway model. The present study highlights the urgent need to improve the collection, transparency and sharing of FLW data. There is a real need for better and standardized approaches for FLW data collection and measurement protocols; otherwise, it is difficult to precisely assess the causes and scale of the problem.

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Abstract # ADMI031

Re-thinking post-harvest losses in perishables: contextualizing losses with the example of pineapple in Uganda

Katharine Troeger[1], Anja Christinck[2], Brigitte Kaufmann[2], Oliver Hensel[1]

[1]University of Kassel, Faculty of Organic Agricultural Sciences, Department of Agricultural Engineering,

[2] DITSL – Deutsches Institut für Tropische und Subtropische Landwirtschaft GmbH

Corresponding Author: k.troeger@uni-kassel.de

Introduction/Background: Post-harvest losses (PHL) which result in food lost for human consumption can have negative impacts on both food security and resource use efficiency. Consequently, their magnitude is aggregated at the global level and PHL severity is stressed especially for perishables (Gustavsson 2011; Kummu et al. 2014). On these grounds, the need for quantification is emphasized and the development of standards for global accounting and reporting are in progress (Lipinski et al. 2013; FLW Protocol project). Furthermore, loss reduction interventions and innovations are ideally meant to be pro-poor; to benefit the most vulnerable. However, the direct relation between reducing food losses and improving resource efficiency appears to be too simplistic, if looked at from an economic and policy perspective (Koester 2014).

From a technical perspective, fruits and vegetables fall into the category of horticultural perishables, describing their vulnerability to spoilage and decay and need for careful handling and protection to maintain specific product quality (FAO&UNEP 1981; Prusky 2011). From an economic perspective, and in terms of market value, perishables are differentiated in multiple ways for a diversity of consumers. Moreover, the set-up of market-driven fresh fruit and vegetable supply chains and the post-harvest handling within it, could be looked at as a human activity system from a social science perspective. Such human activity systems evolve at the interface of ecological, technical, economic, as well as social and institutional context conditions (Kaufman et al. 2013). To be able to design appropriate intervention strategies, it is necessary to assess the specific food supply system and its context conditions as well as the distribution of benefits among the actors, with a particular focus on dependent and vulnerable actors. The systematization of causes for food losses developed through HLPE (2014) served as a starting point for this case study to frame the assessment of risk bearing food loss conditions in Ugandan pineapple supply chains as well as cause-effect relations and side-effects.

Objectives: The overall objective is to assess food losses along different pineapple supply chains in Uganda and to identify cause-effect relations. On this basis, risks and drivers for food losses are derived and criteria for their assessment in light of food security as well as a transformation strategy are suggested.

Methods/Design/Approach: Data was collected in the Central and South-West regions of Uganda, including the districts of Luwero, Kayunga, Masaka, Ntungamo, Bushenyi, Mbarara, and Isingiro through observations of activities, as well as informal and semi-structured interviews with actors along different pineapple supply chains. Actors were mainly interviewed in their place of occupation to make the dialogue more comfortable for them. Interview partners were asked to describe their activities related to the pineapple business as well as damages and losses. Furthermore, information on prices, seasonality as well as their challenges was collected. Interviews included farmers, rural brokers, traders, retailers,

consumers, processors as well as representatives from research projects and institutions, such as NOGAMU and the National Multistakeholder Platform (over 60 in total).

Results/Findings: Generally, the conditions to maintain fresh pineapple according to specific technical criteria along local supply chains in Uganda are not optimal due to e.g. the lack of standardized production technologies, the lack of cooling facilities, insufficient road infrastructure, overloading and rough handling of the fruits. However, these prevailing conditions did not result in high quantitative food losses in the Central region including Kampala markets due to the demand diversity of these markets which encourage the utilization of damaged fruits. By contrast, quantitative losses are more prevalent in supply chains of South West Uganda, where collection centres and markets are more dispersed, and approaches to utilizing fruits that are damaged or reduced in technical quality are lacking. Interviews revealed that consumers with budget constraints sought fruits with cosmetic blemish in order to benefit from the lower cost. Therefore, to assess the severity and relevance of quality losses in a specific supply chain, the evaluation criteria need to reflect the diversity of consumer preferences. Moreover, a more detailed understanding of particular needs and constraints faced by consumers is necessary to minimize negative effects of supply chain interventions on vulnerable actors, e.g. on those making the local 'munanasi' juice, which is made of spoilt pineapples. With regard to processing and value addition activities in the visited regions, simple box-type, natural convection solar dryers are frequently used on farm level to produce dried pineapple crisps. Dried pineapples are mainly produced for export to international markets with specific quality requirements. Given the climatic conditions in the area however, the amount of rejected produce can be quite severe. As local utilisation and marketing alternatives for those products are limited, the question can be raised whether this technology is appropriate to reduce food losses and further assessment of the economic benefits is needed.

Conclusion: Based on the observations of pineapple supply chains in Uganda, post-harvest losses emerge in complex food supply systems and relate to both, positive and negative side-effects. Thus, the system should be analysed with an integrated approach, and the call for loss quantification and transformation should be merged with the need for actor-oriented perspectives. Therefore, to tackle food losses in such a way that it is relevant for the respective actors along the chain, it is proposed to develop participatory loss assessment protocols on the grass roots level.

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Abstract # ADMI032

Embedded greenhouse gas emissions of global food wastage: past, present and future

Stephen D Porter[1], David S Reay1, Elizabeth Bomberg[2], Peter Higgins[3]

[1]School of GeoSciences, University of Edinburgh, Edinburgh, UK

[2]School of Social and Political Science, University of Edinburgh, Edinburgh, UK

[3]Moray House School of Education, University of Edinburgh, Edinburgh, UK

Corresponding Author: Stephen.Porter@ed.ac.uk

Introduction & Objectives: It is estimated that a quarter to a third of all food produced for human consumption is lost or wasted at some point along the food supply chain with an embedded greenhouse gas (GHG) emissions penalty of over 3 Gt CO2e (FAO 2013). This is the equivalent of about 2% of total global GHG emissions for 2007 (World Bank 2015).

It has further been postulated that patterns of post-harvest loss/food wastage (the terms here are used interchangeably) along the food supply chain are closely coupled to the level of economic development of a country (Parfitt et al 2010). Greater losses are estimated in the earlier phases of the food supply chain of relatively poor countries (ie. during primary production at the farm level as well as post-harvest storage and transport) compared to greater losses in the later consumer-focused stages in relatively rich countries. An FAO study that focused on a single year – 2007 – reached similar conclusions (FAO 2013). However, it is unclear whether this conclusion is borne out when the full history of food production is reviewed.

The aim of this paper is therefore to examine, temporally and geographically, the distribution of food loss and waste along supply-chain from 1960 to 2011 and how this may relate to economic development (such as per capita GDP). Alongside this analysis we estimate the embedded GHG emissions of this food loss and waste, identify 'hot spots' of emissions over time and space, and propose a model that could be used to develop pathways of future food wastage and associated GHG emissions to 2030 and beyond.

Methods/Design/Approach: A mass-flow model, similar to that of (Gustavsson et al 2013), is employed to estimate food wastage at each of five stages of the food supply chain (production, post-harvest handling and storage, processing, distribution and consumption). The data for the model is from the FAO food balance sheets, covering the annual periods of 1960 to 2011 (the earliest and latest available dates). Losses (and the embedded GHG emissions) are calculated with commodity, country and annual granularity. Historical loss findings are examined in relation to various development indices (e.g. per capita GDP) to derive a food wastage projection model for future pathways.

Results/Findings: From the quantification of historic and potential food losses, a 'heat-map' is produced that visualises how losses have changed over time, where losses are most prominent currently and possibly in the future. This identification of 'hot- spots' makes clear where technical, social, and/or policy interventions could produce the greatest mitigation impact.

Conclusion: In this paper we identify where, as a society and groups of societies, we are most profligate in terms of food wastage. We estimate what the climate impact has been of this wastage by quantifying the GHG emissions over the period 1960 to 2011 and suggest a model for estimating future food wastage/emissions pathways. This work will assist future research focused on understanding why the 'high impact' wastage occurs and on specific intervention strategies to address it. By so doing we may

not only achieve some level of food wastage and climate change mitigation, but also improve food security.

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Abstract # ADMI033

Machine Vision: A New Opportunity for Advancing Quality of Agricultural Produce in Bangladesh

Md. Abdul Momin

Department of Farm Power and Machinery, Bangladesh Agricultural University, Mymensingh

Corresponding Author: mominfpm@bau.edu.bd

Background: Machine vision is the ability of a computer to "see" the object in question and assess its properties. A basic machine vision system (MVS) consists of a camera, a computer equipped with an image acquisition board, and a lighting system. The advantages of a MVS are that it can be accurate, nondestructive, yields consistent results, improves industry's productivity, makes agricultural operations and processing safer for farmers and processing-line workers, provides better quality and safer foods to consumers.

Production and consumption of agricultural products, especially fruits and vegetables in Bangladesh is increasing. The associated processing industry is, however, at various stages of development and yet to implement comprehensive good agricultural practices. To ensure safety and quality standards are met and to further support the rising consumer demand for fresh produce, there is clearly an urgent need for cost-effective, non-destructive, and specific on-line quality control systems. For instance, although Bangladesh produces a substantial amount of agricultural products, the post-harvest processing is limited by manual and inadequate technologies being used for grading, sorting, processing, storage, and packaging; inefficient handling and transportation; involvement of diverse actors and poor infrastructure (Baqui, 2005). As a result, post-harvest losses of agricultural crops, especially perishable products, can reach up to 40 to 50 percent, a situation that is far from satisfactory and can be easily improved with suitable technologies.

In terms of exports, private-sector initiatives in the agro- industries of Bangladesh have seen exports grow to around 50 agricultural products to the European Union (EU), Middle-East and North-American countries. Moreover, low product prices on the local market are encouraging many traders to look for opportunities abroad. Increases in such exports would help to provide a price edge and offset the declining number of growers. However inadequate post-harvest management practices are hampering the development of these exports. For instance, agricultural products are returned at times to the exporter due to inadequate compliance with sanitary standards, or the inability to meet the consistent quality and freshness needs of foreign consumers. Given this current state of crop production and processing, for Bangladesh to expand its agricultural sector further it needs to tap into the export and processing markets by upgrading post-harvest management practices (e.g. automatic grading, sorting, inspection, etc.) to ensure value-added, high quality agricultural produce is supplied by the agro-processing sector.

Considering the possibility of introducing the mechanized postharvest processing and quality control in Bangladesh, a very recent feasibility study of a machine vision system for grading mango fruits has been conducted. Mango (Mangifera indica) is an important and popular fruit among all fruits produced in Bangladesh. It is one of the most relished fruit crops in Bangladesh covering the largest area (32,011 hectares) and the total annual production (104,7849 metric tons) being in the third position after banana and jackfruit (BBS, 2011). However, the post-harvest processing of mangos is still predominantly being done manually. The farmers examine all the harvested mangos by naked eye and sort/grade by hand. Traditional visual inspection, which has supported the sorting and grading, is however labor intensive,

expensive, and prone to human errors and variability. An automated grading make these labors, already in shortage and expensive, available for the most needed farming or horticultural operations thereby increasing production. A concerted effort in the area of machine vision will improve the quality of mango and empower Bangladesh to compete in global export trade.

Objectives: The objectives of this work is to construct a simplified machine vision system that can efficiently acquire images suitable for further processing, and develop an algorithm for grading mango based on selected features using image analysis.

Methods: Machine vision system was composed of a XGA format CCD camera fitted with a C mount lens of 6 mm focal length with polarized light filter, a desktop computer and twelve fluorescent lamps (each 18W, 54V, color temperature: 6500K; Philips Lifemax) for illuminating the samples. The system illuminates the mangos with fluorescent lighting panels and captures color images in the machine vision unit. To develop the image processing algorithm at first the different color spaces such as RGB (Red, Green and Blue) and HSI (Hue, Saturation and Intensity) of the acquired color images were studied and analyzed for image thresholding to discriminate the object from the background (Fig. 1). After thresholding the image, features such as projected area, perimeter, and roundness of the objects were extracted, which provides the size and shape properties of mangos (Fig. 1). Mangos with different size that were physiologically mature and green condition were used for this experiment.

Results: The projected areas of different grades of mangoes in terms of pixel counts provides clear separation of minimum, maximum, average and standard deviation values for all three classes (large, medium and small) of mangoes and no overlaps were found among them. However, for the perimeter and roundness features clear separation was not observed and overlaps were found with each mango class. Hence it is apparent that using perimeter and roundness in the grading of different mango classes (based on mass) cannot be obtained as accurately as with projected area. Therefore, projected area can serve as a good indicator of the mass of mangoes. This indicator gives excellent grading accuracy of 100±0% for mango size or mass classification (Fig. 1).

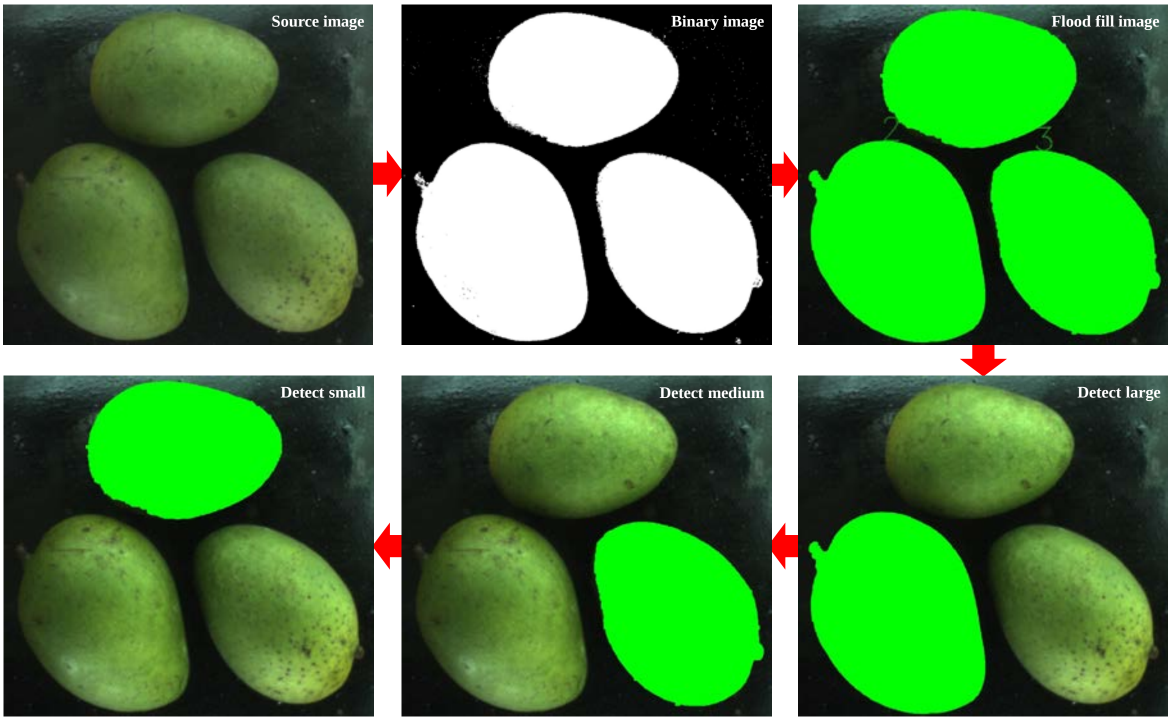

Fig. 1 Image processing operations performed for developing mango grading algorithm

Conclusion: Fluorescent lighting was efficient in providing the necessary illumination to produce good quality images for machine vision system to grade mangoes. The developed algorithm is simple yet successfully graded mangoes (100%) into three mass/size grades based on projected area as the indicator. This simple, accurate, and efficient process can be seen as the first stage of mechanizing the mango grading operations in Bangladesh.

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Abstract # ADMI034

Food loss in Dominican Republic

Leandro Feliz Beltre

FAO RD Link with Latin American Network Loss Prevention and Food Waste

Corresponding Author: lfeliz@xtratarget.com

The Dominican Republic, a nation located in the Greater Antilles, occupies two thirds of the island of Hispaniola with a population of about 10.2 million people.

The aim of the study, conducted in the third quarter of 2014 was to estimate the volume of food that is wasted in the distribution chain in order to design a strategy to reduce these losses. The survey considered both quantitative and qualitative aspects in order to not only analyze trends and estimates of waste volumes, but also to determine the causes and motivations that define these trends.

The information was collected directly through interviews with owners, managers and employees of major supermarkets, convenience stores, food industries, collection centers and markets, and managers of hotels, restaurants and agribusinesses.

Among the main results of the study, the total food loss in the analyzed sample is estimated to be 1,127,468 kg weekly. 93 percent is discarded in the production stage and 7 percent in the marketing and processing stage. The area where the greatest amount of food losses were recorded in the post-harvest process is in Constanza, La Vega Province, located in the northern part of the country.

The main reason for food waste is physical damage or bruising to the food itself, indicated by 43 percent of respondents. This factor causes brokers and sellers of products to reject a lot of foods that are in optimal conditions for consumption, especially for the export market, in the case of fruit, vegetables and tubers such as potatoes.

The next two reasons for loss were handling and transport problems and the state of decomposition upon arrival because they are not traded on time. These two causes together cause 28 percent of waste, while excess production accounted for 7 percent of total waste of food producers in the areas under study.

Other causes identified by the producers, which together accounted for 22 percent of the cases were poor planning and management problems of the producers, who grow the same products at the same time creating an oversupply and depressed prices; weather in terms of abundance of rains affecting products such as potatoes, when stored in a manner not adequate causing decomposition of these; contamination by pests affecting the storage of rice; the quality of products, which affects potatoes and carrots with nematodes (two roots); and finally the leftovers that are rejected by size.

In many cases foods such as potatoes and carrots are used to sell to other markets with lower economic potential as is the border (between Haiti and the Dominican Republic), and in other cases they are reintegrated into the soil as nutrients for the next crop.

One of the recommendations raised at the results of the survey, which notes that agricultural production has the highest levels of loss, is working hand in hand with the Ministry of Agriculture to develop public policies to support producers in developing efficiency programs and planning of harvest and post-harvest to avoid high levels of waste produced, especially in the areas of fruits and vegetables, where the average loss is estimated to be around one 20 percent of crop production.

Another aspect that is recommended is that the Food Bank establish cooperation agreements with the producers in the area of Constance and other areas of interest, in which a donation of agricultural products that can be used by the Bank protocol is developed to increase product availability. This initiative will require the Bank to install a storage facility in the area and develop an efficient management and distribution system to preserve the properties of food and keep them in optimal condition for distribution. As favorable for the realization of these agreements aspects, with the willingness to donate their surplus and in many cases represent a problem of space and incur costs to remove or reinstate them as organic matter to the soil stands.

Abstract # ADMI035

Current Status and Determinants of Farmers Knowledge and Use of Postharvest Technology: Results from India

Hemant Pullabhotla, Kathy Baylis

Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign

Corresponding Author: pullabh2@illinois.edu

As agricultural demand increases and production resources become increasingly stressed, there is increasing recognition of the critical importance of reducing postharvest losses among researchers and policy-makers. Cutting world post-harvest loss in half is equivalent to increasing global agricultural land by 15%. However systematic evidence on the current state of awareness and adoption of postharvest technology by farmers in developing countries is very limited. This is a necessary first step to better design policies and programs for extension and technology adoption among farmers. In this study we examine the current extent of farmers' knowledge of postharvest loss (PHL) reduction technology and use of such technology. We also provide preliminary analysis of the individual, village and market level factors that affect technology adoption and farmer behavior with regard to postharvest activities. We use data from a new survey of 3000 farmers across 60 villages in four districts of Bihar; a resource poor region of India, where more than 70 percent of the farmers have operational landholdings of less than 0.5 hectare. In this survey we collect data on a variety of village-level factors related to agricultural resource availability, marketing and postharvest infrastructure, as well as farmer-level information pertaining to agricultural input and operating costs, agricultural practices, credit availability and usage, asset ownership, market access, and awareness and use of PHL technology. We examine current postharvest processes employed by farmers for output sold in the market, as well as for the output that they store for their own consumption and for use as seed. Previous studies indicate that farm households store a significant share of the output for their own consumption; typically for long periods, and under poor storage conditions, usually within the farmer's house. Using detailed data on the prices received by the farmers for various quality grades, we quantify the incentives that are currently available for farmers to adopt better postharvest practices. We document the costs incurred by farmers for the current methods they use, and also their awareness of other methods and technologies. We further assess farmers' perception of storage losses that they incur for various crops. The study also examines issues of food safety, particularly focusing on the unsafe use of pest and rodent controlling chemicals for grain stored for home consumption. Using the rich data on household and village-level factors from the survey we then analyze the determinants of currently observed postharvest processes and level of farmers' knowledge. It is likely that individual characteristics such as education, gender, landholding size, access to credit and others have a significant effect on technology choice. Additionally the quality of village-level institutions, transportation infrastructure, proximity to market centers, local agricultural market structure, agro-environmental factors related to cropping pattern and weather variability are also likely to influence postharvest choices. The baseline survey forms the start of a longer term study. The results from this baseline survey would help determine the costs and benefits to farmers of current PHL activities, and to identify where gains might be made - either by introducing technology and/or by changing institutions. Further steps in this study include evaluating the impact of various extension approaches and appropriate postharvest technology interventions on technology adoption and farmer outcomes in the study villages. The analysis from these next steps is expected to help inform and refine agricultural programs focusing on postharvest loss reduction.

Abstract #

Evaluation of postharvest losses in the production and marketing chain of bananas (Musa cavendish)

Murillo Freire Junior, Antonio Gomes Soares Brazilian

Brazilian Agricultural Research Corporation EMBRAPA

Corresponding Author: murillo.freire@embrapa.br

In Brazil there are high postharvest losses in banana's production and marketing chain. In order to evaluate the main factors that contribute to these losses, a survey was prepared for and completed by the farmers. The objective of this study was to identify and evaluate the main factors contributing to post-harvest losses of bananas and propose how to reduce them. Through technical visits to the main banana producing regions in Brazil, we evaluated and observed the procedures used by producers and wholesalers, from harvesting to the commercialization of bananas. It was identified that the harvest is manual, performed by an employee with a machete. The other employees are used to collect banana bunches and take them the packinghouse to be washed and packed. Generally, the time of banana harvest is determined by one person looking at the size of the fruit trees empirically. Although the cooperatives have developed an appropriate scale for measuring the length and size of banana fingers, they do not use it. This scale is important because it facilitates the classification of the fruit. The selection and cutting of the banana bunches in trees are made without counting the weeks after issuing the navel. The transport of the banana bunches to the packinghouse should be carried out by a cable-based conveyor. Sometimes the fruits that have been cut are placed on the ground over banana leaves, inside the orchards without sunlight until they are ready to be washed and packed. This depends on the technology adopted by the farmers. During the packinghouse process, it was verified that bunches are individually removed and are only packed after being washed and classified according to size and caliber. The fruits can be packed either in plastic boxes and wooden boxes, depending on the final destination market. It was found that the non-withdrawal of floral remnants (pistil) that are at the banana fingertips may cause physical damage and injuries in other fruits. These pistils may scratch the fruit shell. In the current way of packaging bananas, it was found that the amount of fruit wrapped in plastic and wooden boxes is above the maximum volume of those boxes. This prevents the correct stacking of the boxes, causing losses by compression and cutting. These losses happen because the bottom of the box is compressing the banana bunches that are in another box immediately below. Therefore, it was observed that a high rate of mechanical damage caused quality losses and decreased the shelf life of fruits. The trucks used to transport the banana loads are supplied by wholesalers. It was also found that the cost of transportation is funded by the wholesalers. It was observed that some of the trucks do not have cooling systems. This may turn into a big problem because losses on quality of fruit will appear when temperatures inside the trucks rise during the transportation to the final destination. It was also observed that fruit packed into the boxes may have different damage during the stacking process. This is because the boxes are not placed on pallets, changing their position from up to down during the logistic process until they reach the supermarket. The banana bunches do not allow good accommodation inside the plastic boxes because of their shape. Often the fruits are slightly above the level of the boxes causing losses during the entire process. When packing banana bunches in the boxes, it is necessary for the employee to do a little compression due to the weight used (16kg plus 5%). This weight is slightly above the box volume. If the bunches were divided into bouquets, the problems of mechanical damage would be dramatically reduced, since it would be easier to accommodate bananas in plastic boxes. The

decreasing of the weight of the banana bunches in plastic boxes, could help greatly to reduce the mechanical damage during transportation. Regardless of the level of technology used, there is a lack of training for all employees involved in the entire banana chain. Training should cover the necessary precautions for handling the fruit, the use of adequate boxes, and proper cooling systems during transportation.

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Abstract # ADMI036

FAO study on postharvest losses of cassava, mango and tomato in three Caribbean countries: Trinidad and Tobago, Guyana and St. Lucia

Majeed Mohammed[1] , Kelvin Craig1, Joseph Mpagalile[2] and Vyjayanthi Lopez[3]

[1]Project Consultants (FAO Project TCP-SLC-3404)

[2]Agro-industries Officer, AGS, FAO Headquarters, Rome,

[3]Plant Production and Protection Officer, FAO-SLC, Barbados

Corresponding Author: majeed.mohammed@sta.uwi.edu

Using the FAO (2012) assessment methodology of food losses, studies were conducted to measure the magnitude of postharvest (PH) losses for cassava, mango and tomato in the Caribbean countries of Trinidad and Tobago, Guyana and St. Lucia. After mapping the PH handling system for each commodity, 3-4 Critical Loss Points (CLPs) were identified with each CLP representing points along the food supply chain where losses were highest. At each CLP random samples of each commodity was bought and divided into three replicates. Weights were taken in each replicate and separated into marketable and unmarketable categories. For marketable samples data were taken on qualitative losses as the commodities moved along the food supply chain. Likewise, for the unmarketable samples weights were taken to determine those that were damaged according to physical, physiological, pathological and entomological losses and the causal factors associated with these losses were identified. The unmarketable samples were considered as PH losses.

Although PH losses of cassava roots in Guyana were only 3% more than those in Trinidad, there were major differences in the nature of these losses at the CLPs. At CLP#1 total losses averaged 6.5% mainly due to physical damages, where pathological and entomological damages were 3.0% and 3.5% respectively. No physiological losses were measured at CLP#1 and 2 and total losses at CLP#1 were at least three times more than CLP#2. PH losses of tomatoes were measured at three critical loss points (CLPs) after screening the value chains of both countries. The critical loss points were at harvest (CLP#1), packinghouse operations (CLP#2) and retail markets (CLP#3). Total PH losses for tomatoes were measured at 27% and 34% for Trinidad and Tobago and Guyana respectively. PH losses of mangoes were measured at four critical loss points (CLPs) after screening the value chains of both countries. The critical loss points were at harvest (CLP#1), development of value added food products such as kuchela and frozen mango slices (CLP#2 and CLP#3), and display and sale of ripe fruits at retail markets (CLP#4). Total PH losses varied according to cultivar, country and type of value added food product. For the fresh fruit losses were 17% for cv. Julie for Trinidad and Tobago and 32% for cv. Buxton spice for Guyana. PH losses of mangoes and tomatoes were measured at three critical loss points (CLPs) after screening the value chains in St. Lucia. The critical loss points were at Agricultural Co-operatives where growers wholesaled their commodities (CLP#1), the Marketing Board retail outlet (CLP#2) and the Municipal market (CLP#3). PH losses in the development of cassava farine were also measured at two processing facilities. Total PH losses for tomato and mango at the Agricultural Co-operatives (CLP#1) were 7% and 8%, at the Marketing Board Retail outlet (CLP#2) losses were 8% and 13%, and at the Municipal markets (CLP#3) losses were the lowest at 5% and 2%. The studies were conducted under a project (TCP-SLC-3404) titled Reduction of Postharvest Losses along the Food Chain in the CARICOM Sub-region funded by the Food and Agriculture Organization's Technical Cooperation Programme.

Abstract # ADMI037

Food Systems and Postharvest Loss: Preventive Measures and Adaptations

Adebola Adedugbe

Farmideas, Nigeria

Corresponding Author: bolaadedugbe@gmail.com

Introduction: Agriculture has and according to most observers, will continue to have a central role to play in the development process of most developing countries. Agriculture and its associated value chains are expected to contribute to local food security, to provide work opportunities in rural areas, and to have a catalysis effect on the development of related economic sectors. Agriculture faces many challenges, making it more and more difficult to achieve its primary objective- feeding the world. As the global Population climbs steadily towards 9 billion, natural systems that support us all may not be able to withstand the pressure that this growth exerts. Water scarcity, land degradation and the loss of natural (ecosystem) services we all depend on, point to fundamental problems caused by unsustainable development. Estimates suggest that one-third of agricultural production is wasted and does not reach food consumers. If portions of that lost production could be preserved and used by consumers, food supply would be increased. At the same time, resources (arable land, water and energy) would be preserved with corresponding potential gains for smallholder farmers in developing nations. Postharvest loss prevention, therefore, offers an important opportunity to advance world food security now and in the future. This paper provides a short description of local adaptation strategies to preserve food and improve food security in sub Saharan Africa. Keywords: Agriculture, food consumers, food loss, Postharvest loss, Smallholder farmers.

Objectives: There is a fast growing gap between food supplies in developing countries and the rest of the world. While some countries enjoy surplus food production, others are confronted with famine. Since the dawn of agriculture, farmers have prepared soil, sown seeds, tended seedlings, watered and nourished their crops before gathering, or harvesting them once mature. And what happens to crops once they've been harvested? Postharvest crops need to be handled, often dried, stored, and sent to market. Loss also implies what this physical damage will mean in terms of economic loss which includes losses due to downgrading a product or discounting in anticipation of physical losses. For example, cassava can be processed into low quality cassava chips to avoid fresh cassava spoiling, but a significant amount of value is lost. This journey, from field to plate, is referred to as a 'value chain', meaning the chain of activities that operators in a specific industry perform in order to deliver a valuable product to the market. This paper identifies the need to increase smallholder farmers capacity in order to gain a stronger position in the global marketplace. To help them recognize, establish and describe different components in the supply chain connecting producers to consumers and how each link contributes to the final product offered to the customer.

Method, Design and Approach: With the shift towards Sustainable Development Goals (SDG) to replace the Millennium Development Goals (MDGs) after 2015, approaches that severe multiple purpose and provide cross-cutting benefits are highly needed. Thus, preventing postharvest loss requires innovations in measuring the extent of postharvest loss, developing appropriate technologies, integrating systems, and evaluating policy, as well as effective transfer of information and education. Some tools and methods used to prevent food loss are Cassava Adding Value for Africa(C:AVA); Intervention modeling tool and Refrigerated trucks.

Result/ Findings: C:AVA (Cassava Adding Value for Africa) is an initiative supported by the Bill and Melinda Gates Foundation, which seeks to develop value chains for high-quality cassava flour (HQCF) in Ghana, Malawi, Nigeria, Tanzania, and Uganda. Cassava is a staple crop in Africa, but has a short shelf life after harvesting. One way of reducing losses is to process it quickly into HQCF. The Intervention modeling tool could be described as a 'nifty app' for loss reduction decision making. It aims to answer the question which interventions at which locations will be most effective given the resources available? This tool is intended as an imaginative way of getting people to think about key factors affecting investment in loss- reduction projects. It doesn't make decisions for the user, but shows how three important factors, efficiency, adoption rate and investment, interact. Some world class companies like Archer Daniels Midland Company (ADM) and Cargil and food retailer Walmart have successfully deployed storage and preservation technologies in several regions of the world. These companies have invested in post-harvest food solutions such as closed- top, refrigerated trucks to transport harvests to markets and processing facilities and in modern storage and processing equipment.

Conclusion: Africa's food loss is valued at over USD 4 billion dollars every year as a result of post-harvest inefficiencies across the staples agricultural value chain. Post-harvest losses significantly endanger the livelihoods of stakeholders across the value chain by reducing valuable incomes and profitability. Post- harvest losses are a major contributor to food insecurity in Africa and there is an urgent need to mitigate the negative impacts across the agricultural value chain. Unfortunately, there is very little data to demonstrate the real impact of post-harvest losses in Africa.

African governments must take bold steps toward reducing the high level of post-harvest losses across the continent; because value chain actors and particularly small holder farmers are losing potential incomes through systemic inefficiencies. If we are serious about breaking the cycle of poverty, we must develop efficient systems for ensuring that the food we produce is properly stored, transported and marketed.

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John Bowman, Philippe Villers, Steve Sonka. Post Harvest loss can mean more food for All IIP Digital, US Department of State Post Harvest Exclusive from Analysing loses to Adding Value University of Greenwitch, National Resource Institute (NRI)

Abstract # ADMI038

Harvesting: Effects of Crop Maturity and Moisture on Losses

Marvin R. Paulsen

Agricultural and Biological Engineering Department, University of Illinoisos

Corresponding Author: mpaulsen@illinois.edu

Introduction: In a review of present post-harvest losses in developing countries due to harvesting operations for all types of manual, partially mechanized, and full combine harvesting methods, the overwhelming number one cause of harvest losses has been crop maturity and moisture content (Paulsen et al., 2015). The ability to harvest at optimal crop maturity and moisture content is a moving target with maturity always increasing and moisture first decreasing and then becoming variable dependent on ambient air temperatures and relative humidities. Falling outside of optimal harvest maturity and moisture, affects shatter losses where grains, oilseeds or pulses fall out of panicles and pods or ears drop to the ground and stalks/ stems lodge causing difficulty in cutting and gathering harvest operations. In addition to physical losses, quality losses such as kernel breakage, pericarp, seedcoat or hull damage can also occur which affect millability, processing and storability. Moisture content affects the amount of impact needed to thresh kernels from plant materials; and at too high of moisture, kernel pericarps are soft and easily punctured, whereas at too low of moisture, kernels are hard/ brittle and easily broken.

Objectives: The objective of this research is to glean and assimilate from literature the reported effects of crop maturity and moisture content on harvesting losses for the primary cereal grains, oilseeds and pulse crops in developing countries. A sub-objective is to also report effects of moisture on qualitative characteristics of harvested cereal grains, oilseeds, and pulses.

Methods: Most research that centers on harvest loss does not focus directly on crop moisture or its effect on those harvest losses. This research takes the perspective of looking at moisture effects on harvest operations which include cutting, gathering, handling, threshing, separating, and cleaning. Cereal grains include rice, wheat, maize, sorghum and millet. Oilseeds include soybeans, safflower, sunflower, mustard, etc. Pulses include cowpeas, chickpeas, pigeon peas, etc.

Results and Conclusions: Crop moisture has a major effect on the amounts of shatter losses in grains, oilseeds and pulses and on their ability to thresh and threshing damage to kernels. Soybeans are extremely sensitive to moisture content and if harvest moisture is at or below 13.0% the kernels will easily shatter and fall out of their pods on to the ground (Paulsen et al., 2014). Tabular results of harvest maturity characteristics and optimal harvest moistures for each crop are shown in Table 1. As available, information on expected moisture change as harvest is delayed is given for various crops along with probable harvest losses and expected quality changes. While the small holder farmer cannot change climate or the rate of moisture change, knowledge of expected harvest losses and quality changes for a given moisture can facilitate future decisions about the degree of mechanization that could allow faster harvest before higher losses and quality degradation occur.

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Abstract # ADMI039

Effective Rice Storage Technologies for Smallholding Farmers of Bangladesh

Richard Trcay, Corey Rosenbusch

World Food Logistic Organization, USA

Corresponding Author: rtracy@gcca.org

Introduction: The World Food Logistics Organization (WFLO), a core partner of the Global Cold Chain Alliance (GCCA), in partnership with the University of California, Davis and the World Vegetable Center (AVRDC), supported a USAID-funded pilot project under the Hort CRSP (now known as the Hort Innovation Lab) to establish a Postharvest Training and Services Center (PTSC) in Arusha, Tanzania in order to help reduce food losses in East Africa from the very high levels being reported in the literature. Programming for the PTSC was effectively concluded by October 2013, but a USAID/Save the Children- funded initiative (TOPS) enabled WFLO to conduct an evaluation to gather information on capacity building outcomes, best practices, gender issues, and evidence of success or failure. This evaluation was conducted by a team of WFLO consultants during October 2014- April 2015. II.

Objectives: This paper will summarize the major findings from the TOPS-supported evaluation of the PTSC following three of the four objectives. (The fourth objective concerned refresher training workshops for Master Trainers).

1. To determine the major capacity building outcomes and impact of the PTSC and Training of Trainers (ToT) program.
2. To identify best practices in the management of the PTSC and its extension services.
3. To identify problems, concerns and obstacles to making the PTSC a sustainable and replicable model.

Approach: During 2011-2012, 36 young professionals from Benin, Ethiopia, Ghana, Kenya, Rwanda, Tanzania, and Uganda were trained as postharvest specialists through an innovative 18-month e-learning program which concluded with a week-long workshop held at the PTSC in Arusha, Tanzania. These participants became Master Postharvest Trainers and designed their own PTSCs, focusing on the key crops within their locations, and returned to train thousands of local farmers, association leaders, and extension workers in their own countries on the new postharvest technologies acquired. In conducting the evaluation of the PTSC, the WFLO team visited sites in Ethiopia, Tanzania and Uganda where Master Postharvest Trainers are working. Data on the 36 Master Postharvest Trainers was collected via email. Cluster sampling was used for collecting data from 50 local trainees in and near Arusha. Cluster sampling was achieved by a two or multi-stage process: randomly choosing 10 trainee groups with which to work and them randomly selecting 5 individuals from within each of those groups. Through written and face-to-face surveys, and with additional interviews and site visits for observations, WFLO amassed a large amount of data that formed the foundation of the evaluation. WFLO also offered workshops for local stakeholders and consultants on project monitoring and evaluation practices, and provided technical postharvest training updates for many of the Master Postharvest Trainers and other local practitioners.

Findings: The evaluation revealed that the two training-oriented components of the PTSC model were fully implemented. The 18- month long ToT program produced 36 postharvest specialists (Master Trainers) who then trained more than 22,000 farmers, extension workers, food processors, and marketers in Sub-Saharan Africa over two years. In addition, approximately 1,500 local farmers, traders, food processes, and marketers were trained via programs provided in Tanzania by the PTSC staff at the AVRDC site, SARI staff at the Njiro site, and by locally and internationally based postharvest trainers. 100% of those who have participated in training programs in Tanzania reported being satisfied with their experiences and marking one or more changes in their practices that led to reduced losses and increased earnings. Identified best practices include providing a range of hands-on postharvest learning opportunities applicable to a variety of clientele in different communities. Trainees should also learn how to calculate the costs and expected benefits of any technologies that are being promoted. Challenges for the PTSC include implementation of three components intended to provide a sustainable source of outside income. The adaptive research projects, postharvest retail shop and postharvest services (pre-cooling and fee-based cold storage provision) were not fully implemented.

Conclusion: The PTSC Model included five components:

1. Training of Postharvest Trainers
2. On-site postharvest training and demonstrations
3. Adaptive research, including cost/ benefit analyses of potential postharvest innovations
4. Postharvest Retail Shop with tools, goods and supplies, open to the public
5. Postharvest services for fees such as grading, packing, storage, transport and marketing advice

The first two components were found to be a great success, exceeding expectations and reaching far beyond M&E targets. The postharvest ToT program was expanded and is currently being provided by a US based NGO for young horticulture professionals in 27 countries without USAID support. The adaptive research component was nearly achieved but fell short. Several of the new technologies currently being studied at AVRDC have not yet been fully documented and none of the research results have been published. The retail shop and postharvest service components are still in the planning stage. The local partners in Tanzania have been unable to implement them fully due to administrative, financial and legal constraints. Improvements for future projects could include selecting local partners that are capable of implementing all five components of the PTSC model, with the commercial skills needed in order to take an agri- business approach. This would ensure that the PTSC has a sustainable financial base for operations, and could survive without continued donor support.

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Abstract # ADMI040

Effective Rice Storage Technologies for Smallholding Farmers of Bangladesh

Md. Abdul Awal, Md. Afzal Hossain, Md. Rostom Ali, Md. Monjurul Alam

Department of Farm Power and Machinery, Bangladesh Agricultural University (BAU), Mymensingh, Bangladesh

Corresponding Author: awalbau@gmail.com

Background: Paddy is the main food and accounts for about 93% of the total food produced in Bangladesh. The country has produced around 34.45 million tons of rice, in FY 2013-14. The farmers usually store rice using traditional storage structures to meet their own consumption, facing emergency needs, getting better price and seeds for the next sowing season. Rice stored in hot humid Bangladesh has a high degree of insect infestation, rodents and deteriorates quality significantly. The storage time of rice varied from 2 to 7 months irrespective of rice, farm and region with the overall average being 5.5 months. The most common traditional storage technologies used by farmers in Bangladesh are Gola, Dole, Motka, Dhari, and gunny/plastic bags or sacks (Bala, 1989). Storage losses are higher in Bangladesh than in other developing countries where better storage systems are available. The average in-store losses of rice in large, medium, small and marginal farmers were 4.48%, 3.92%, 4.0% and 3.59%, respectively. Hopf *et al.*, (1976) surveyed on stored grain losses at farm and village level reported that 5% rice was damaged or lost in woven bamboo bin storage structure in Bangladesh. Grain losses may occur in storage due to insect infestation and fungal growth. Temperature and moisture are the most important factors affecting the abundance of insects and fungi. The losses of rice post-harvest in Bangladesh are more than 13% (Calverley, 1994). Lack of suitable rice storage structures at smallholding farmers of Bangladesh are often forced to sell their produce immediately after harvest, to avoid post-harvest losses from storage pests and pathogens. Consequently, farmers receive low market prices which directly impacts their livelihood, food and income security. To remedy these problems, improved storage technologies, such as silos, IRRI bags, PICS bags, and Super Grain bags may be used in Bangladesh. Hermetic storage in airtight bags has emerged as a new and significant improved storage method that protects grain from insect and fungal infestation.

Objective: The overall goal of this study was to compare hermetic storage technologies: PICS bags, GrainPro super bags, and Keppler-Weber small silos with traditional storage practices in lab and on-farm households thereby increasing grain quality and improving rural livelihoods.

Materials and Methods: A comprehensive study was carried out under the project USAID Feed the Future Post harvest Loss Reduction Innovation Lab (PHLIL) – Bangladesh component to determine the effect of storage period and storage structure on rice quality technically and financially for both traditional and hermetic storage technologies at the Department of Farm Power and Machinery lab, Bangladesh Agricultural University, Mymensingh as well as Farmers houses of Phulpur, Mymensingh district and Monirampur, Jessore district of Bangladesh. Phulpur is located at 24.9500°N 90.3500°E of Mymensingh district and Manirampur upazilla of Jessore district is located at 23.0167°N 89.2333°E. Two focus group discussion (FGD) on hermetic storage especially procedure of use of GrainPro Bag was conducted at Nagua East village, Phulpur, Mymensingh and Harina village, Manirampur, Jessore.

The lab experiment laid out in completely randomized design (CRD) with three replications and four treatments. Treatments were Plastic drum, Dole, Motka and GrainPro bag which were placed on a wooden pallet in a laboratory room in the Department of Farm Power and Machinery, Bangladesh Agricultural University, Bangladesh. Moisture content, relative humidity, 1000-seed weight,

germination percentage and insect infestation were assessed as experimental design. Daily temperature and relative humidity of inside and outside of the room were recorded. Field data were collected through a pretested well-structured questionnaire in purposive sampling technique from 200 farmers of different sizes (Marginal, Small, Medium and Large) from the study areas. Two GrainPro bags were set to conduct experiment in each farmer house and lab with their traditional structure.

Results: In Jessore, it was found that 13, 47, 1, 3, 2, 10, 2, 1, 4, 1, 2, 3, and 11% of farmers of the study area use Plastic bag, Dole, Kerosene tin, Motka, Bamboo auri, Bamboo gola and Plastic bag, Bamboo gola and Motka, Bamboo berh, Gunny bag, floor of the tin shed building, Bamboo gola and Gunny bag, Dhari, and Bamboo gola, respectively. About 57% and 9% of the farmers stored their paddy for food and seed purposes, respectively. About 57% of the farmers stored their own harvest and 58% of these farmers used traditional dole for storage and 11% put *Neem* leaf (as an insecticide) in their storage containers. In Mymemsingh, 8, 58, 1, 2, 5, 3, 1, 4, 2, 1, 3, 3, and 9% of farmers of the study area use plastic bag, Dole, kerosene tin, Motka, Bamboo gola and Plastic bag, Bamboo gola and Motka, Bamboo berh, gunny bag, bamboo gola and Plastic Drum, floor of the tin shed building, Bamboo gola and Gunny bag, Dhari, and Bamboo gola, respectively. About 52% and 7% of the farmers store their paddy for food and seed purposes, respectively. About 74% of the farmers store their own harvest and 47% use traditional dole for storage and 17% put *Neem* leaf in their storage containers.

The on-farm experiment was carried out to identify existing rice storage structures and problems at farmers' level in Phulpur, Mymensingh and Manirampur, Jessore. GrainPro bags were provided to 40 farmers at Phulpur and another 40 farmers at Manirampur. Rice variety BRRI dhan28 was used and 15 kg of grain was stored in each of two bags for up to four months. Four different species of insects were identified in farmers' storage. Maximum insect infestation (~1 insect/gram of grain) occurred in the Dole traditional storage container followed by Motka (0.2 insects/gram of grain). No insects were found in grain stored in the GrainPro bags. Seed germination (97%) was higher and damaged grain (1%) was lower for grain stored in the GrainPro bags than for grain stored in traditional storage (95% seed germination; 6% damaged grain). MC (11.8%) was unchanged in GrainPro bag, but increased by >2% in the traditional storage. Only three insect species were identified in the lab experiment, but other results were similar to those seen in the on-farm experiments.

Conclusions: Majority of the farmers (47% in Jessore and 58% in Mymensingh) use Dole for storing their paddy due to its availability, cheap and light weight. It is easy to dry, clean and handle before storage. A number of farmers of both the study areas used consciously *Neem and Nishinda* leaf as insecticides in their storage container. Maximum insect infestation was found in traditional storage container Dole in both lab and farm households and there was no insect infestation in GrainPro bags at farm households and lab. GrainPro bags were found superior to all three of the traditional storage methods.

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Abstract # ADMI041

Qualitative loss of maize under different bag storage modes

Vishal Kumar, Dinesh Rajak, Anuradha Kumari, Mukesh Shrivastava and P.D. Sharma

Department of Processing and Food Engineering, College of Agricultural Engineering, Rajendra Agricultural University, Pusa, Bihar, India

Corresponding Author: vishal.cae@gmail.com

Post-harvest losses (PHL) in India amount to 12 to 16 million metric tons of food grains each year, an amount that the World Bank estimates could feed one-third of India's poor. With 2.85 % of India’s geographical area and 8.07 % of population, Bihar is the third most populous state in the country (2001 census). About 80% of Bihar’s population is dependent for its livelihood on agriculture. Bihar is the third largest producer of vegetables; fifth largest producer of fruits and eighth largest producer of grains in India. In spite of high volume of production and a good range of crops, the earnings from farming are poor. Postharvest loss is one of the major problems in the region as it increases food prices and reduces farm income, particularly for smallholder farmers.

Maize is the third most important cereal crop in India after rice and wheat. It accounts for ~9 per cent of total food grain production in the country. Maize recorded the highest annual growth rate of 2.5 per cent in the area as well as 5.5 per cent in production during the period 2004-05 to 2013-14. There has been an increasing trend towards substituting other coarse cereals with maize. However, Maize suffers heavy post-harvest losses estimated at 20-30 per cent and storage loss alone takes the major share. In Bihar, farmers store Maize crop in homes, on the field, in the open, jute or polypropylene bags, clay structures and baskets. During storage, quantitative as well as qualitative losses occur due to insects, rodents and micro-organisms.

Hermetic storage bags are airtight storage bags used worldwide for the prevention of post harvest storage losses. The intrinsic advantage of the hermetic storage of dry cereal grains lies in the generation-by the aerobic metabolism of insect pests and microorganisms-of an oxygen-depleted and carbon dioxide-enriched inter-granular atmosphere of the storage ecosystem. A hermetic storage bags is a safe, cost-effective storage method that controls insect infestations in addition to preserving the quality of grains, while allowing for pesticide-free, short-term and long-term qualitative and quantitative seed preservation, without refrigeration, maintaining seed vigor and pest control.

Hermetic bags need to be validated for its effectiveness for storage of food grains under Bihar condition. The present study was undertaken in response to requests by farmers, traders and private seed companies to determine the effectiveness of hermetic bags for storage of maize grain. Hence, a comparative study on storage behavior of Maize in different storage bags was made to assess the qualitative and quantitative loss in different storage modes used in the region and to validate the advantages of hermetic super grain bags over the conventional storage bags.

The storage behavior of freshly harvested and chemically treated (Alminium Phospide) maize grain (*Shaktimaan I*; 12.2% w. b.) was studied at ambient condition (30± 5 ºC) in four different modes, i.e. in hermetic bags (super bags), polyethylene bags, plastic bags and jute bags. The variation in ambient storage environment such as temperature and relative humidity of were recorded on a daily basis while weekly changes in physical properties such as grain moisture content, water activity & colour index and degradability in terms of degree of insect infestation, germination percentage and production of aflatoxin

were recorded. The experiment was initiated at Pusa, Samastipur Bihar on September 18, 2014 and terminated on May 8, 2015.

It was observed that the variation in grain moisture content (0.245, w.b.), water activity (0.132) and colour index (0.232) was least in the super grain bags while the variations were maximum in case of chemically untreated jute bags (0.855, 0.166 and 0.426 respectively) . The germination percentage was maximum for maize stored in super bags (92%) and least for jute bags (44%) after 8 months storage period. No visible damage due to pest infestation was observed in maize samples stored in super bags. However, Maize stored in other storages modes was largely infested with weevils which resulted in qualitative and quantative loss. The aflatoxin levels under of the stored maize in hermetic bags were least and under the acceptable limit i.e. 20ppb throughout the storage period. However the aflatoxin levels in other storage bags were around 100-150 ppb rendering it unfit for human consumption.

It was concluded that maize could be stored under ambient conditions up to eight months in hermetic storage bag with minimum qualitative loss. There is no requirement of any chemical treatment of grains stored in hermetic super bags as the micro environment developed is sufficient enough to restrict the growth of pests, insects and micro-organism. The hermetic bags can be a key post-harvest technology for reducing PHL at storage in the fight against hunger and ensuring food security.

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Abstract # ADMI042

Assessment of Moisture Measurement and Maize Dryers in Ghana

Samuel McNeill[1], P. Armstrong[2], E. Osekre[3]

[1]Biosystems and Agricultural Engineering Department, University of Kentucky, Princeton, KY

[2]Research Engineer, USDA-ARS-CGAHR, Manhattan, KS

[3]Entomologist, Department of Crop and Soil Sciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

Corresponding Author: smcneill@uky.edu

Introduction: A team of entomologists, agricultural engineers and other scientists from the KSU Feed the Future Innovation Lab for the Reduction of Post-Harvest Loss embarked on a 5-year study to investigate methods of preserving grains in four countries (Bangladesh, Ethiopia, Ghana, Guatemala). Upon returning from assessment trips to each country in 2014, two common problems were identified across all locations, namely that accurate measurement of grain moisture and timely drying could greatly reduce damage to grain caused by insect and mold activity during subsequent handling, storage and processing. Mold problems from mycotoxins are not only related to grain loss but also health, causing immune suppression, liver disease, cancer and likely stunting in children. Accurate moisture measurement and timely drying of maize can greatly reduce aflatoxin concentrations and ultimately lead to safer, higher quality and more nutritious food products for consumers (PACA 2015).

Most small holder farmers in these and other developing countries typically dry their grains either on packed/bare soil with or without mats or tarpaulins, by the roadside, or on concrete floors in the open sun (Imoudu and Olufayo, 2000, Opit et al., 2015). The major problem with this simple and inexpensive method of drying is the slow removal of moisture. Because grains are often harvested at a high moisture content (>20% wet basis), growth of microorganisms can occur before grains are well dried because of the surrounding high ambient temperature and relative humidity levels. After several days of slow drying, the resultant maize quality can be poor with low storability and possibly high concentrations of mycotoxins. Accurate measurement of grain moisture is critical when monitoring drying processes and storage environments. However, most commercial moisture meters are priced beyond the reach of most small holder farmers, so traditional means of estimating moisture are widely used (Opit et al., 2015). A low-cost moisture meter has been developed and compared with a commercially available meter at four locations in Ghana (Armstrong, 2015). Initial results showed the low-cost meter to have an error of ± 0.5%, but more tests are being conducted.

Objectives: The specific objectives of this activity are to:

1. Work with in-country partners to collect baseline grain moisture data during maize harvest, prior to threshing, after drying and during storage with a commercially available moisture meter and a new, low cost meter.
2. Evaluate the performance of commercially available solar grain dryers when drying maize and by computer simulation under historic weather conditions.
3. Conduct a systematic approach to identify critical control points for mycotoxin reduction.

Approach: Two US agricultural engineers on the Feed the Future Team worked at the Kwame Nkrumah University of Science and Technology (KNUST) campus in Kumasi, Ghana from 12-19 June, 2015. They met with other engineers and scientists to discuss their participation in the project and assistance with field activities. Training was provided to graduate students in the Agricultural Engineering Department for the GrainPro solar bubble dryer (SBD) and in the Entomology and Plant Pathology Departments for mycotoxin analysis (aflatoxin and fumonosin) using quantitative Romer test kits. All students were trained in the use of a commercial moisture meter (John Deere Moisture Tester Model SW08120) and a low-cost moisture meter (PHL meter) developed by a member of the team (Dr. Armstrong). Detailed instructions and data collection sheets were developed during this activity to facilitate field activities, compilation of results and report generation.

Objective 1: Evaluate a low cost Post Harvest Loss meter (PHL) in comparison with a commercial meter and obtain baseline moisture levels in bagged storage in the Middle Belt region of Ghana. Moisture measurements were taken at four locations during monthly sample collections beginning in March 2015. Locations were in Ejura (two separate warehouses), Techiman and Wenchi. The commercial meter provided by John Deere (JD) and the Post Harvest Loss meter (PHL) were used. The PHL meter was designed specifically for Feed the Future Innovation Lab projects as an easy, low cost method to measure moisture of several different grains stored in bags. It utilizes equilibrium moisture equations to calculate MC based on the temperature and relative humidity of the void space within the grain environment.

Objective 2: Evaluation of a solar dryer for maize. The solar drying systems seen in Ghana (Opit et al., 2015; Preuss, 2013) are not widely used presently but could be built in many parts of the country and elsewhere where climatic conditions are favorable - abundant sunshine during the harvest season, warm average temperatures (above 16 C), and low relative humidity levels (average below 70%). Some low cost solar dryers have previously been tested at the Savannah Agricultural Research Institute (SARI) near Tamale. These units were designed for smallholder farmers and reported to achieve high operating temperatures ((≥50oC), which not only provides more rapid drying than on a tarp in open air, but also thermal disinfestation of insects. Although these dryers are no longer in place due to their light construction and limited funding to maintain/rebuild the structures, scientists remain interested in more work with similar or improved designs. Thus, a portable, commercially available solar dryer was selected to study and evaluate this technology. The PHL meter will be used to monitor temperature and relative humidity levels of air outside and within the dryer during operation.

Objective 3: Determine mycotoxin levels during harvest, prior to shelling, after drying and during storage. Affordable moisture meters and solar driers could have a large, positive and immediate impact in mitigating mycotoxin problems. Ideally, these technologies could be adaptable to the farm or village level, and possibly financed through farmer based organizations. Alternatively they may be offered by a service provider as their use could be extended to other grain or agricultural products.

Results:

Objective 1: Averages values measured with the JD and PHL meters for maize temperature, and moisture across all sites for each month are shown in Table 1, along with the relative humidity of the void space within the bags from the PHL meter. A gradual drop in temperature and rise in RH within the grain during this time was observed, which should correspond with similar ambient air changes during the period. The JD and PHL measurements initially had some measurement separation for March and April. However, measurement protocols were improved afterwards and subsequent measurements were in better agreement. The PHL meter values are consistently below the John Deere meter. In a separate study in the USDA lab in Manhattan, KS, similar values between the JD and PHL meter for wheat showed about the same measurement error compared to the standard oven method (Armstrong, 2015).

Table 1. Average of measured variables across sites for each month (Armstrong, 2015)

Month	Moisture, %wb		Temperature, C		RH, %
	JD	PHL	JD	PHL	PHL
Mar	13.4	10.8	30.3	31.3	51.6
Apr	13.6	11.5	30.3	31.1	56.7
May	13.8	12.6	28.9	30.3	63.3
Jun	14.2	13.5	26.4	29.1	68.0
Jul	14.6	13.6	27.1	29.5	68.9

Objective 2: Field trials with the solar bubble dryer are scheduled to begin in mid-September and will be tested at two locations in the Middle Belt. These tests will be repeated during the Minor Season (Nov-Dec) and plans are underway to test the dryer in the North, near Tamale.

Objective 3: Grain samples will be collected for insect and mycotoxin levels after the drying tests in Objective 2.

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Abstract # ADMI043

Palm Kernel Oil: DDVP Mixtures as Protectant of Cowpea Seed Against Cowpea Seed Beetle

Samuel Adelani Babarinde, Oladele Abiodun Olaniran, Timothy Abiodun Adebayo, Damilola Olanike Odeleye, Toyin Oluwaseyi Adegbmiro and Adedayo Aishat Adeoye

Department of Crop and Environmental Protection, Ladoke Akintola University of Technology, P.M.B. 4000, Ogbomoso, Nigeria

Corresponding Author: sababarinde@lautech.edu.ng

Introduction: Cowpea seed beetle, *Callosobruchus maculatus*, is an agricultural insect pest attacking pulses in Africa and Asia. The insects feed on seeds thereby reduce weight; destroy the market value and germination ability of seeds (Babarinde *et al*., 2015). With the high rate of damage to crop by this insect, control becomes highly inevitable. The use of synthetic pesticides is an effective strategy for control of postharvest biological losses in some developing countries due to its timeliness and appropriateness in times of emergency. However, uncontrolled use of these pesticides in reducing postharvest losses has diverse ecological demerits, which may increase both cost/benefit and risk/benefit ratios. Botanicals are alternative to overdependence on synthetic insecticides for the control of stored product because botanicals have insecticidal potential, with some ecological and economic advantages (Isman, 2008; Babarinde *et al*., 2014; 2015; Arnason *et al.*, 2015). Botanicals are currently gaining wider acceptance in developing countries due to their availability, cost effectiveness and compatibility with other control methods. Palm kernel oil (PKO) is edible plant oil derived from the kernel of the oil palm, *Elaeis guineensis*. DDVP is an organophosphate, widely used to control household pests, in public health, and protecting stored products from insect pests. Despite its efficacy against a wide range of pests, it is dangerous to a number of aquatic species. It can inhibit cholinesterase levels in humans which may lead to short- or long-term neurotoxic effects. Fixed oils like soybean oil, palm oil and groundnut oil have been exploited for their protectant ability against storage pests (Law-Ogbomo and Egharevba, 2006; Udo and Harry, 2013). Although, previous studies by Obeng-Ofori and Amiteye (2005), Babarinde *et al*. (2008) and Yaya *et al.* (2009) have highlighted the potentials of mixing synthetic pesticides with botanicals in management of postharvest insect infestation, this study is perhaps the first study on the potential of mixtures of DDVP and PKO for the protection of postharvest losses due to bruchid infestation in stored cowpea seeds. DDVP: PKO formulations were made in order to reduce DDVP cost, prevent residual effect of the synthetic pesticide and also establish the insecticidal properties of PKO against *C. maculatus.*

Objectives: The objectives of this study are to evaluate

- the effect of DDVP and PKO mixtures on reproductive parameters of *C. maculatus* and
- the potentials of the mixtures in reducing the seed damage due to insect infestation.

Methods:

***Callosobruchus maculatus* culture**

Callosobruchus maculatus was cultured on Oloyin cowpea local variety under ambient condition in the Crop and Environmental Protection Laboratory, Ladoke Akintola University of Technology (LAUTECH), Ogbomoso, Nigeria as described by Babarinde and Ewete (2008).

Procurement, formulations and application of DDVP-PKO mixtures

DDVP was obtained from Kaal Agrochemicals, Ogbomoso. PKO was obtained from Jagun Market, Ogbomoso. N-hexane (a product of BDH Chemicals) was obtained from CEP Laboratory, LAUTECH, Ogbomoso. The following formulations of DDVP-PKO mixtures (1:1. 1:2 and 1:4) were made. (i) 3 ml of DDVP and 3 ml of PKO were mixed to obtain ratio 1:1; which was ½ replacement of DDVP by PKO (ii) 2 ml of DDVP and 4 ml of PKO were mixed to obtain ratio 1:2; which was 2/3 replacement of DDVP by PKO (iii) 1 ml of DDVP and 4 ml of PKO were mixed to obtain ratio 1:4; which was 4/5 replacement of DDVP by PKO. Each formulation was added to 62.5 g cowpea seed in 150 ml capacity glass jars covered with netted lids to obtain 2.0 ml DDVP:PKO formulation per kg cowpea seed. A control of seed without DDVP-PKO formulation and a PKO seed treated (2.5 ml per 62.5 g cowpea seed to obtain 40 ml per kg cowpea seed) were included. Each formulation was dissolved in 6.5 ml n-hexane as a carrier. The experiment was set up in three replicates.

Entomological procedure

Five pairs (sex ratio 1:1) of teneral *C. maculatus* adult were introduced into each treatment. At 5 days after infestation (DAI), data were collected on the number of eggs laid and all insects, dead or alive were removed from the experimental set up. At 35 DAI, data were collected on the number of first filial progeny and reproductive efficiency (RE) and Percentage seed damage (PSD) were calculated as follow:

$$RE = \frac{\text{Number of emerged } F_1 \text{ adults}}{\text{Number of eggs laid}} \times 100$$

While

$$PSD = \frac{\text{Number of seeds with bruchid exit holes}}{\text{Total number of seeds per treatment}} \times 100$$

Experimental design and Statistical analysis: The experiment was laid out in completely randomized design. Percentage data were transformed to arcsine and count data transformed to square root after which they were subjected to analysis of variance (ANOVA), and where there was significant treatment effect, means were separated using Tukey's HSD at 5% probability level.

Results: The treatment significantly (F= 11.81, d f = 4, 14; p=0.001) affected oviposition of *C. maculatus.* The number of eggs (134) laid on untreated cowpea seeds was significantly higher than the number of eggs (36.00-86.67) laid on cowpea treated with other treatments. Also, the formulations affected F_1 progeny emergence (F=3.48, d f= 4, 14, p=0.050). Progeny emergence (1.67) observed in seed treated with ½ and 2/3 replacement of DDVP by PKO was significantly ($p<0.05$) lower than 21.33 observed in the untreated cowpea seed.

The different mixtures of DDVP-PKO significantly (F = 3.548, d f= 4, 14; p = 0.047) affected *C. maculatus* reproductive efficiency. The reproductive efficiency of *C. maculatus* in cowpea treated with ½ and 2/3 replacement of DDVP by PKO (0.83 and 0.97 respectively) was significantly ($p<0.05$) lower than 13.93 observed in the untreated cowpea seed. Percentage seed damage in all treatments (1.70-5.12%) was significantly (F = 4.84, d f = 4, 14, p = 0.020) lower than 11.01% seed damage observed in the untreated control.

Conclusion: From the result of this study, effective postharvest cowpea seed protection against the infestation of cowpea seed beetle can be achieved by reducing DDVP by 66.67% (2/3) and replacing it with PKO (v/v). This simple formulation will be easily adoptable by resource-poor farmers, since it involves no specialized technology.

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Abstract # ADMI044

Alternative Hermetic Storage Containers for Use by Smallholder Farmers

Thomas Brumm, Denis Bbosa, Carl J. Bern, Kurt A. Rosentrater, Rashid A. Suleiman

Iowa State University, Iowa USA

Corresponding Author: tbrumm@iastate.edu

Maize (*Zea mays*) and common beans (Phaseolus vulgaris L.) are important crops for many smallholder farmers in the world. Maize weevils (Sitophilus zeamais) cause a significant loss in quality and quantity during maize storage especially in tropical regions (Jacobs and Calvin, 2001; Longstaff, 1981, 1986). Similarly, the bean bruchid beetle (Acanthoscelides obtectus Say) causes similar damage to common beans in storage (Cardona, et al., 1989). Hermetic storage of maize and common beans has been shown to be effective in controlling maize weevils and bruchids in numerous studies (e.g., Gummert, et al., 2004). Many different container types can be used by smallholder farmers for hermetic storage with various advantages and disadvantages. Plastic bags and steel drums are used to effectively hermetically store cowpeas in West Africa (Baoua et al., 2013; Murdock and Baoua, 2014; Murdock et al., 2012). The bags are made in Africa, typically last two years and are not effective against rodents. Steel drums are rodent proof with long life, but costly. Moussa et al. (2011) estimated annual storage costs at 20 U.S. $/Mg for plastic bags and 16 U.S. $/Mg for steel drums. Hundreds of thousands of Postcosecha galvanized steel silos are in use around the world, particularly in Central America (Fischler, 2011). Local artisans fabricate the silos in sizes from 100 to 3000 kg of storage. The silos prevent depredation due to rodents and birds and can provide hermetic storage if properly sealed. Initial cost of the silo is high, but can be used for over 10 years. GrainPro (2015) markets membrane bags for hermetic storage of grain worldwide. Bags are available in numerous sizes and can be used to hermetically store many types of grain (Yakubu et al., 2011). This paper presents the results of two field- scale tests of recycled containers used edible oil containers and steel barrels. Recycled containers could be used in effective hermetic storage systems for smallholder farmers and also provide protection against rodent depredation. The objective of the first study was to determine the effectiveness of used edible oil containers to hermetically store maize and common beans. The study was conducted in the Kamuli District of Uganda. Heavily infested maize (90 live maize weevils per kg) and common beans (240 live bruchids per kg) were purchased in the local market and stored in 10-L used but cleaned edible oil containers under two conditions: (1) hermetically sealed; and (2) open to air infiltration but closed to insect migration in or out of the container. Each container (replicated in triplicate) held approximately 8 kg of maize or beans. The containers were stored at ambient conditions (approximately 23C) for four weeks. The weight, quality characteristics (moisture content, test weight, foreign material or broken corn and foreign material, and damage, following methods used for determination of U.S. grades), and degree of infestation (number of live and dead insects per kg) were determined before and after storage. Representative samples were created using a Boerner divider. Results were averaged across the treatment triplicates. After four weeks of storage, the number of live maize weevils nearly tripled (91 live weevils/kg to 257 live weevils/kg) in open containers hermetically sealed containers containing maize. The hermetically sealed containers resulted in 100% weevil mortality (zero live weevils/kg). Moisture content increased in both hermetic and open containers. Test weight did not change significantly for the hermetically stored maize but decreased in the open containers (53.8 lb/bu to 52.6 lb/bu). Broken corn and foreign material (BCFM) did not significantly change in the hermetically stored maize, but increased in the maize in the open containers (0.7% to 1.2%). The amount of damage did not

change significantly for hermetic or open containers â## the maize was already heavily damaged (~36%) at the beginning of the test. Used edible oil containers were effective in hermetically controlling maize weevils in stored maize. After four weeks of storage, the number of live bruchids decreased by 25% (241 live bruchids/kg to 181 live weevils/kg) in open containers containing common beans. The hermetically sealed containers resulted in 100% bruchid mortality (zero live bruchids/kg). Moisture content did not change significantly in either the hermetically sealed and open containers. Test weight decreased in both the hermetically stored beans (54.4 lb/bu to 52.8 lb/bu) and the open containers (54.4 lb/bu to 53.2 lb/bu). Foreign material (BCFM) did not significantly change in either the hermetically sealed or open containers. The amount of damage increased for both the hermetically sealed containers (41.2% to 43.3%) and open containers (41.2% to 47.5%). Used edible oil containers were effective in hermetically controlling bruchids in stored common beans. The objective of the second study (Bbosa, 2014) was determine the effectiveness of steel barrels as hermetic storage containers. Steel barrels could be used by smallholder farmers for hermetically storing larger amounts of maize as well as protecting against rodent and bird depredation. The study was conducted in Ames, Iowa USA. Six 208-L (55-gallon) steel barrels were each loaded with 170 kg (375 lb) of commercially comingled maize and seeded with an initial weevil populations of 25 live weevils/kg of maize. The barrels were placed in a room at 27C under non-hermetic conditions for about three weevil lifecycles. After 120 days, the weevil population increased to an average of 99 live weevils/kg. Three of the six barrels were then hermetically sealed for 21 days. Representative samples were obtained using a brass sampling probe before and after hermetic sealing. Samples were analyzed for broken corn and foreign material (BCFM), moisture content, test weight, and mechanical damage. Oxygen level inside the hermetically sealed barrels was measured using oxygen sensors mounted in the center of the sealable lids. After 21 days, the weevil population was zero live weevils/kg in the hermetically sealed barrels (100% mortality) and an average of 214 live weevils/kg in the non-hermetic barrels. Means of barrel oxygen content, ending number of live weevils per kg of maize, test weight (TW), moisture content (MC), temperature and humidity were significantly different between the hermetic and non-hermetic storage treatments. Broken corn and foreign material (BCFM) and mechanical damage (MD) were not significantly different among the treatments. As in other similar storage studies, some small amount of spoilage was seen in both treatments even though the initial moisture content was 13.4%, well below levels generally considered safe for maize storage. Hermetic storage can be used to control maize weevils in maize and bruchids in common beans. Used edible oil containers may be an effective hermetic alternative to bags and steel silos for smallholder farmers. Sealed steel barrels can be an effective hermetic maize storage option for smallholder farmers, particularly when rodent depredation is of concern.

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Abstract # ADMI045

Wheat supply chain optimization for post-harvest loss minimization

Yogendra Shastri[1], Arvind Jangid[1], Luis Rodriguez[2], Yanfeng Ouyang[3], Tao Lin[2], Wei-Ting Liao[2], Patricia Paulausky[2]

[1] Department of Chemical Engineering, Indian Institute of Technology, Bombay, India

[2] Department of Agricultural and Biological Engineering, University of Illinois at Urbana-Champaign, USA

[3] Department of Civil and Environmental Engineering, University of Illinois at Urbana-Champaign, USA

Corresponding Author: yshastri@iitb.ac.in

Introduction: Grains such as wheat, rice, and soybean suffer extensive losses along the post-harvest supply chain, especially in countries such as India and Brazil. Minimization of these losses is necessary yet challenging due to the highly complex nature of the supply chain. Several potential solutions such as better utilization of storage facilities, building additional/better storage and transport facilities, modification of the pricing structure, and better crop flow management have been proposed. However, determining the optimal combination of these strategies and interventions is critical. Equally important is to provide a generic decision making framework that can be used for different regions and crops.

Objectives and approach: The overarching objective of our work is to achieve this through the development of a supply chain optimization model. We have developed a large scale optimization model (Figure 1) for the post-harvest supply chain of wheat in India. India is one of the major wheat producing countries and suffers from extensive post-harvest losses. The model simulates the flow of wheat along the supply chain from the farmers to the consumers in a particular region such as a district or a state. The model considers three post harvest markets for wheat, namely, on-farm, village, and regional (Mandi). Most of the wheat produced is currently sold at the regional markets, where private traders and government agencies such as Food Corporation of India (FCI) are the primary purchasers. This property is captured in the model. The storage of the wheat at government as well as private and cooperative godowns is modelled. Two different storage modes, namely, covered and CAP (Cap and Plinth) are modelled. The relative availability of each of the storage modes can be specified or optimized for a new storage facility. Finally, periodic removal of wheat from these storage facilities to meet the retail and Targeted Public Distribution Systems (a government operated subsidized supply scheme) demand is modelled. The possibility of milling wheat before the retail sale is also modelled. The loss of wheat along the supply chain as a function of storage, transport, and handling mode is calculated. At each stage, the market size and storage capacity constraints are enforced. The transportation of wheat along these different links is also modelled. This includes small distance transport using bullock carts as well as relatively long distance transport using trucks and tractors.

The decision variables include the management decisions such as the quantity and schedule of wheat flow between different locations. The decision variables also include design decisions such as the location of a storage facility or a regional market that can be used to provide recommendation for infrastructure development. Thus, the model integrates design and management decision making in a single framework. The objective function is minimization of the total cost and post-harvest losses. The cost includes the operating cost of the supply chain as well as the capital cost associated with any infrastructure developed as part of the design. The model simulation horizon is one year and the capital costs are annualized. The post-harvest loss factor can also be used as a constraint to model the maximum loss permitted along the supply chain. This allows the model to study the impact of tighter bounds on the loss on the design and management of the supply chain.

One of the key reasons identified for extensive losses in wheat in India is the presence of smallholder farmers. These farmers, due to lack of storage facilities, want to sell wheat as soon as it is harvested. This leads to market glut during the harvesting season. Therefore, the model simulates the details of wheat flow from individual farms, including smallholders, during the harvesting season. The main advantage of this feature is that the model can recommend optimal strategies as a function of the farm size, which is often correlated with the economic capacity of the farmer. Such level of detail in the simulation enables the model to provide unique insights.

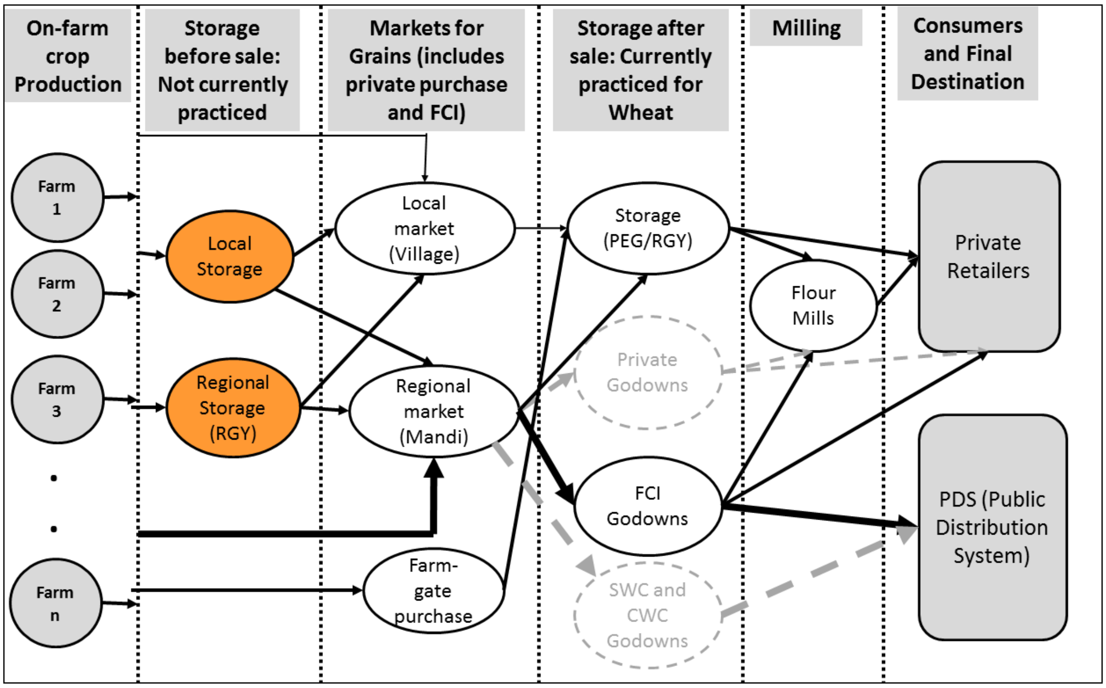

Fig 1. Scope and important components of the supply chain optimization model for wheat in India

Results: The model has been applied to solve a case study for wheat production in Madhya Pradesh, a major wheat producing state in India. Extensive data search has been conducted to parameterize the model. This included data pertaining to the number of farmers, farm sizes, yields, existing Mandi locations, existing FCI godown locations, and FCI godown capacities. The data search has enabled us to simulate the model at the district level, including for a collection of several districts together.

Preliminary results indicated that additional storage locations to regulate the market arrivals led to better supply chain efficiency. Moreover, reducing an upper bound on the acceptable loss along the supply chain modified the supply chain design. For existing infrastructure and facilities, the model recommends the optimal operational strategy, including optimal Mandi arrivals as well as storage management. Additionally, the model also recommends optimal modifications to the supply chain by identifying the new storage facilities, storage methods, and transportation links. Moreover, the sensitive parameters in the model will be determined to identify critical data/measurement needs.

Conclusions: The simulation results have illustrated that the model provides valuable inputs on reducing postharvest losses at reduced overall cost by identifying the optimal interventions.

Abstract # ADMI046

Low Cost Postharvest Storage Technology For Smallholder Fruits and Vegetable Farmers in Southwestern, Nigeria

Olubukola Odeyemi1, J.G. Bodunde1, and O.T. Onifade2

[1]Department of Horticulture, Federal University of Agriculture, Abeokuta, Nigeria, [2]Agricultural Media Resources and Extension Centre (AMREC), Federal University of Agriculture, Abeokuta, Nigeria.

Corresponding Author: bukie09@yahoo.com

Introduction: Fruits and vegetables not only provide human beings with nutritional and healthy foods, but also generate a considerable cash income for growers in many countries (Liu, 1999). The agricultural sector in Nigeria contributes 32.92% of Gross Domestic Product while the crop production index is 99.93 as at 2011 (FAO Statistical Yearbook, 2013). Most of those who work in the agricultural sector are smallholder farmers (SHFs) who produce about 80% of the total food consumed and are mostly women, about 60-80% (Eric *et al,* 2004). They produce relatively small volumes of produce on relatively small plots of land. However, these SHFs experience considerable losses on fruits and vegetables cultivated right from the field but the greatest loss occur during the postharvest handling of these produce especially during storage. They are faced with the challenge of how best to store their produce so that it does not need to be sold immediately and how best to maintain the quality and safety as it moves from the field to the final consumer (Odeyemi *et al*, 2012). Roughly one-third of the edible parts of food produced for human consumption, gets lost or wasted globally, which is about 1.3 billion ton per year (FAO 2011). Losses can also show up as decreased nutritional quality (loss of vitamins, development of health dangers such as myco-toxins) or decreased market value (Kitinoja and AlHassan, 2012). More so, these losses have a devastating impact on food security, quality and safety for poor people and on the environment (FAO 2011). It also depresses incomes along agricultural value chains, and can have particularly devastating impact on SHFs. However, overcoming the socioeconomic constraint of inadequate infrastructure is essential to achieving the goal of reducing postharvest losses (Kader 2005).

Objectives: In view of all these challenges associated with the postharvest loss of fruits and vegetables by SHFs, this study was carried to identify primary low cost storage technology available for fruits and vegetable farmers in Southwestern Nigeria, to determine the rate of adoption this technology and the challenges associated with identified storage technology.

Methods: The study was carried out in two phases. The first phase involved conducting a face to face interview with officers-in-charge of information dissemination at three important research institutes in Southwestern Nigeria namely Nigerian Stored Products Research Institute (NSPRI), National Horticultural Research Institute (NIHORT) both in Ibadan, Oyo State and Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State. These research institutes assist farmers with training, adaptation of improved technology and provide other extension services that are of relevance to them. The purpose of the interview was to assess local storage structure/technologies that have been developed for storing fruits and vegetables for primary storage. The second phase of the study involved random selection of 120 SHFs from the four geopolitical zones in Ogun State namely Abeokuta, Remo, Ijebu-Ode and Yewa zones. The respondents were interviewed using a well structured questionnaire, field notes and observations were used to collect information. Contact was made with the SHFs through the assistance of agricultural extension officers in each zone. Data collected were analysed using frequencies, percentages and rankings.

Results: Results showed that the low cost storage technology identified by the three institutes for fruits and vegetable in primary storage in Southwestern, Nigeria is the Evaporative Cooling Structure (ECS). This is a locally fabricated low temperature storage structure characterised by low temperature in its inner chamber and ease of use. It is made by placing a wall inside another wall and the space in between them is filled with river bed sand and constantly kept wet. It relies on the principle of evaporation and does not depend on electricity which makes it very suitable for rural dwellers in developing countries. As water evaporates it draws energy from its surroundings which produce a considerable cooling effect (Practical Action, 2012). The lid is made up of ply wood lined with jute sack. The ECS is a low cost technology that has been recommended to SHFs by these institutes with various designs which include pot-in-pot, pan-in pot, block-in-block and brick-in-brick. The estimated cost per unit of a standard brick-in-brick ECS design with inner dimension of 250cm x 100cm x 72cm cost is $327 (₦65,400).

The demographic characteristics of the SHFs shows thar 62% were male while the remaining 38% were female both with average age of 38 years. The average age of the respondents shows that most of them are in their active and productive ages. The result also showed that 79% of the fruit and vegetable farmers farmed less than one hectare of land. This could be as a result of traditional land tenure systems and fragmentation of farm land due to inheritance from family while the remaining 21% farmed more than one hectare which was mostly land leased by the State Government and were basically engaged in fruit production. The major fruits cultivated were mango, pineapple, orange, guava, avocado, banana, plantain while vegetables included tomato, celosia, amaranthus, telfaria, pepper and jute mallow. Farmers were asked for the storage methods/technology adopted for fruits and vegetable after harvest. Their response and direct observation suggested that after harvesting in the study area, there was no use of special storage technologies or facilities. However, the farmers adopt the following methods of selling their produce which include (i) selling produce before harvesting majorly fruits at maturity on the tree (ii) produce are harvested by farmers and sold to market women (middlemen) (iii) produce are sold by farmers on market days to consumers and middlemen (iv) excess produce are left in the open shelf either for sale or family consumption. Also, farmers identified some local methods of preventing the fruits from drying out, on the field such as keeping under shade, wetting and soaking of produce in water. On the level of awareness of the ECS by SHFs, results shows that 88% were not aware of this technology while adoption was low among the informed 12%. Reasons for low adoption by SHFs include low volume of the ECS (24%), no adequate information on utilization from research institutes (32%), lack of trust in the efficiency of the ECS (23%), expectation from the government (9%), risk from theft of produce (8%), cost of construction/maintenance (4%).

Conclusion: In conclusion, Evaporative Cooling Structure is a low cost technology for primary storage of fruits and vegetables available for SHFs in Southwestern, Nigeria. Farmers adoption of this technology is low due to a huge information gap between the farmers and the research institutes involved in the disseminating of information on the use of the technology. Better adoption of this technology by SHFs requires effective communication and building trust of the farmers in this technology coupled with adequate follow up action by these research institutes. This will help to reduce postharvest losess on fruits and vegetables and also increase the incomes of SHFs.

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Abstract # ADMI047

Assessment of Different storage methods in extending shelf life of Uapaca kirkiana (Muell. Arg.) Fruits

Jacinta A. Nyaika

Lilongwe University of Agriculture and Natural Resources-Bunda Compass, Lilongwe, Malawi

Corresponding Author: Jnyaika@gmail.com

Uapaca kirkiana (Muell. Arg.), a highly valued wild indigenous fruit tree species in parts of Southern Africa, has been under domestication program for the past decade. The uapaca fruits are a source of income to rural households and a good nutrition and food source. They also bridge up hunger months in Malawi. Uapaca fruits are gathered from the ground when ripe, plucked or shaken off from the branches when unripe. The fruit are widely marketed mostly in informal markets; household consumption and marketing are limited by a short shelf life of about 3 days for ripe fruit. To overcome this problem an evaluation of the influence of storing uapaca fruits at different physiological stages in various storage methods was done. This study was done at Lilongwe University of Agriculture and Natural Resources-Bunda Compass, in the Forestry and Horticulture Laboratory from November to December, 2014. Fruits segregated physiologically as ripe, partially ripe and unripe were stored in the refrigerator (5^0C), woven baskets (covered by a cotton cloth), polyethylene sack and Zeer pots. Data was collected on the temperature for each storage method for the period of the study, sugar content on the day of setting the experiment and on a fortnight interval for six weeks, number of days taken for 50% and 90% of the fruits to rot and or develop moulds, weight loss and colour change. Data was the analysed using genstat statistical package.

Results showed that the temperature for the different storage methods remained constant for the period of the study, and the coldest temperature were for the refrigerator, 5^0C, seconded by Zeer pots (10^0C), woven baskets (23^0C) and Polythelene sacks (28^0C). the study also found out that there were significant differences for the treatments in terms of weight loss for the different storage methods used. Uapaca fruits that were ripe and stored in the refrigerator and zeer pot lost weight of 0.3g per 1000Kg of the fruits fortnightly for the duration of the study whilst the unripe and partially ripe fruits kept in the same storage methods did not lose much weight (0.1g/Kg). Uapaca fruits in the woven baskets had highest sugar content at every physiological stage of the fruits. Ripe fruits stored in the woven baskets had accumulated a sugar content of 28µg/100g of the fruits, followed by 23µg/100g for the partially ripe fruits and 12µg/100g for the unripe fruits. Fruits that were stored in the Zeer pots accumulated 26µg/100g for the ripe, 20µg/100g for the partially ripe and 09µg/100g for the unripe fruits and ripe fruits in the refrigerator accumulated 05µg/100g for the unripe fruits, 07µg/100g for the partially ripe and 12.6µg/100g the ripe fruits. 50% off the fruits in the woven basket had gone bad by then of 4days, and 7days 90% had gone bad for the ripe fruits whilst the unripe took 8 days for 50% of the fruits to go bad, and 11 days for 90% of the fruits to go bad. Unripe fruits stored in the Zeer pot took 14 days for 50% of them to go bad, 17days for 90% of the fruits to go bad. The ripe fruits in 0the Zeer pot took 10 days to go bad at 50% of the sample and 12 days for 90% of the sample to go bad. Unripe fruits in the refrigerator took 11 days for 50% of the sample to go bad, and 15days for 90% of the sample to go bad.

The study has demonstrated the potential for an alternative low temperature storage using the evaporative cooling of the zeer pot which is cost effective than refrigeration to lengthen storage shelf life of fresh U. kirkiana fruit, but the possible menace of using this method at a large scale and different areas needs to be evaluated.

Abstract # ADMI048

Effects of force on the development of dry bruise on strawberry fruit

Louise Abayomi, Stavrod Pyrotis, Debbie Rees , John Orchard

University of Greenwich, Chatham Maritime, Chatham, Kent, UK

Corresponding Author: l.abayomi@gre.ac.uk

Introduction: The UK demand for strawberries has expanded during the last decade and it is getting increasingly important for growers and importers to meet consumers quality requirements (FAO, 2014). Bruising of strawberry fruit is a defect undesired by marketers and consumers alike, who often reject fruit where elevated levels are apparent on the fruit surface. Furthermore, bruised areas make the fruit more susceptible to pathogen entry, and thus results in waste. Strawberry is a high value, perishable horticultural product. The combination of short shelf life as well as high production and transportation cost underlines the significance of minimizing postharvest losses. Generally, the amount of energy applied to strawberries is a good predictor of bruising (Holt & Schoorl 1982), with several types of forces resulting in bruised fruit (Ferreira et al. 2008). However, further understanding of the mechanism of dry bruise development on strawberries has to offer important information for growers, breeders and retailers, particularly as climatic conditions during seasons is becoming less predictable, necessitating a rethink in traditional produce handling and marketing strategies.

Objectives: The hypothesis that softer strawberry fruits are more susceptible to development of bruising when subjected to compression was tested. The study also examined the possible relationship between increased temperature, lower fruit firmness and increased incidence of dry bruise.

Methods: Planting locations and fruit source - Candonga strawberries were grown at two commercial farms (SP1 and SP2) in Huelva, Spain. Fruits were picked at regular intervals during the harvest period. Fruits were placed in a cold store at the farms and subsequently transported at 4'C by road to a packhouse based in Kent, UK. Fruits were sampled at the Kent packhouse then transferred to the Natural Resources Institute, UK (NRI) for further analyses. Force application - Strawberry fruits were compressed using TA-XT plus (stablemicrosystem Ltd, UK) Texture analyser. A cylinder of 50mm diameter was adopted, with a constant compression of 10 Newtons over 10 sec. Dry bruise evaluation - Fruits imposed to artificial bruise were stored at 4'C for 48h. Afterwards the maximum depth (mm), width and length (cm) of dry bruise of the area was recorded using a ruler. Dry bruise that had developed at other areas of the fruit was not recorded.

Results: Increased dry bruised area of fruits was observed when higher temperatures prior harvest took place during the growth period. Growth temperature 2 days, 7 days, 14 days and 21 days prior harvesting were recorded. The strongest correlations were observed between firmness and temperature 14 days prior to harvesting. Therefore the relationships between firmness, temperature and dry bruised area of fruits were based on average temperatures during this period. At the SP1 site, the highest dry bruised area of strawberry fruits was noticed during the second half of the period when increased mean temperatures (above 17'C) were observed. For both commercial farms, however, the depth of dry bruising varied throughout season and no clear trend was noticed. Further, at both sites there was a negative relationship between firmness and dry bruised areas.

Conclusion: Though the time of harvesting and/or delay in postharvest cooling (Nunes et al. 1995) are known to have negative effects on the quality of strawberries, the amount of energy and type of force also plays a significant role in the development of dry bruise. Generally fruits had increased dry bruised

area when subjected to an additional force imposed by the texture analyser as the season progressed, with increased temperatures leading to decreased levels of firmness. Decreased firmness of strawberry fruits was related to increased temperature levels before harvest. Firmness varied over the harvest season and the amount of dry bruised fruits increased as temperatures reached at higher levels from winter to summer. Growers may want to observe climate conditions two weeks prior to harvesting in order to aid decision making in ensuring batches of fruit reach the consumer with optimum quality, and minimise the potential for waste.

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Abstract # ADMI049

Simulated Ghost Fishing Experiment of Collapsible Crab Trap Fishery in Thailand: Impact and Reduction

Anukorn Boutson[1], Santiphong Putsa[1], Suriyan Tunkijjanukij[1] and Takafumi Arimoto[2]

[1]Kasetsart University

[2]Fish Behavior Section, Tokyo University of Marine Science and Technology

Corresponding Author: ffisakb@ku.ac.th

Ghost fishing is the term used for lost or abandoned fishing gear that continues to catch fish without human control and induce mortality of aquatic animals. It is environmentally detrimental and the fish caught are wasted. The ghost fishing mortality rate is currently an intangible and remains of significant concern to both fishers and fisheries managers.

Collapsible traps targeting blue swimming crab, Portunus pelagicus have recently becomes a major type of fishing gear, and have operated for over a year in the Gulf of Thailand. Small scale fishers operate their traps inshore with the numbers of 200-300 traps/boat, while commercial scale fishers operate further offshore with the numbers of 2,000-5,000 traps onboard. Both fishing types have the possibility to lose their traps at sea. According to the fisher interview, inshore fishing may lose 2-20 traps/fishers/day, mainly as a result of float line either cut or sinking due to entanglement with other trap owners or other gears, particularly crab bottom gillnets and some trawlers that conduct inshore (illegally), while offshore grounds lose traps as a result of trawler's activity. The ghost fishing effects on the blue swimming crab and other animals from the trap fishing in Thailand have been very poorly evaluated and reported.

This study was undertaken to investigate the impacts of ghost fishing, quantify the catch rate, estimate mortality of aquatic organisms, and describe changes in the catch rate over a year in a small scale fishing ground (inshore) in Si Racha Bay, the upper Gulf of Thailand. Reducing the negative impacts of ghost fishing by installation of escape vents to the trap was tested. The impacts were examined by simulated lost-gear experiments to compare between conventional and vented traps, with about one year scuba-diving monitoring from 6 Jan 2013 to 15 Jan 2014, at a depth of 4-6 meters. Twelve pairs of box-shaped traps, 36x54x19 centimeters in size, were compared between the conventional and vented trap with escape vents 35 x 45 millimeter in size. Observations on each trap type were conducted by diving in the day time to monitor the situation after initial deployment every day for the first two weeks, then continuously every two to three days or three to four days for three months, and about once a month afterward up to 374 days. In each dive, we tried to minimize interference in order to maintain the condition of ghost fishing as autonomous in environment. In each trap we recorded the baited and trapped conditions and the number of newly entrapped, escaped, or dead animals. We also observed their behavior and condition with underwater video recording.

In our underwater observations, we found the fish bait that was placed within traps was either consumed or decomposed completely within three days in vented traps and four days in conventional traps. Throughout the 374 days of this experiment, the numbers of aquatic animals trapped in the conventional trap was significantly higher than vented traps as shown in Table 1. In conventional traps, 520 individuals from 25 different species were entrapped. Rabbit fish (n=98), toad fish (n=71) and catfish (n=45) were dominant economic catch species (71.4%), while 149 individuals (28.6%) were considered as non-commercial value species, of which the sea urchin (n=105) and butterfly fish (n=23) were

dominant. For the vented traps, there were 222 animals from 24 different species entrapped, of which 144 individuals were classified as commercial catch (64.9%). The dominant of those economic species were toad fish (n=41), rabbit fish (n=19) and blue swimming crab (target species) (n=17). There were 78 animals considered as non-commercial catch (35.1%), such as the sea urchin (n=55) and butterfly fish (n=11). We assumed an individual crab and fish had escaped if there was no carapace or skin and skeleton found. In total number entrapping, escapement was high from both conventional and vented traps types as 368 (70.8%) and 185 (83.3%) individuals respectively. However, mostly the commercial species such as spiny rock crab, mangrove stone crab, rabbit fish and toad fish escaped from the vented traps at a higher rate than conventional traps (Table 1). The CPUE of all entrapped animals in conventional traps was significantly higher than vented traps at each time of observation. Besides, the vented traps showed a lower entrapment and mortality number than conventional traps. These demonstrate the positive functions of escape vents in reducing the negative impacts of ghost fishing, not only in the number of entrapped but also in the mortality rate.

This study used simulated trap experiments to evaluate the ghost fishing impacts between conventional and vented traps. The traps can continue ghost fishing for more than one year. The results showed reduction of negative impacts on target species (blue swimming crab) by escape vents traps. In addition, vented traps can also reduce the entrapment of marketable and non-marketable value species that relate to loss and discards problem issues. This an effective way to minimize the mortality rate of smaller individuals of the target species and in particularly for by-catch. There are three more prioritized countermeasures against ghost fishing; prevention of fishing gear loss, retrieval of lost gear, and development of designed degradation of fishing gear. Future studies should be carried out to investigate the number of ghost fishing traps in Si Racha Bay by evaluating the number of fishers, the number of trap operations, the trap loss rate etc. Eventually, studies could calculate the potential economic loss of fishers and the negative impacts to the fishing sector from the fishing gear loss.

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Abstract # ADMI050

Expanding Food Processing Capacity as a Tool for Ensuring Food Security and Safety

Mammie Hutchful[1], Esther Sakyi-Dawson[2], Sammy T. Sackey[1]

[1]Institute of Applied Science and Technology, University of Ghana, Legon

[2]Department of Nutrition and Food Science, University of Ghana, Legon

Corresponding Author: sams@ug.edu.gh

Ghana is characterized by the dependence of a large proportion of the employed population on agriculture as a source of livelihood [1]. That the country has not met its goal to reduce or eliminate severe poverty and hunger as set in the Millennium Development Goals (MDG) clearly shows the failure of agriculture as an industry. The main factors contributing to this situation include low agricultural productivity which cannot support industrialization, infrastructural constraints, limited support for food crop farmers, and high postharvest losses. The existing food processing sector is underdeveloped, lacks quality control and product benchmarks. There is therefore a need to expand food processing capacity to justify expanding agricultural productivity and enhance food and nutrition security.

Currently, less than 15% [2] of the Ghanaian workforce are employed in the industrial sector with only a small proportion engaged in agro processing and the majority in mining, quarrying and manufacturing. The agro-processing industry is dominated by cocoa and oil palm with minimal industrial scale processing of staple crops such as, maize, yam, cassava, plantain, cocoyam, etc. The development of a robust agro-industry sector targeting the major staple crops and other natural products would ensure food security, safety and nutrition and create the types of jobs that most people who leave school seek. Processing would also reduce “waste” which according to the estimation of city authorities constitutes 60% of urban waste stream destined for landfills and responsible for major sanitation and drainage problems. What is considered “waste” if concentrated in an industrial facility can be transformed into animal feed, bio fuel etc.

The University of Ghana’s Institute of Applied Science and Technology (IAST) was established to advance the development of Ghanaian industry through the conduct of industry led research and serve as a vehicle for the transfer of knowledge, technology and innovation from the University to industry. The key priority area is the processing and packaging of indigenous foods. The different staple crops are distributed all over the five main agro-ecological zones defined on the basis of climate, reflected by the natural vegetation and influenced by the soils in the ten political regions of Ghana. Typically processing capacity has been limited to the urban areas. However, due to the perishable nature of most of these crops and poorly developed rural road networks, significant losses occur during transportation.

The IAST proposed solution is the establishment of small to medium scale processing plants in the rural communities where crop production is high. This is achievable since Ghana has high electricity coverage of about 72% [3] out of which 60% represents the rural areas.

As part of this proposal IAST seeks to establish a food processing and packaging incubator and an enterprise development and technology transfer centre. This incubator would address the key problems within the agricultural value chain through training, skills development and transfer of knowledge, technology and innovation. The target groups are micro, small and medium scale enterprises in food processing and packaging, as well as students of tertiary institutions who should be the next generation of food processing and packaging entrepreneurs. The processing and packaging of agricultural produce

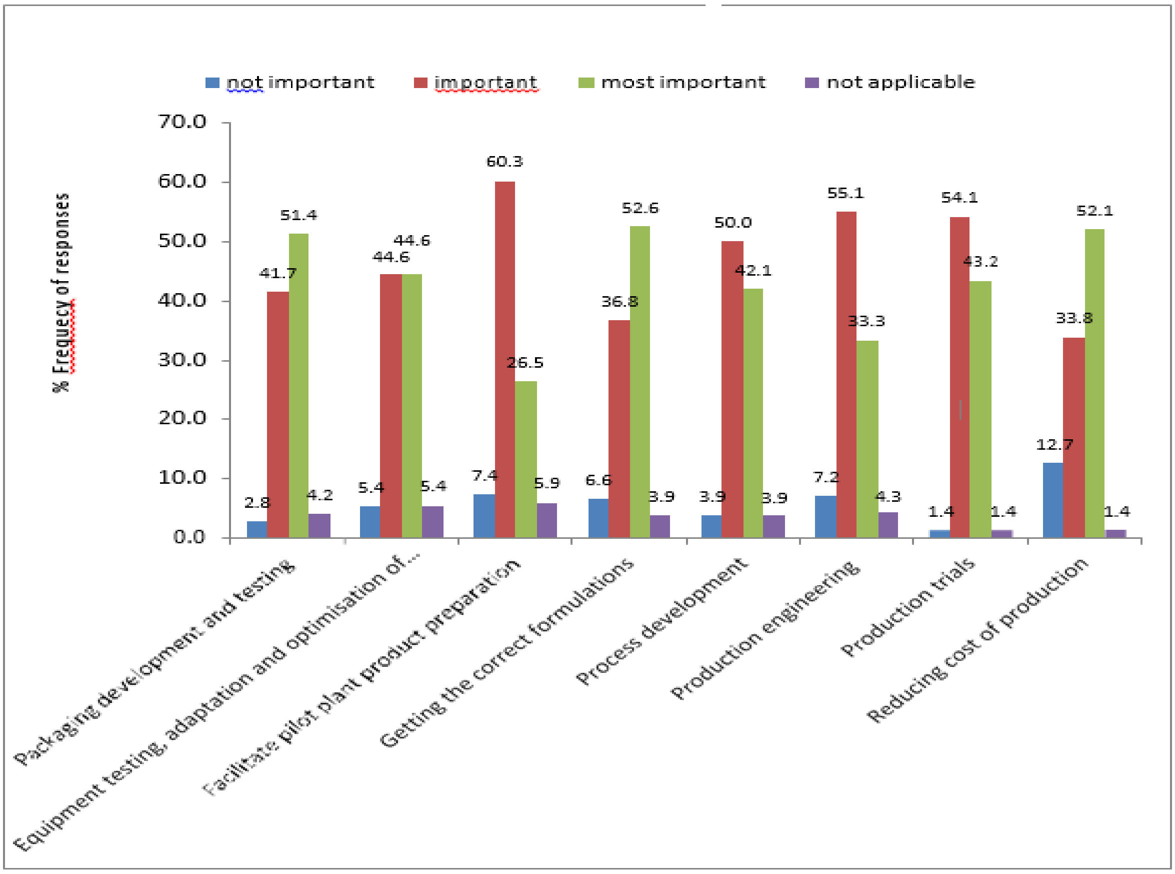
would also provide an opportunity for rural development, stem the tide of rural urban drift and reduce the levels of biological waste in urban areas.

The focus of such industrial activity is to preserve and/or process roots and tubers, grains and cereals and fruits and vegetables within the production catchment area. This will contribute to the enhancement of agricultural productivity, provide a stable market for farmers and reduce postharvest losses in Ghana.

The University of Ghana has the requisite expertise for running the incubation facility: School of Agriculture, Department of Nutrition and Food Science, Food Process Engineering, Agricultural Engineering, Material Science Engineering, Department of Biochemistry, West African Centre for Crop Improvement and a vibrant Business School. The Institute has also developed very good working relationships with current food processing and packaging industries as well as national bodies that govern these industries including the Association of Ghana Industries and the National Board for Small Scale Industries which also serve on its advisory board.

Three needs assessments fora have been organized between 2013 to 2015, with industry players from the food processing and packaging sector; roots and tubers production and processing sector and the fruits and vegetables sub sectors.

Based on these interactions, the need for skills development in production engineering and processing and pilot plant facilities for product trials and packaging were articulated (Fig. 1).



Source: Institute of Applied Science and Technology and Department of Nutrition and Food Science, University of Ghana

Fig. 1 Processing and packaging issues

In all the interactions with industry, particularly at the roots and tubers forum focused on cassava and the vegetable needs assessments forum, issues on post-harvest losses dominated the discussions. Farmers were identified as the worst affected by post-harvest losses. It stands to reason therefore that reducing post-harvest loss and adding value through processing would lead to wealth creation for farm families.

Resources

1. 44.7%. Source: GSS, Ghana Living Standard Survey, Sixth Round, (GLSS6), with Labour Force Module, August 2014
2. Source: GSS, Ghana Living Standard Survey, Sixth Round, (GLSS6), with Labour Force Module, August 2014
3. Energy (Supply and Demand) Outlook for Ghana, 2013

Abstract # ADMI051

Molecular Camouflage: Natural Barrier Coatings to Increase the Marketable Shelf Life of Fresh Produce Without Refrigeration

James Rogers

Apeel Sciences, Santa Barbara, California, USA

Corresponding Author: james@apeelsciences.com

Apeel Sciences has developed a low-cost method to extract organic molecules from agricultural byproducts and turn them into a water-based formulation that can be dip-coated onto the surface of fresh produce, forming a thin, organic, edible, natural barrier coating that reduces water loss and oxidation, slows cellular respiration, and camouflages crops from biotic stressors. The purpose of Apeel's work with the Bill and Melinda Gates Foundation (BMGF) and the UK's Department for International Development (DFID) is to transfer the benefits of this technology to smallholder farmers in sub-Saharan Africa (SSA) via the development of low cost, highly distributable, easy-to-use packets of an optimized formula for cassava that can be mixed with water and dip-coated onto the highly perishable roots immediately after harvest.

In the intervention strategy for postharvest loss mitigation outlined below, an innovative alternative to incumbent wax-based coatings used in the developed world will be tested and optimized for its ability to extend the marketable period of cassava in SSA. Our existing edible coating (Edipeel™ v1.0) will initially be tested on fresh unprocessed cassava to establish the coating's ability to extend marketable shelf life. Thereafter, product optimization will proceed through an iterative design-engineering-feedback-analysis cycle coordinated between Apeel Sciences and the University of Nairobi, Kenya. This iterative process will be used to optimize the formulation for use by smallholder farmers under typical field conditions. The suitably-optimized coating will then be evaluated under different storage conditions to establish optimal application procedures and to quantify improvements in marketable shelf life. During the process, we will encourage researchers to experiment with additional uses, such as application to bananas, tomatoes, avocados, and mangos.

Root crops such as cassava have gained importance in SSA as alternatives to common staples due to their ability to grow in impoverished soils with low external inputs and because they can be "stored" in the ground. They are an alternative source of carbohydrates for the millions who depend on conventional staples such as maize and rice. Cassava has also become popular among urban dwellers as a healthy alternative to processed foods such as cereals. However, the marginal growing environments in which these roots are cultivated are frequently characterized by large distances to processing centers and a deficiency in transport infrastructure such as roads. To complicate matters further, cassava roots have a very short shelf life due to postharvest physiological deterioration (PPD), which rapidly renders the roots unpalatable and thus unmarketable within 24-72 hours of harvest. Consequently, cassava roots must be consumed, or processed, soon after harvesting. The short shelf life of the roots severely limits marketing options due to high postharvest losses, which increases overall marketing costs and restricts access to distant markets and processing facilities.

Apeel's strategy to develop packets of water-soluble edible coatings circumvents the need to invest in the development of infrastructure and the establishment of a cold chain in much the same way that the development of cellular phones circumvented the need to install "landlines" across vast expanses of the developing world. However, much like establishing cellular phone coverage required the installation of cellular antennas, the successful adoption of Apeel's technology will require the "installation" of

training programs for smallholder farmers. These programs must be designed to be mindful of the fact that many farmers cannot read and that even those who can often need proof of product efficacy in addition to product use training. Thus, during the field-testing phase of this intervention, we will work with smallholder farmers and extension workers to develop an effective smallholder training program. Once we have identified a successful pilot program, we will implement that program by training extension workers, commercial partners, and NGOs to demonstrate the efficacy of the product to smallholder farmers and instruct them as to how to use the product effectively. Additionally, printed pictographic instructions on the product packaging will reinforce formal product training programs. By using our coating technology to protect their produce, it is believed that smallholder farmers will be able to reduce the perishability of their produce to the extent that they gain leverage in negotiations with buyers and are able to earn a higher price for their labor. Ultimately, we believe that this intervention will increase the access of smallholder farmers and traders to lucrative urban markets, where demand for fresh high quality produce is on the rise.

Although the optimization of our products for smallholder farmers is critically important to the success of this intervention strategy, for our products to have a sustainable impact, their value will need to be demonstrated commercially in SSA. In order to pave the way for commercialization, Apeel has partnered with two large cassava processors in Nigeria (Allied Atlantic Distilleries Ltd and Thai Farm International) to evaluate the economic potential of the products in SSA. Both processors purchase large quantities of cassava from local contract growers (including smallholders) and process the cassava into value added products. Apeel will work with these processors because each of them have indicated that they offer significantly lower pricing to rural smallholder farmers whose cassava is of poor quality due to transportation delays to their cassava processing facilities. Since the distribution and use of our products would allow these processors to receive higher quality cassava from a much broader geographic region, these processors have an economic incentive to assist in the product development process, which would include their willingness to support some level of extension training to educate their growers as to how to effectively use the product. Thus, this economic incentive should rapidly increase the pace with which we are able to realize the objectives outlined in this intervention strategy.

The Goal: Develop an economic system in which uneaten agricultural products are recycled to produce a natural preservative that may be used to reduce postharvest losses for smallholder farmers.

Abstract # ADMI052

Paddy Drying Technologies for Small Farmers and Traders in Bangladesh

Chayan Kumer Saha[1,*], Ashraful Alam[1, 2], Md. Abdul Momin[1], Md. Monjurul Alam[1]

[1]Department of Farm Power and Machinery, Bangladesh Agricultural University (BAU), Mymensingh-2202, Bangladesh

[2]Bangladesh Rice Research Institute (BRRI), Gazipur, Dhaka, Bangladesh

Corresponding Author: csaha@bau.edu.bd

Background: Drying of paddy is an important post harvest operation which permits production of quality seed, long term storage, keeps better quality, permits the continuous supply of the product throughout the year and takes advantage of higher price after harvesting season. Improper or delayed drying leads to loss in grain quality, in addition to the estimated 14% loss from cutting through storage (Bala et al., 2010). Sun drying is the most common process in Bangladesh for reducing paddy moisture content due to its low cost. Grain usually is spread on the ground in the sun; the process is labor intensive and poor in controlling grain temperature. The value of forced solar drying over passive solar drying remains a matter of debate (Mohsin et al., 2011).

To reduce post-harvest losses and increasing quality of storage paddy, it is necessary to adapt drying technologies for paddy at small scale traders and farmers' level. The drying team identified a low cost dryer (STR) design (Phan, 2003) and a Hohenheim solar bubble dryer (SBD) that may have potential application in Bangladesh. STR uses heat which generates through burning rice husk briquette and an axial fan blows hot air through the grain bin. On the other hand, SBD uses sunlight to trap heat inside the dryer, and solar panel operates two fans blow the hot air though drying section. The STR and SBD have capacity of drying grain up to half and one ton, respectively.

Objectives: The overall goal of this research is to adapt and disseminate STR Dryer and Solar Bubble Dryer (SBD) for paddy at small scale traders and farmers' level. The specific objectives of the research are to study spatial distribution of air temperature in and outside of STR and SBD dryers, and also to investigate the technical performance of STR and SBD dryers.

Methods: STR and SBD dryers were installed at the workshop of the Department of Farm Power and Machinery, Bangladesh Agricultural University, Mymensingh, Bangladesh. The drying team conducted technical studies of the STR and SBD dryers on Boro paddy during April 30-May 5 and May 27-June 5, respectively. Spatial distribution of temperature in the dryers was evaluated with nine k type thermocouple sensors in vertical and horizontal locations in the STR dryer, and with 14 k type thermocouple sensors both inside and outside of the SBD. Moisture content of the grain was measured at three locations in the STR dryer and 12 locations in the SBD. For the STR dryer, there were three treatments (sample sizes of 300, 400 and 450 kg of grain) and three replications; the maximum capacity of the STR dryer as currently designed is 500 kg of grain. Only three trials were conducted with the SBD due to time limitations resulting from late arrival of the equipment. Drying rate, drying capacity and efficiency for both dryers were calculated.

Results: Spatial distribution of hot air through the grain was uniform in STR dryer. Four hundred and fifty kg of grain could be dried uniformly to 10.7% from 21.6% in less than four hours (Table 1). The study suggested using STR dryer for maximum of its size (half ton) for higher drying efficiency. Controlling the heat source of this dryer is an important variable and operator's experience and training

are needed to keep the temperature uniform across the entire drying period. STR dryer also requires a steady supply of electricity for blower operation.

Table 1. Performance of STR dryer in the 2015 Boro season

Treatment	Initial moisture content (%)	Final moisture content (%)	Total energy input (MJ)	Drying time (hr)	Drying rate (kg/hr)	Drying capacity (kg/hr)	Drying efficiency (%)
S300	23.9	10.4	193	4.0	11.3	75.0	57.6
S400	22.9	10.6	198	4.5	12.2	88.8	67.9
S450	21.6	10.7	184	3.7	15.0	121.6	73.1

Temperature throughout the SBD was uniform and heavily dependent on the amount of solar radiation/sunlight available. The proposed rake stirring mechanism in SBD was not effective and moisture condensation occurred on the bottom portion of the grain layer. Drying time was 2-3 days and the grain moisture content was not always reduced to less than 12%. More trials of this dryer are needed to determine whether the relatively poor performance observed this year is a function of the sub-optimal weather conditions under which the experiments were conducted. Finding a place for this dryer on farm will be difficult as the length of just the dryer section is 25 m.

Conclusion: Spatial distribution of temperature inside STR and SBD dryers was uniform because of fan and dryer design. STR dryer can be an effective means of drying grain in the small farmers and traders' level. SBD performance heavily depended on sunlight hour. Both the dryers need to be tested in Aman paddy season (Ocotber-November) at lab before piloting at the farmers' field.

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Abstract # ADMI053

Infrastructure Constraints in Developing Countries With High Postharvest Losses: Impacts On Design and Deployment

Mitchell Meier, David Blumberg

Blumberg Grain, USA

Corresponding Author: vrosa@blumbergpartners.com

Many developing countries lack adequate transportation networks such as trains and roads to efficiently move grains and perishables more than what is considered to be a tractorable distance from the point of production, which is typically under ten kilometers. This limit on tractorable distance significantly reduces the quantity of foodstuffs that can be aggregated in a single site, such as large bins or large scale cold chain storage. In most cases the electrical and fuel demands of large scale storage sites also far exceed the available local supply, or the supply simply does not exist. Additional economic constraints force the farmer to sell his goods as soon as possible to pay debts or provide money for the next crop's inputs. This need to sell quickly also requires minimal proximity to trading and storage sites.

Design of storage solutions revolves around the ability to fit into the current market of the immediate region as well as provide a value addition of the product to the producer for incentive to sell or store their crop at the storage facility.

Similar constraints for transportation can be found in all developing countries of the world, and is exacerbated in rural agricultural areas. These rural areas being the prime target for accessible storage require simple, light, durable, and networked storage facilities. Flat warehousing is considered superior to bins of similar holding volume due to the significant reduction in civil works and power consumption. Governments of some countries also have a desire to maintain high agricultural employment, which leads to less automation for actual handling of the product. With the increase in manual labor the focus on standardizing the product is key, everything from moisture content and foreign material percentages to washing and pre-cooling of produce.

Designing storage and preprocessing facilities must rely on modular design to facilitate further expansion as the infrastructure and customer base improve. With the ability to have warehouses stack together the initial building size can be kept small and is easily deployed, even capable of being shipped in a single standard shipping container. Similarly, the machinery that is designed to assist in standardization of the product must be small enough to transport in container and also simple enough to be locally erected and serviced. Nothing in the design can rely exclusively on exotic parts, such as non-standard bearings or exotic electrical equipment et cetera.

Power demands of processing equipment must also be kept to a minimum as in many cases the power will need to be generated on site. The utilization of farmer waste products can be a reliable source of fuel for the generation of electricity or heat for drying. Utilizing renewable sources of energy can minimize the need to high electrical demands but also improve the countries standing as a green energy user, which is likely to become a significant requirement for monetary assistance in the coming years.

When storage facilities are deployed in rural areas of developing countries with proper design considerations, the single site can accept and store many different goods as the growing season cycles. Holding crops for a period of time after the initial harvest helps to stabilize the price and allow the producer to sell the product at an optimal time before its expiration further adding value to the farmer and incentivizing the use of high quality storage facilities. Some crops and perishables have a very short harvest season and storing in facilities designed to extend the life of the product, as the network of small warehouses ships out product over a much longer period of time.

All design considerations for storage and processing must be made under the specific conditions of the region for deployment. These designs can then be amended to suit a certain locality based on the specific needs of the producer and the available infrastructure. Flexible designs are key to establishing high quality and rapidly deployable storage facilities.

A further advantage of bringing most or all of a given product into networked storage creates the opportunity to build the basis for a commodities exchange through price discovery. Exchanges allow for access to the global markets and the ability of small rural farmers to then make more informed decisions on what to produce and when, and also by providing access to information on best farming and producing practices. This information can then incentivize the producers and governments to further utilize high quality storage and limit the losses of crops due to spoilage. All of which is dependent on the ability of the producer to easily access storage when it is needed and to maintain high quality standards of product that is expected on the global market.

Abstract # ADMI054

Low-cost cold storage options for smallholder farmers to reduce postharvest losses in fruits and vegetables

Jane Ambuko[1], Florence Wanjiru[1], Esther Karithi[1], Margaret Hutchinson[1], Britta Hansen[2], Lusike Wasilwa[3], Willis Owino[4] and Ngoni Nenguwo[5]

[1]Department of Plant Science & Crop Protection, University of Nairobi, P.O Box 29053-00625, Nairobi

[2]Horticulture Innovation Engine, UC Davis, One Shields Avenue, Davis, CA 95616

[3]Kenya Agricultural and Livestock Research Organization, P.O BOX 57811-00200, Nairobi

[4]Department of Food Science and Technology, Jomo Kenyatta University of Agriculture and Technology, P.O Box 62000-00100, Nairobi

[5]World Vegetable Center (AVRDC), P.O Box 10 Duluti, Arusha, Tanzania

Corresponding Author: ambuko@yahoo.com

Introduction: The horticultural sub sector is one of the key drivers of economic growth in Kenya. The sub-sector is dominated by smallholder farmers with limited resources. Significant efforts have been devoted to increasing production volumes of fruits and vegetables through improved production practices. However, increased production has also been accompanied by high postharvest losses. Although, precise quantitative data in developing countries is scanty, most reports estimate postharvest losses in fruits and vegetables to range between 40-50%. However in some instances, the losses can be as high as 80% or more. Deterioration of fruits and vegetables is attributed to biological and environmental factors. One of the key environmental factors that affect the postharvest quality of perishable commodities is temperature. It is estimated that with every 10 °C increase in temperature, the rate of deterioration increases two to three times. Therefore maintaining low (safe) produce temperature from harvest to the retail stage (cold chain) is critical for quality preservation. Despite the critical need to maintain a cold chain in postharvest handling of perishable commodities, the high cost of conventional cold rooms is out of reach for majority of smallholder farmers in developing countries. As a result, the farmers are forced to harvest and sell their produce immediately making them vulnerable to exploitation, especially by middle men. This scenario calls for efforts to find low-cost cold storage options for smallholder farmers to enable them extend the marketing period and reduce postharvest losses in perishable commodities. According a recent report by the Food and Agriculture Organization, FAO (FAO-HLPE, Report # 8), lack of cold chain infrastructure in developing countries is cited as one of the main drivers of postharvest losses. The report also recognizes low-cost cold storage technologies based on evaporative cooling as a good alternative for smallholder farmers in rural areas that lack connectivity to the electricity grid.

This paper highlights the findings of studies conducted to evaluate the efficacy of three low-cost cold storage technologies to preserve the quality and extend the shelf life of selected horticultural commodities. The technologies include Coolbot, zero energy brick cooler (ZEBC) and evaporative charcoal cooler (ECC). Although these technologies (except ECC) are new in Kenya, they have been used in other regions including USA and Asia to preserve quality of perishable commodities such as fruits, vegetables and root/tuber crops. The studies in Kenya were aimed at adapting these technologies to local conditions; building them from locally available materials and also testing their efficacy in locally produced fruits and vegetables.

Materials and Methods: The Coolbot™ is an electronic gadget which upon connection to a standard air conditioner (AC) overrides the AC's thermostat thereby tricking it into working harder. This makes it possible to achieve temperatures as low as 0^0C without ice building up on the evaporator coils of the AC. Without the Coolbot™ the AC can only lower the room temperature to a minimum of 18^0C, below which ice builds up on the coils. Studies on the efficacy of the Coolbot™ technology were conducted in Makueni County which is one of the major mango producing counties of Kenya. An insulated room (3.7 X 3.7 X 4.0 M) was built from 200 mm thick structural insulated panels made from polystyrene. The room was fitted with an air conditioner (LG brand of 24,000 BTU) and Coolbot™ which was sourced from *Store It Cold* LLC (USA). The system was then optimized according to the manufacturer's instructions. Mango fruits were sourced smallholder commercial farmers in Makueni County and sorted for uniformity. The fruits were separated into two batches for storage in the Coolbot™ cold room and ambient room conditions. In either case, the fruits were either packed in modified atmosphere packages (Activebag®) or left unpacked. The temperature on the Coolbot™ was set at 10^0C which is considered as a safe temperature for mango fruits to prevent chilling injury. Temperature of the fruits and room was monitored regularly using Xsense® data loggers. A random sample of 5 fruits was taken from each treatment every 4 days for measurement of ripening-related changes including color, firmness, physiological weight loss, total soluble solids, respiration and ethylene evolution. Additionally changes in quality attributes including sugars and vitamins were determined.

In the second set of experiments, efficacy of the zero energy brick cooler (ZEBC) and evaporative charcoal cooler (ECC) to preserve postharvest quality of leafy vegetables was evaluated. The ZEBC was made from bricks arranged to make a double wall measuring 220 X 200 cm and 60 cm high. Wet river bed sand was sandwiched in between the two walls. The top cover of the ZEBC was made from fiberboard and sisal gunny bags stuffed with sisal waste (a byproduct of sisal products processing). The materials and size are an adaptation of the original model aimed to suit local conditions. The ECC was made from a double wall made from chicken wire and packed with charcoal. The sand and charcoal in ZEBC and ECC respectively serve as a medium to hold water for evaporative cooling. Pilot studies to test the two technologies were conducted in two popular indigenous leafy vegetables in Kenya – Amaranthus (*Amaranthus spp*) and black nightshades (*Solanum spp*). The vegetables were separated into three batches for storage in the ECC, ZEBC and ambient room conditions (control). In each case the vegetables were sorted into similar bundles to those used by small scale traders. For each storage condition, some of the bundled vegetables were packaged in Xtend® modified atmosphere package to establish the synergistic effect of MAP and cold storage. Three bundles were sampled from each storage option and evaluated for parameters associated with loss of quality in leafy vegetables including physiological water loss (PWL), wilting, yellowing and loss of vitamin C.

Results: Results of these studies show that the three technologies (Coolbot, ZEBC and ECC) were effective in preserving quality and extending the shelf life of the stored produce. At the set temperature of 10^0C in the Coolbot™ cold room, the shelf life of mango fruits was extended by at least 18 – 26 days compared to those stored at ambient room conditions. The shelf life was extended further (8 – 10 day longer) when cold storage was combined with MAP. The slow progression of ripening in the mango fruits stored in the Coolbot™ cold room was evidenced by higher hue angles, low respiration rate, lower ethylene and higher firmness values throughout the storage period. In the ZEBC and ECC study, relatively lower temperatures (14.5 – 18^0C) were realized through evaporative cooling in comparison to the control room's (24 – 30^0C). Additionally the relative humidity in the chambers ranged from 88 – 99.5% compared to the ambient room's 45 – 60%. Under these conditions, quality of the leafy vegetables stored in the ZEBC and ECC was preserved for a relatively longer period than those stored at ambient room conditions. In both chambers, the vegetables remained farm-fresh for 3 days and in a saleable state for at least 5 days without MAP. Combining the cold storage with MAP further increased the shelf life for an additional 3 to 4 days. This was evidenced by lower PWL, slower wilting and yellowing rates. The vegetables in ECC and ZEBC also retained higher vitamin C levels compared to those stored at ambient room conditions.

Conclusion and recommendation: The results show the efficacy of the low-cost cold storage technologies to preserve quality of mangos and leafy vegetables. Despite its efficacy, the Coolbot™ technology requires connection to electricity therefore not ideal for majority of the smallholder farmers in rural areas with no electricity. The evaporative cooling technologies (ZEBC and ECC) which require no electricity offer an option for temporary storage. They can be used by farmers for temporary holding of produce in the field as they await traders or transfer to cold rooms which may be located away from the production areas. Despite the great potential of these technologies, there is limited adoption and hence the need for concerted efforts by researchers, extension agents and development partners to raise awareness by demonstrating their benefits to the potential users.

Acknowledgement: The pilot study on Coolbot™ Technology was funded by USAID-Kenya through the Kenya Feed the Future Innovation Engine (KFIE). The studies on ZEBC and ECC were funded by USAID through the World Vegetable Center (AVRDC) and the German government through Horticultural Innovations and Learning for Improved Nutrition and Livelihood in East Africa (HORTINLEA) project.

Abstract # ADMI055

Effect of Storage Methods and Ripening Stages on Postharvest Quality of Tomatoes (*Lycopersicon esculentum* Mill) CV Chali

Esa Abiso, Neela Sateesh and Addisalem Hailu

Department of Postharvest Management, College of Agriculture and Veterinary Medicine, Jimma University, Jimma, Ethiopia

Corresponding Author: esaabiso@su.edu.et

Background: Tomato is recognized as one of the most important commercial and dietary vegetable crop on the world (Bauer *et al*., 2004). The introduction of cultivated tomato into Ethiopian agriculture dates back to the period between 1935 and 1940 (Workneh, 2010). The annual production of tomato in Ethiopia is 4593 hectares which yields about 89702 tons (FAOSTAT, 2010). It is a popular and widely grown vegetable crop in Ethiopia, ranking 8th in terms of annual national production (workneh *et al*., 2011). However it's highly perishable nature limits the postharvest life of the fruit. Improper harvesting time (maturity), ripening conditions and lack of suitable storage facilities cause a glut during the peak harvesting period, high amount of postharvest loss and a large portion of yield sold very cheap. Sometimes the postharvest loss of the fruit reaches 100% during market absence. Temperature and relative humidity management to extend shelf life and maintain postharvest quality of perishables are the main problems in tropical countries like Ethiopia. So management of these factors is crucial tasks to extend shelf life and maintain quality of the fruit. Mechanical refrigerators are the best option to do, however it is unaffordable for farmers and small retailers to buy and run in developing countries. In addition they require electric energy to operate where it is impossible to get electric in most part of the country. So development of cheap, mechanically operate storage methods is important tasks to overcome these problems.

Objectives: The general objective of this study was to determine the effect of different evaporative cooler storages and ripening stages on shelf life and postharvest quality parameters of tomato fruit.

Materials and Methods: The study was conducted at Jimma University College of Agriculture and veterinary Medicine by the year 2013/14. The mean maximum and minimum temperature of Jimma are 26.8^{0}C and 11.4^{0}C, respectively and the mean maximum and minimum relative humidity are 91.4% and 39.92% respectively. Fruits with uniform size, ripening stage, free from damage and fungal infection brought from Melkassa Agricultural Research Centre. A factorial completely randomized design (CRD) experiment was laid out with two factors being storage methods (Zero Energy Cooling Chambers, pot in pot storage, desert cooler and control), and ripening stages (breaker and light red stage) each with three replications. Average daily temperature, relative humidity, shelf life, deterioration and weight loss percentage, pH, titratable acidity, total soluble solid, fruit firmness, Lycopene, β-carotene, Chlorophyll A and B were evaluated as response variables. The collected data were subjected to Analysis of Variance using SAS 9.2 statistical software. Fisher's least significance difference was used to establish the multiple comparisons of mean values.

Results of the study: Results of the study showed that retaining of tomato postharvest quality and shelf life were much better inside the evaporative coolers as compared to storage at room temperature. Harvest at early ripening stage also extends the shelf life of the fruit compared to late ripe harvest. Reduction in inside storage temperature and increment in relative humidity was seen throughout the storage period. Heat moves from higher temperature of air, brick and eucalyptus stick walls to lower

temperature of the moistened sand and jute sack due to convection and conduction, respectively. During this conversion process the inside storage temperature decreases below wet-bulb temperature (Islam, 2012). Temperature decreased in average to 21.37^{0}C, 20.03^{0}C, and 21.02 ^{0}C for ZECC, pot in pot storage and desert cooler storages respectively; while the average room temperature was 26.43^{0}C throughout the storage period. Relative humidity increased in average to 87.86%, 88.47%, and 84.74% for ZECC, pot in pot storage and the desert cooler storages respectively while the room relative humidity was 54.22%. Temperature and relative humidity have a direct effect on the fruit rate of respiration which directly affects the shelf life (Okole and Sanni, 2012).

Tomatoes retained 19 days stored inside Zero energy cooling chamber, 24 days stored inside pot in pot storage, 23 days stored inside desert cooler, while retained 14 days at room temperature all harvested at breaker ripening stage. Tomatoes fruits harvested at light red ripening stage retained 14 days stored inside Zero energy cooling chamber, 21 days inside pot in pot storage, 21 days at desert cooler, while it was only 11 days at room temperature. Parvez and Tustuo, (2012) reported Zero energy Cooling Chamber extend the shelf life of tomatoes up to 17 days while it was only 7 days at room temperature storage. Getinet *et al*., (2008) also reported evaporative coolers increase the shelf life of perishables through temperature and relative humidity management.

Decay started early on the 6th day for fruits stored at ambient temperature but ware late started after the 11th day for fruits stored inside the evaporative coolers. Storage of tomato at low temperature and high relative humidity decrease early deterioration percentage Moneruzzaman *et al*. (2009). Weight loss of the fruits increased progressively during the storage. Minimum weight loss was recorded for tomatoes stored inside Pot in pot storage (2.58%) and maximum weight loss was seen for fruits stored at room temperature (15.45%) both harvested at breaker stage after 10 days of storage. cold stored fruits had a low weight loss due to temperature effects on vapor pressure difference and increased water retention. In addition, higher respiration rate also resulted in higher transpiration of water from the fruit surface which led to increase in percentage of weight loss. Generally, weight loss and deterioration percentage, total soluble solid, Lycopene and β-carotene content increased with increment of storage time, but were early and fastest on tomatoes stored at room temperature.

Highest firmness was retained for tomatoes stored inside pot in pot storage (5.598N) and least firmness was recorded for ambient storage (3.585N) both harvested at light red stage after 10 days of storage period. Fruit firmness is an important quality attribute that influences consumer's acceptance and determine the shelf life of most perishables. When fruits become less firm which causes due to high moisture loss and enzymatic change they are very susceptible for microbial and mechanical damage. Titratable acidity, fruit firmness, Chlorophyll A and B content decreased with the increment of storage times which were also fastest on tomatoes stored at room temperature.

Conclusion and recommendations: In general, it could be concluded that evaporative coolers give an alternative approach to mechanical refrigerator for prolonging postharvest shelf life and maintain quality of tomato fruits. Zero energy cooling chambers need a bigger space as compared to other evaporative coolers, and even at the smaller size it is probably too large for one family's needs. So its application is better for on-farm storage. Pot in pot storage method requires a small space relatively and it can be used in individuals household to extend the shelf life of their produce. But for on farm storage it is difficult to design very big pots and the pots could be easily broken. The designed passive cooler is appropriate for retailers at market place; where it can with stand breakage in busy market places. However, the above conclusion was derived from results of study conducted within one time. So, further studies repeatedly in different months and locations should be conducted in order to give confirmative results.

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Abstract # ADMI056

The FTT-Thiaroye processing technique. An innovation for post-harvest loss reduction in fisheries & aquaculture

Aina Randrianantoandro

FAO, Italy

Corresponding Author: Aina.Randrianantoandro@fao.org

Addressing bottlenecks of critical loss points at different stages of the food chain, with improvements in the preservation, processing, and storage techniques of fish help maintain the product quality, extend shelf life, and improve its marketability. In Africa in particular, where smoking and drying are widely used for processing fish for small and medium scale fisheries, the practices and techniques are constrained by significant challenges related to post-harvest losses, environmental issues, consumer and value chain actors' health.

Physical and quality losses in smoking processes correspond mainly to the quantity of fish inadvertently dropped into the fire or poorly smoked owing to non-effective smoking and storage techniques. For traditional sun-drying, high post-harvest losses occur in linkage with adverse climatic conditions (rainy season and cloudy periods) in addition to humid periods that lengthen the drying process. The non-compliance with sanitary requirements, (especially related to high level of contaminants such as the Polycyclic Aromatic Hydrocarbons/PAHs) and the inconsistencies of the products (in terms of size, quality, etc.), can contribute to as much as 30% to 70 % of losses of a fish consignment's quality deterioration and physical removal from the supply chain. Financial losses of value chain actors led by the products' retention and destruction seizure by fish inspection services in domestic markets, as well as the rejections at export border entry points, are significant dimensions to be mentioned.

To overcome these challenges posed by inefficiency in fish smoking the Food and Agriculture Organization of the United Nations (FAO) engaged in a collaborative undertaking with the CNFTPA, a Senegal-based fisheries institute, to design, pilot test and validate the FAO-Thiaroye fish processing technique (or FTT). It is the most recent development achieved in that perspective. The technique was drawn from capitalizing the assets of existing improved kilns (like the Banda, Altona or Chorkor) and addressing their drawbacks that are sources of post-harvest losses. It was developed by adding new components that are noticeably an ember furnace, a fat-collection tray, and an indirect smoke generator system, hence leading to a better control of the PAHs levels, and occurrence of post-harvest losses, in addition to securing other important environmental and social benefits.

In the course of its piloting as a smoking technique, the initiative tapped on another opportunity, the potential of the FTT for drying fish. As far as the drying of fish is concerned, the FTT-Thiaroye allows this process regardless of the climate conditions and variability. The high postharvest losses occurred at this stage - at least 10% and up to 50% - observed for sun-drying process has been reduced to near zero. In many African countries such as Côte d'Ivoire, Ghana, Tanzania, Togo and Senegal, this system has proven to be efficient in reducing post-harvest losses, increasing income of small-scale fish operators, and at the latest stage, improving livelihoods and food security of fishing communities.

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Abstract # ADMI057

The Potential to Reduce Losses of Yam Tubers During Storage on-farm in West Africa by Curing.

Deborah Rees[1], Marcin Glowacz[1], Louise Abayomi[1], Evelyn Adu-Kwarteng[2], Charles Tortoe[2]

[1]University of Greenwich, Chatham Maritime, Chatham, Kent, UK,

[2]CSIR-Crop Research Institute, Kumasi, Ghana

Corresponding Author: d.rees@greenwich.ac.uk

Introduction: Yam (*Dioscorea spp*) is an important staple crop in West Africa. Tubers may be stored for several months. However, losses during storage and transport are very high. In some parts of West Africa, it is estimated that 10-50% of tubers are lost during on-farm storage (Amusa et al., 2003) and a further 10-40% are lost during transport due to damage and rots (Rees and Bancroft, 2003).

Wounds incurred during harvest have a significant impact on rates of deterioration as they increase rates of water loss, causing tissue stress, and provide a route for infection by rotting pathogens.

However, as for many other root crops, yam tubers are able to heal wounds even after the plant has been harvested (Passam et al., 1976). The wound-healing process involves the initial synthesis of a water/pathogen resistant barrier layer, followed by the formation of a new "wound" periderm (skin) underneath the resistant layer. There is some confusion in the literature as to whether the resistant layer consists of lignin (a branched carbohydrate with phenolic side groups) or suberin (similar to lignin but with more aliphatic (lipid) side groups).

The practice of "curing" root crops involves placing the crop under conditions that are most favourable for wound-healing for a few days immediately after harvest. In the case of potato tubers this involves keeping tubers at temperatures of approximately 15 -10°C, and high humidity for 7 -10 days before low temperature storage. In the case of yam tubers on-farm an appropriate curing method would be to maintain high humidity for a period prior to placing tubers in a more ventilated lower humidity environment, usually used for storage to discourage rot growth. Despite potential advantages, the curing of yams is not widely practiced in West Africa. This appears to be partly because it is difficult to define the optimum conditions effectively.

Objectives: The objectives of this study were

- To define the optimum conditions for curing of yam tubers, and to determine whether these conditions can be simulated by appropriate methods on-farm in West Africa.
- To determine whether optimum curing conditions differ among yam varieties/species and whether there is variation in wound-healing efficiency between varieties/species. This information is important for developing recommendations to farmers on how they treat different varieties/species

Approach: This study compared a range of West African yam varieties, including varieties from two commonly grown species; Dioscorea rotundata and D. alata, for their wound-healing efficiency, and for the optimum conditions for curing. Wound-healing efficiency was followed by the rate of synthesis of the initial barrier layer (observed by staining) (Van Oirshot et al. 2006; Brundrett et al. 1991), and also resistance to subsequent rotting.

Results: The results indicated that while most varieties studied produced lignin, some produced suberin, explaining the confusion in the literature. No difference in optimum conditions (temperature/humidity

(RH)) was detected. 35 □C and > 85% RH
fully synthesized by 10 days. However, even under optimum conditions there was a very significant difference in the efficiency of healing by variety.

Field observations on the keeping qualities of yams of different varieties on farm in Ghana will be presented. These are consistent with our observations on wound-healing efficiency.

As a first step to promoting the practice of curing as a practical on-farm strategy, on-station trials were conducted simulating on-farm storage, in order to identify appropriate methods to obtain best curing conditions. Curing strategies included covering tubers with sacking for 10 – 14 days prior to normal storage in yam barns with good ventilation. In this case it was possible to demonstrate that curing reduced weight loss during long-term storage.

Initial results following promotion of curing on-farm are presented. While there are promising results, there are also examples of trials where the conditions used provided very little, if any reduction in losses. These were cases where the curing process was continued for too long, or the humidity achieved during curing was too high, leading to condensation and promotion of rots.

Conclusion: These examples prove to emphasize the importance of ensuring that extension services fully understand any practices to be promoted to farmers.

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Abstract # ADMI058

From harvest to the table: maintaining the nutritional properties of traditional African vegetables

Freya Scoates

Exosect, USA

Corresponding Author: freya.scoates@exosect.com

ThereIs significant pressure to reduce the use of chemlcal pesticidesInstored grains and other dried commodities both to addrass concerns ragardlng operator exposure but also because residues can lead to consumer rejection.Optimising the delivery of the pesticide can reduce the amount required for affective control. EntostatIs an elactrostatlc micro-powder dellvery platform formulated using blends of waxes and polymers, which can have an active Ingredient dispersed within Its matrtx.The Entostat adheres to Insect cuticles and grain kernels and thus can be used to effectively target storage pest species. Increasing the expoaure of the Insect to the pesticide and evenly distributingIn grain during admixture.

Objectives: The objective was to produce a dual active fonnulatlon based on Entostat technology that was effective against grain pests atlower appllcatlon rates and concentrations that conventional products containing deltamethrln and plrlmlphos-methyl.

Methods:

Determining optimal does actives: Entostat technology based formulations with deltamethrln and plrlmlphos-methyl were formulated separately, without the addition of synerglst plperonyl butoxlde (PBO), at a range of concentrations. Dose-response bioassays were carried out against *Oryzaephilus surinamensis* to determine the optlmal rate of Inclusion of each pesticide. An appllcatlon rate of 50 ppm of formulatlon was selected. Both actives were formulated into the same wax blend for the following studies.

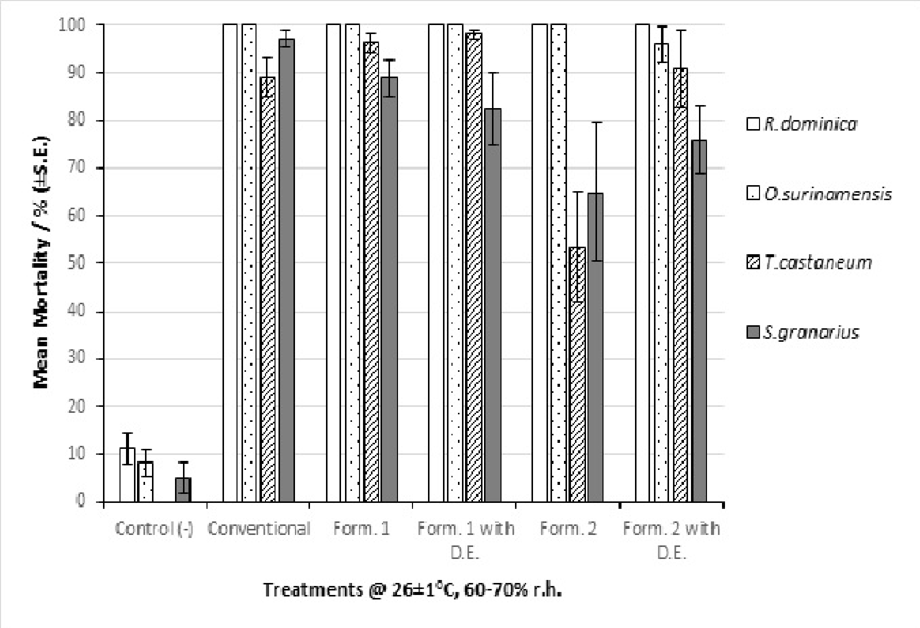
Efficacy: The Entostat technology based and conventlonal formulatlons were tested for efficacy against four different stored grain beetle pests: *Oryzaephilus surinamensis*, *Tribolium castaneum*, *Rhyzopertha dominica and Sitophilus granarius*. Only adult lndlvlduals were used. They ware tested against grain treated wth either the Entostat based formulation, a conventional deltamethrln formulation or untreated, residue-free grain In glass Jars fllled with 50 g of grain.The Entostat based formulation was tested at 50 ppm, both with and without dlatomaceous earth at 400 ppm to test for additive or synergistic effects.

Distribution: To test the homogeneity of distribution during application,the Entostat based formulation was applied to grain by bulk mixing following EPPO guidelines, treating thre batches of 20 kg wheat with the formulation applied at 50 ppm. Ten 50 g sub-samples of each batch ware removed for bioassay. Untreated, residue-free grain was used as a control.

Results:

Determining optlmaldose actives: When varying rate of deltamethrIn Entostat based formulations ware tested against Oryzaephilus surinamensis, rates of over 0.1 ppm deltamethrIn grain were found to achieve >95% mortality. The conventional formulation is applied at a rate of 0.25 ppm to achieve similar rates of mortality. When varying rates of pirimiphos-mathyl in Entostat were tested against Oryzaephilus surinamensis, rates of over 0.58 ppm were found to achieve >95% mortallty.The conventiona lformulation is applled at a rate of 1 ppm to achleve slmllar rates of mortallty.

Efficacy Mortality of four grain beetle pasts exposed to the following treatments Control: Untreated, residue-free grain Conventional formulation: 0.2& ppm deltamethrln, 2.25 ppm piperonyl butoxlde synergist Formulation 1:0.125 ppm deltamathrin, 0.5 ppm pirlmiphos-methyl, no synergist (with and without diatomaceous earth) Formulation 2:0.0625 ppm deltamethrin, 0.5 ppm pirlmlphos-methyl, no synarglst (with and without dlatomaceous earth).



The Entostat technology based formulation containing 0.125 ppm deltamethrln and 0.6 ppm pirlmiphos-methyl was as efficacious against all four grain pests compared to the conventional formulatlon, despite the latter containing twice the concentration of deltamethrin and a synergist, PBO (2.25 ppm).

Distribution: In the distribution experiment, sub-samples from across the bulk of the grain treated with the 0.125 ppm deltamathrin and 0.5 ppm pirimiphos-methyl formulatlon all resulted in close to 100% mortallty, indicating that the formulation was present at at efficacious concentrations throughout the bulk of the wheat.

Conclusions: We demonstrated that by formulating agrochemicals in a dual formulation with a delivery platform such as Entostat, it is possible to apply pesticides at lower concentrations than they are currently used, while still achieving equivalent control of the target pest. The Entostat based formulation was applied at 0.125 ppm detlamethrin and 0.5 ppm pirimlphos-methyl, compared to 0.25 ppm daltamethrin in a conventional deltamathrin based formulations and 1 ppm pirimlphos-methyl in a conventional pirimlphos-methyl based formulatlon. This has the potential to reduce chemical residues in stored grain.Tha formulation also distributes evenly in grain, despite the low application rate. This indicates that there is significant potential for chemical pesticides to continue as important components in storage.

Abstract # ADMI059

From harvest to the table: maintaining the nutritional properties of traditional African vegetables

Charles Parkouda[1*], Regine Kamga[2], Fatoumata Ba/Hama[1], Abdou Tenkouano[3], Bréhima Diawara[1]

[1] Département Technologie Alimentaire / IRSAT/ CNRST, Burkina Faso

[2] AVRDC – The World Vegetable Center, West and Central Africa, Yaoundé, Cameroon

[3] AVRDC – The World Vegetable Center, West and Central Africa, Bamako, Mali

Corresponding Author: cparkouda@yahoo.fr

Traditional African leafy vegetables have several values and properties that make them useful plants to the communities growing them. These vegetables are rich in pro-vitamin A, vitamin C, several mineral micronutrients, and health-promoting phytochemicals with antioxidant, antibiotic and anticancer and other nutraceutical properties (Yang and Keding 2009) and in certain cases, their nutritional content exceeds that of exotic crops. They are culturally accepted as dietary complements to staples, but their potential for increased household income and nutrition has been insufficiently exploited (Pasquini and Young, 2006). Nevertheless, traditional vegetables, once harvested, start to lose their nutritional and sensory quality. Being very perishable, they are often sold at loss during the season of availability, hence the need for appropriate postharvest loss reduction strategy. The losses are caused by mechanical, physiological or pathological factors, which may be aggravated by deficient post-harvest technologies (Kouamé et al., 2013). To minimize postharvest losses, Kouamé et al. (2013) recommend the development of simple handling techniques, the development of transport and storage infrastructures, as well as an efficient marketing system.

Current conservation options include drying under sun, under shade or more often with solar/gas dryers, which can affect the quality of the nutritional produce if not well done. However, there has been little research for the development and dissemination of suitable methods of conservation/processing of traditional African vegetables. In this study, we compared a few loss-reduction options for handling traditional African vegetables. Freshly harvested leaves and fruits were subjected to drying, blanching and drying, and storage using traditional and improved methods. The physical, proximate composition and mineral contents of the fresh and processed vegetables were subsequently determined, using standard procedures.

Results showed persistence of the green color and freshness of leafy vegetables (amaranth, African nightshade, jute mallow and Roselle) up to 7 days after harvesting with the improved storage system (compared to one day with traditional storage system), while African eggplant and okra fruit kept their characteristics for about 25 days. Blanching resulted in loss of total mineral (from 2.90% to 2.07%) and household processing system resulted in a significant additional losses of total mineral; only 23-53% mineral are retained in the leaves. The level of micronutrients *Amaranthus cruentus* leaves were generally high and ranged as follows: minerals – Ca (20.85±2.8 g/kg), Fe (233.39±52 g/kg), Na (8.3±0.11 g/kg), Mg (9.82±1.04 g/kg), Cu (6.56±0.96 mg/kg), Zn (64.48±37.6 mg/kg), P (4.98±0.82 %), and K (28.58±5.92 g/kg). Steam blanching for 10 min and boiling for 60 min resulted in considerable loss of β-carotene in okra leave. Fresh stored produce using improved system kept their quality for long time while the dry conservation reduces the volume and the weight of vegetables, thus facilitate their storage and their transport.

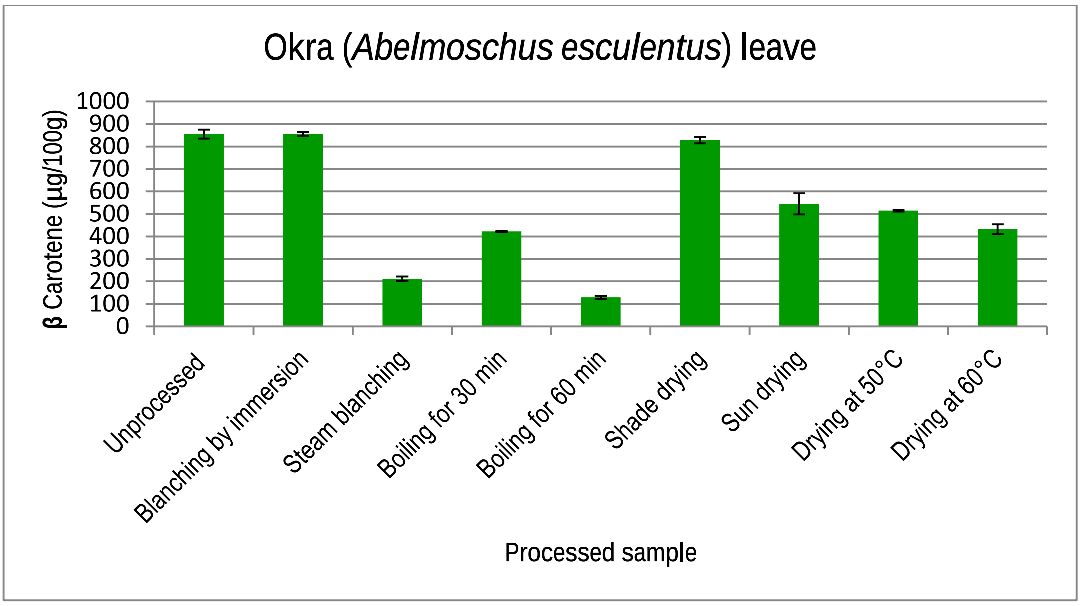


Fig. 1 Effect of some postharvest processes on the βcarotene content in okra leave

The results from this study have been packaged into a reference manual of "Good Handling and Hygienic Practices" for growers and other actors along the vegetable value chain. It provides capacity building opportunities for farmers to properly handle, package and protect produce in a way that reduces losses, extends shelf-life and justifies higher prices. With these skills farmers can develop business linkages and higher end retail markets where they can earn higher incomes for their produce.

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Abstract # ADMI060

Measuring post-harvest losses in wheat logistics chain: a Brazilian study case

Daniela Bartholomeu[1] , Fernando Rocha[1], Thiago Pra[1], Jos Vincente Caixeta-Filho[1], Luis Rodriguez[2], Yanfeng Ouyang[2], Guilherme Maia[2]

[1]University of São Paulo, São Paulo - State of São Paulo, Brazil, [2]University of Illinois at Urbana-Champaign, Illinois, USA

Corresponding Author: daniela.bartholomeu@usp.br

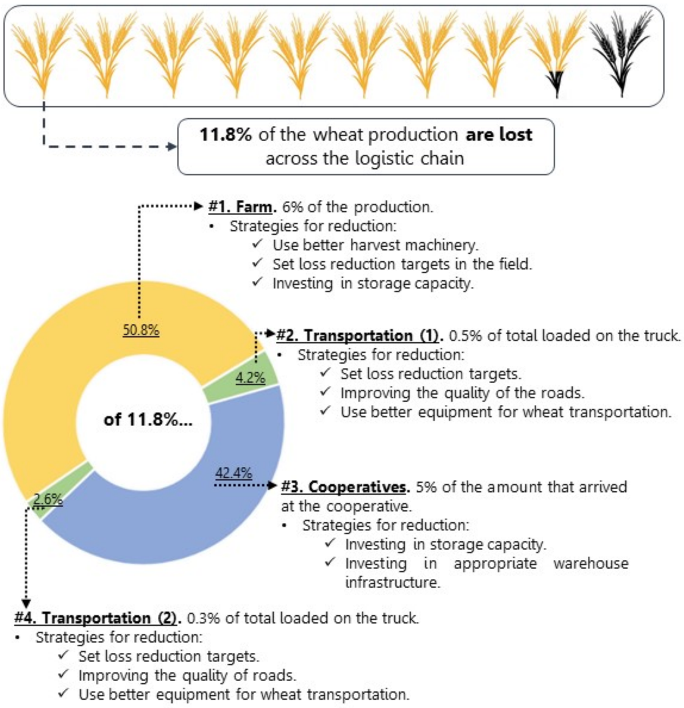
Introduction: According to WRI (2013), about 25% of every calorie grown is not consumed by humans because of food losses across all stages of the food value chain. About 24% of total food loss occurs at production or harvest, 24% at handling and storage, 4% at processing and packaging, 12% at distribution and marketing, and 35% at consumption. Specifically at transportation stage, food loss occurs due many factors, but the majority is related to failure in infrastructure, as, for example, poor road conditions and old heavy- duty vehicles. Better road conditions, availability of alternative modes of transportation or even an appropriate warehouse infrastructure are important to allow lower food loss in transportation. In Brazil, there is a high dependence on road transport, which accounts for more than 60% of all cargo moved within the country. Brazil has 1.6 million kilometers of roadway, but only 221,000 km are paved. According to CNT (2013), 46% of the Brazilian Federal road systems paved are in poor states of Conservation. Besides that, the heavy- duty fleet is about 17 years, and there is a lack of storage capacity. In this context, food loss in transport and storage in Brazil is a relevant issue to be studied, once the country is an important player in global food production.

Objectives: This study aims to measure quantitative losses across wheat grain logistics chain in Rio Grande do Sul (RS), a Brazilian state responsible for about 50% of national production of wheat. Besides this, it is important to highlight the representative participation of smallholders in wheat production in RS state and the strong presence of cooperatives in the logistics chain of wheat. Based on the main results of the study, this paper suggests some strategies to reduce losses in different stages in supply chain.

Methods: The study was divided in two phases. In the first phase, it was done a literature review aiming to characterize wheat logistics chain in Brazil and, specially, in RS State. The second one was related to field trip and primary data collection. Two different questionnaires were built and applied to agents involved in wheat logistics chain in RS State: (a) cooperatives and wheat mills; and (b) trucking companies. It was visited 6 cities in RS State, and the total distance traveled was almost 590 miles. A total of 13 agents in wheat logistics chain in the RS State were interviewed: 5 trucking companies, 3 wheat mills, 2 cooperatives, 2 port terminals/traders, and 1 union.

Results: Wheat grain losses were quantified during following stages in logistics chain: harvesting (on farms), storage (in cooperatives), processing (in wheat mills) and transportation (from farms to cooperatives; and from cooperatives to wheat mills). The main results are presented in Figure 1. [Figure1] During harvesting, losses occur due crops left behind in fields due to (i) poor mechanical harvesting, (ii) inappropriate machinery regulation, or (iii) inappropriate speed of harvesters. During transport from farms to cooperatives (Transportation1) losses involve a considerable uncertainty rate, because there is no weighing of vehicles on farms. Some aspects of this transport stage are: (i) the short distances involved between smallholders and cooperatives; (ii) the use of overweight vehicles; and (iii) the unpaved roads. During storage in cooperatives, the main factors causing quantitative losses in this stage is the poor conditions of storage infrastructure. During transport from cooperatives to mills

(Transportation2), the uncertainty is lower than Transportation1 stage due the presence of weighing structure at cooperatives and mills. Transportation2 is characterized by: (i) paved roads; and (ii) more efficient loading operation. During wheat industrialization process, mills said there is no significant loss. Total wheat grain loss across logistics chain is about 11.8%. The main stages responsible for those losses are harvesting and storage in cooperatives. Transport accounts for 0.8% of total loss. In this context, the strategies suggested for reducing losses in logistics chain include (but are not limited to): 1. Set loss reduction targets: From a management system, even if simple, each agent can establish baselines, identify the most critical stages or activities, and set loss reduction targets along the logistics chain. 2. Choose a better transportation service level: truck companies that respect the maximum limit weight on trucks, more productive heavy-duty fleet, and loading and unloading more efficient systems. 3. Private and public investments on: a. appropriate warehouse infrastructure: improving static capacity of storages in Brazil and introducing hermetic technologies for crops; b. roads: improving quality of roads; c. alternative modes of transportation with lower loss rates, such as waterways and railways.



Conclusion: This study aimed to characterize wheat grain logistics chain in RS State and to measure the quantitative losses across each stage from farmers to mills. From the surveys, it can be highlighted: Quantitative total wheat grain losses: a. Wheat grain losses in RS State are about 11.8%, which is 200,000 ton per year. b. This amount means that the wheat lost in RS State it would be enough to feed almost 3,000 people per year. c. It represents that about 6,700 trucks loaded with wheat do not arrive in final destination. â#¢ Different losses occur across different stages in wheat grain logistics chain: a. Harvesting and storage in cooperatives are the main stages, accounting for about 93.2% of total loss. b. Transport accounts for 6.8% of total loss. c. Losses in Transportation1 are higher than losses in Transportation2, because of differences in uncertainty degree and transport conditions. Different agents across wheat logistics chain have different point of view about losses: a. In general, farmers are not aware of the losses. They do not know and do not measure losses, because there is no weigh system on farms. They prefer overload the vehicle than choose a better transportation service level. b. Cooperatives and mills are more aware of this issue, because quantitative losses means monetary losses during commercial transaction among them.

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Abstract # ADMI061

AflaSTOP: Off-farm Testing of Alternative Storage Devices to Monitor Aflatoxin and Fumonisin Changes in Maize

Sophie Walker[1], Victor Kagot[1], Claudia Probst[2]

[1]ACDI/VOCA, Washington D.C., USA, [2]Washington State University-Irrigated Agriculture Research Extension Center, Washington, USA

Corresponding Author: swalker@acdivoca.org

Introduction: Improper storage of maize grain has been discussed as a likely source of post-harvest problems, such as an increased incidence of moldy (e.g., aflatoxin- or fumonisin-contaminated) and/or insect-infested (e.g., weevils and large grain borer) grains. Currently polypropylene bags (PP bags) are the most common container for grain storage in small-scale farming households. However, a recent study conducted by AflaSTOP in the Eastern Province of Kenya and funded by USAID and the Bill & Melinda Gates Foundation has shown that grain stored in common PP bags experienced increased aflatoxin contamination up to 277 percent over a six-month period. Other storage devices (e.g., metal silo, GrainPro Grain Safe and PICS bags) showed promising results by keeping aflatoxin levels steady over time as well as preventing insect manifestation even without the use of fumigants and insecticides.

Objectives: The project will test the hypothesis that improved storage devices available in Kenya have the capacity to stop aflatoxin growth during normal storage periods at moisture levels below 13.5 percent or at moisture levels around 15 percent. In case the storage devices only work at lower moisture levels, the project will develop suitable drying devices that will allow farmers to dry their maize sufficiently prior to storage in improved devices.

Methods/Design/Approach: The project tested the following storage devices:

- Metal silo, about 312 kg filling volume; made by local artisans from aluminum; cost ~$144 (all figures in USD) per device
- Plastic silo, about 350 kg filling volume, produced by large-scale water tank manufacturer from heavy-duty reinforced plastic; cost ~$92 per device
- GrainPro Grain Safe, produced and imported into Kenya by GrainPro, up to 1,000 kg filling volume; cost ~$260 per device including frame
- PICs bag, triple-layer plastic bag introduced to West Africa by Purdue University and produced locally by Bell Industries, ~ 90 kg filling volume; cost ~$2.50 per bag
- GrainPro Super Bag, produced and imported into Kenya by GrainPro, patented plastic technology, ~90kg filling volume; cost ~$2.50 plus additional $0.50 for PP bag
- PP bag, traditional storage bag made of polypropylene, ~ 90 kg filling volume; cost ~$0.50 per bag

Contaminated maize was sourced from smallholder farmers in Makueni and Meru, eastern Kenya. Each region's maize was mixed, divided into two treatments (below 13.5 percent moisture level and around 15 percent moisture level), and then returned to the region it came from and placed in the identified storage devices. The experiment used a repeated measure design nested within a randomized complete block design. The project collected samples every month and analyzed them for aflatoxin, fumonism, and grading differences.

Having created a source book of all easily accessible drying options, the project used a humancentric design process to address how to reduce post-harvest moisture in maize from around 20 percent to below 13.5 percent. Other considerations included the temperature the grain was heated to in the process of drying, the mobility of the solutions, and affordability, both in terms of the cost of investing in the drying solution by a small business provider of services and also in terms of the cost of the service offered to the smallholder farmer. Through a process of repeated testing with farmers and potential service providers, AflaSTOP fine-tuned the design of the most successful drying device, the shallow bed batch dryer.

Results/Findings: In both regions, all tested devices showed a significantly reduced increase in total aflatoxin content compared to the traditional PP bags. However, there were significant differences among devices in Makueni for both the aflatoxin content (ppb) and the average percentage of increase at six months (GrainPro Grain Safe 0% increase, PICS bag 1.8% increase per month, metal silo 3.1% per month, GrainPro Super Bag 10% per month, plastic silo 13% per month, PP bag 92% per month). The devices did not stop the growth of fumonism significantly.

There were no statistical differences for maize stored with 13.72 and 14.22 percent moisture (“wet”) compared to grain stored at 12.20 and 13.12 percent moisture levels (“dry”) in regard to aflatoxin increase over time. Over the six-month period aflatoxin levels increased in traditional PP bags between 64-135 percent in Meru and between 243-491 percent in Makueni.

The effectiveness of the Grain Safe, PICS bag, and metal silo to contain aflatoxin increase were not affected by different agro-climatic conditions within and across regions. They were very consistent with low variation among locations, treatments (dry 12.20 and 13.12% MC and wet 13.72 and 14.22% MC), and regions.

In areas where maize was sourced, over 74 percent of the bags tested for aflatoxin were above 10ppb. In one region 61 percent of the bags tested were above 150ppb, and in the second region 35 percent of the bags tested were above 150ppb.

In all cases the hermetic devices significantly reduced the level of insect infestation. Some devices experienced some small level of insect infestation (at the inlet or outlet of the device, where insects from the outside penetrated the bags). All hermetic storage prevented a loss of moisture content as well as insect damage to the grains. Large hermetic devices with grain stored at moisture levels over 13.5 percent suffered from noxious smells.

The shallow bed batch dryer dries around 500 kg of “wet” maize down to a level of around 13.5 percent moisture within four to five hours depending on the starting moisture level. It uses about seven to ten kg of maize cobs an hour as the principle fuel source to create heat. The airflow passed through the grain is heated to between 50-85 degrees centigrade. The estimated operating cost including payback on investment is $2 per 90 kg bag. The dryer is mobile. The drying bed dismantles into sections and the entire device can be loaded onto the back of a trailer. The shallow bed dryer's current cost of Ksh 125,000 ($1,250 based on materials, labor, and profit) is similar to the investment of local SMEs that offer maize-shelling services.

Conclusion: When hermetic storage devices are set up following the manufacturer's instructions, opened just once a month to collect samples, and sealed again, the intrinsic properties of hermetic storage prevented additional growth of Aspergillus, which resulted in arrested aflatoxin levels. While this does not mitigate the initial aflatoxin level or the small increase that does occur, the level is significantly lower than if the grain had been stored traditionally in polypropylene bags.

However, certain devices were more effective at significantly reducing aflatoxin increases in storage than others. Features that seem to influence the effectiveness of the devices included how well the device was manufactured to produce the seal (plastic silos) and whether or not the device was penetrated by insects chewing into the bags (Grain Pro Grain Safe). AflaSTOP has identified three storage devices that may address smallholder farmers' increasing aflatoxin levels during storage: GrainPro Grain Safe, metal silo, and the PICs bag. However it is necessary to determine if farmer practices negatively influence the observed efficacy of the devices.

Between treatments (wet & dry) there was no statistical difference in the increase of aflatoxin levels. This implies that once below 15 percent moisture it does not make a difference to the *aspergillus* whether the moisture levels are 12.2 or 14.2 percent; the aflatoxin levels of increase are the same regardless.

The second stage (March 2015-March 2016) of AflaSTOP will determine whether the devices continue to arrest aflatoxin growth when used to meet the daily needs of a farming family and whether farmers can use the devices effectively without training. The second stage will also investigate issues around farmers' willingness to pay for such storage devices, including whether different information and knowledge influence the willingness to pay, and whether farmers will differentiate storage investments for home consumption as compared to maize stored for later sale.

Working with its partners, AflaSTOP has developed a mechanical dryer that uses locally available fuel sources (cobs) to dry maize to 13.5 percent moisture levels at a similar cost to commercial dryers. The shallow bed dryer can be built within the Kenyan manufacturing space; however, the exact level of manufacturing capacity required to produce the heat exchanger and the fans is not yet clear. To establish whether or not the shallow bed dryer has a potential market as an agricultural service, between now and March 2016, AflaSTOP will investigate the business case for manufacturers, distributors, SMEs, and farmers.

The final stage of the project (August 2015-June 2016) will develop device-specific commercialization strategies. The strategies will look at the business realities of supplying the devices to address clear market issues (chemical-free storage that prevents insect damage to the grain and the ability to dry grain to safe storage moisture levels). Finally the project will investigate how to integrate aflatoxin issues into the commercialization strategies of effective devices.

Additional information on the project is available at the following link:

www.acdivoca.org/aflastop-publications

Abstract # ADMI062

Changes in the mite populations (Rhizoglyphus echinopus) in garlic bulbs (Allium sativum) cv. Perla during the postharvest storage at different temperatures. Evaluation method to study the mite populations

Saavedra-Arriaga A.D.[1], Vergara-Pineda S.[2], Torres-Robles H.[3], Vázquez-Barrios Ma. E. [1], Rivera-Pastrana D. [1], Vázquez-Celestino D. [1], Dufoo-Hurtado D. [1], Guevara-Figueroa T. [1], Mercado-Silva E. [1]*

[1] Universidad Autónoma de Querétaro, Queretaro. Cerro de las Campanas Querétaro, México.

[2] Universidad Autónoma de Querétaro, Queretaro. Avenida de las Ciencias S/N. Juriquilla Delegación Santa Rosa Jauregui. ZIP 76230. Querétaro, México.

[3] Consejo de Ajo de Aguascalientes, Km 1 Carretera Rincón de Romos – Tepezala. Rincón de Romos Aguascalientes. ZIP Rincón de Romos Aguascalientes, México

Corresponding Author:

Rhizoglyphus echinopus is the most important mite species in the garlic crop in Mexico. It causes important economic losses during the storage of bulbs that can reach up to 100 percent if preventive actions are not taken to control the growth of this pest[1]. The procedures to control this organism during planting and crop development include chemical compounds application (karathane, malation). In postharvest storage, the traditional treatment to control the mite infestation is applying agricultural sulfur or aluminum phosphorus. However, the use of this product in garlic destined for human consumption is limited or not appropriate due to the risks involved. The storage of garlic bulbs at low temperature (0 to -1° C) is an option that helps to control the development of the plague and maintain the shelf life. However, this treatment cannot be applied to garlic bulbs used as seed for the next season. The pest development provokes pollution problems generated by the mite droppings, as well as a warming of the garlic bulb that facilitates the growth of secondary saprophytes microorganisms which end the shelf life of the product. The domestic and international standards only indicate the number of mites per bulbs without indicating the method to evaluate them. There is not a consistent method to evaluate the population of this pest on the bulbs. The aim of this work was to develop a method to evaluate the mite population on garlic bulbs cv Perla, and use this method to understand the population changes during the period bulbs were stored at room temperature and 0 °C. Three independent bulbs were transversally cut at the middle of each bulb, the cloves sectioned, and sheets of each section collected independently in falcon tubes. In each section, 50 mL of distilled water were added, and the mix was homogenized for 15 seconds in a blender. The homogenized mixture was placed on a series of sieves (80 to 120 mesh) and washed with abundant tap water. The fraction of 120 mesh was transferred to a 25 mL falcon tube and the mix was brought to 15 mL of volume with a solution of 2 percent formaldehyde in water. The total volume was put in a petri dish on a gridded (1 cm2) background surface. Each sample was observed at 10 X under an ocular microscope and the number of Rhizoglyphus echinopus adults were registered in three squares and then extrapolated to the total number of squares and expressed as number of mites at each section. The total number of mites on each bulb was the sum of both cloves sections and sheets. The main zone of mite development was the inferior section of the bulb on the sheets of this section. All bulbs presented a very wide range of population in the bulbs, which indicated that the mite population is not uniformly distributed. The mite number registered was higher than the mite number indicated in the garlic official standars2 (up to 20 – 40 mites per bulb); which indicated that this method could estimate in a better way the mite population. The mite number was influenced by the storage temperature; the bulbs stored at room temperature showed the highest number (up to 1200 mites per bulb); while at 0 ° C,

the population ranges were narrower (up to 200 mites per bulb) than at room temperature. In both temperatures during storage, a periodical fluctuation was observed which could be associated with the mite reproduction cycle.

The high number of mites found in this work showed that the proposed method could quantify in a better way the mite population in garlic and evaluate its effect during the storage.

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Abstract # ADMI063

Storing up trouble for the larger grain borer: Using Beauveria bassiana in Sub-Saharan Africa

Belinda Luke[1], Daniel Karanja[2], Nick Jessop[3], Clare Storm[3], Aaron Mbogho[4], Mavis Acheampong[5], Eric Cornelius[5], Stephan Asante[6], Maneno Chidege[7], Reinfrid Maganga[8], Rhodes Makundi[9], Christopher Materu[10], Pierre Grammare[11], Olivier Potin[11] and Victor Clottey[12]

[1]CABI Europe-UK, Bakeham Lane, Egham, Surrey, TW20 9TY, UK,

[2]CABI Africa, Canary Bird, Nairobi, Kenya,

[3]Exosect Ltd., Colden Common, Winchester, Hampshire SO21 1TH,

[4]Ministry of Agriculture, Food & Cooperatives, Tanzania,

[5]University of Ghana, Accra, Ghana,

[6]Savanna Agricultural Research Institute, Tamale, Ghana,

[7]Tropical Pesticide Research Institute, Arusha, Tanzania,

[8]Uyole Agricultural Research Institute, Mbeya, Tanzania,

[9]Sokoine University of Agriculture, Chuo Kikuu, Morogoro, Tanzania,

[10]Mikocheni Agricultural Research Institute, Dar-Es-Salaam, Tanzania,

[11]Agrauxine SA, Laboratoire R&D laboratory, France,

[12]CABI West Africa, Accra, Ghana.

Corresponding Author: b.luke@cabi.org

Introduction: Protecting food from post-harvest losses in Sub-Saharan Africa (SSA) is a critical issue in addressing the challenge of food security. Subsistence farmers are particularly affected as a high percentage of their disposable income and agricultural output is devoted to staple food production and storage. In SSA about 70% of typical incomes are spent in crop production, of which 37% is grain crops with maize accounting for 25% of starchy staple food consumption in Africa[1]. Maize is the largest single source of calories providing 36% of daily intake[2]. With 63% of people living in SSA depending on agriculture for their livelihoods, post-harvest loss (PHL) is a major issue3. The most significant pest to maize in storage is the Larger Grain Borer (LGB, Prostephanus truncatus). Losses caused due to LGB are in the estimate of 30% annually with reported losses of up to 60% in some instances[4]. It is estimated that 45 million tonnes of maize is produced annually in SSA[1]. Objectives: An effective fungal isolate of Beauveria bassiana, found in a UK cereal store, was identified for use against European storage pests. Over the course of 10 years' research the isolate was tested and developed and is currently undergoing registration for use in the European market.

Objective: The objective of the present work was to carry out a two year proof-of-concept project on the isolate to determine if it could be transferred to markedly different environments in SSA. If successful this would deliver a prototype, cost effective, safe, sustainable and easy-to-apply insect control product for the protection of stored maize and other staple grains in two exemplar countries, Ghana and Tanzania. The main pest targeted was LGB but Sitophilus zeamais (maize weevil) was also studied.

Methods and Results: A series of experiments were conducted in Ghana and Tanzania to represent East and West African conditions. The first experiment was a maximum dose challenge pathogenicity test to confirm that the isolate was effective against LGB in both countries, and to determine the effect of the isolate on Teretrius nigrescens, a predator of LGB introduced in Ghana and other countries. The UK isolate of B. bassiana was effective in killing LGB (100% after 14 days in both countries) and Sitophilus sp (100% mortality in Ghana and 92% mortality in Tanzania) with limited effect on T. nigrescens (30%mortality after 14 days). The next experiment was artificially infesting maize with LGB and T. nigrescens combinations to determine the effective control of B. bassiana at different concentrations. Maize was treated with B. bassiana at either $1x10^{10}$ colony forming units (cfu) per kg maize or $1x10^{9}$cfu/kg maize with and without T. nigrescens. Results and Discussions: Results showed greater than 80% mortality of LGB with the higher concentration of fungus compared to 70+% mortality at the lower concentration. T. nigrescens had no additive effect on controlling the LGB. A dose response experiment was run, using four different concentrations, $1x10^{10}$, $3.16x10^{9}$, $1x10^{9}$ and $3.16x10^{8}$ cfu/kg maize prepared with either a relatively high (4 g) or low (2 g) dose of kaolin using 250 g maize aliquots over a 3 week time period. Assessments were made on mortality of LGB and grain damage. Mortality is shown in figure 1 and was greater than 90% after 21 days for 1x1010 and $3.16x10^{9}$ cfu/kg maize. Although grain damage increased at the lower B. bassiana levels, this was not always to a significant level, probably due to the relatively small sample size and lack of sensitivity of balances. Based on these results, semi-field trials were conducted at $3.16x10^{9}$ and $1x10^{9}$ cfu/kg maize with a 'low', 2g/kg, level of the coformulant kaolin. Semi-field trials were conducted in two locations in Ghana and at three locations in Tanzania. There were two treatment levels of B. bassiana; $3.16x10^{9}$ and $1x10^{9}$ cfu/kg maize and a control. At the ARI, Uyole, Tanzania site a quarter dose was applied making the concentrations 2.5×10^{8} and 7.9×10^{8} CFU/kg maize. One hundred LGB were added to 2 kg maize aliquots with 8 replicates (5 in Arusha) for each treatment. Samples were destructively taken at weeks 2, 4, 8 and 12. Results from the trial showed that in ARI, Uyole there was over 80% mortality after 12 weeks in both quarter dose treatments. At TPRI, Arusha, Tanzania there was >96% mortality for up to 8 weeks. Both sites in Ghana had >80% mortality for up to 4 weeks. Insect numbers recovered from the University of Ghana site showed that there was a large population increase (>300 insects recovered) by week 8, and this related to an increase in maize dust produced by week 12, with over twice as much dust produced in the controls compared to the $3.16x10^{9}$ cfu/kg maize treatments. Due to high control mortality reliable results could not be gained from the ARI, Mikocheni site.

Belinda Luke. Storing up trouble for the larger grain borer

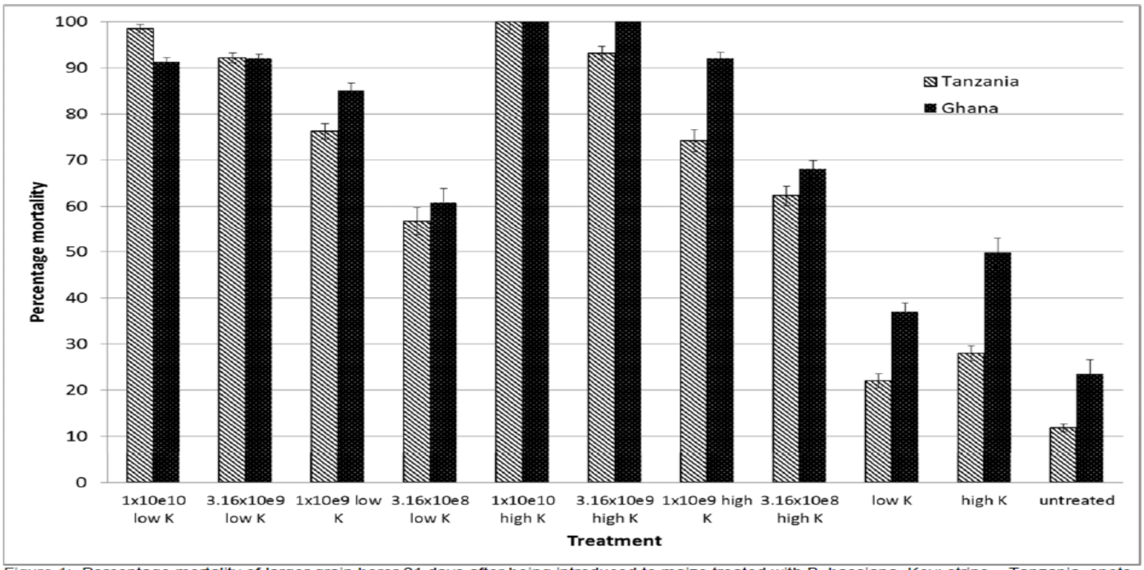

Figure 1: Percentage mortality of larger grain borer 21 days after being introduced to maize treated with B. bassiana. Key: strips = Tanzania, spots = Ghana

Conclusions: In Ghana the higher concentration of 3.16×10^9 cfu/kg maize was effective at controlling LGB but the lower concentration of 1×10^9 cfu/kg maize was not. In Tanzania the one quarter doses of 2.5×10^8 and 7.9×10^8 CFU/kg maize were effective in the cooler area of Uyole and the 3.16×10^9 and 1×10^9 CFU/kg maize treatments were effective at Arusha. It is planned that CABI will manage a phase 2 project to optimise fungal performance and look at longer term storage as well as the economics and routes to market.

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Abstract # ADMI064

Market Linkages Key to Adoption of Improved Postharvest Practices for Horticultural Produce

Elizabeth Mitcham[1], Michael Reid[1], Britta Hansen[1]

[1]University of California at Davis, California, USA

Corresponding Author: ejmltcham@ucdavls.edu

Introduction: Horticultural crops are among the most perishable due to their high water content and susceptibility to water loss and consequent shrivel, continued softening, and microbial decay. Postharvest losses of horticultural crops range from 30-80%. In the developing world, depending on the crop, economic factors and weather conditions. Losses are exacerbated by physical damage from rough handling, Inadequate packaging, and poor transportation; and from poor temperature management, particularly the lack of timely cooling and a cool chain from harvest to market. Recommended practices to reduce postharvest losses are well known among experts in the field, but have not translated into improvements in postharvest handling in the developing world. The challenges to implementing improved postharvest handling practices, even those that require little to no financial resources, are not well understood. Development agencies and donors are keenly interested in reducing postharvest losses in an effort to increase food availability to a growing population and to increase the sustainability of our agricultural systems.

Good Postharvest Management

The principles of good postharvest management begin with selection of the optimum variety with good disease resistance and postharvest life potential. In addition, access to information about market demands and use of planting calendars prior to planting can reduce an over-supply leading to food waste. Production practices should be optimized to produce healthy, pest free produce. Products should be harvested at a stage of development or ripening (maturity) that satisfies market demands and allows for transportation with minimal damage. After harvest, products should be kept in the shade to avoid heating by the sun. Some products must be washed before sorting, and washing must be done with potable water containing a sanitizer. Sorting the harvested products into categories by ripeness and overall quality is important to provide consistent quality to the buyers. A higher price should be possible for the higher quality produce in some markets. Packaging is the next consideration. In the developing world, most horticultural products are packed in very poor containers that do not protect them from abrasion and compression damage. Reusable plastic crates are the best option in most situations, and are in use for certain crops in some developing countries. Local manufacturing of plastic crates, as by A to Z Inc. in Tanzania, should reduce the cost and increase availability. Others are interested to find a local material, perhaps chicken feathers, which could be made into affordable and protective packaging materials. Wrapping produce in plastic bags is a low cost method to containerize the product for sale while at the same time reducing water loss. However, the lack of waste disposal facilities in most countries has led to litter problems to such an extent that Rwanda has banned the use of plastic bags. There is currently no good substitute for plastic bags to reduce water loss of horticulture products that are high in water content. Cooling and temperature management after harvest are rarely practiced in the developing world for perishable horticultural products. In some countries, the cold chain is reasonably developed for dairy and fish. Some of the challenges have included the capital and operational costs, scale of facilities, and lack of effective farmer associations who could share facilities. The introduction of the CoolBot controller with a domestic air conditioning system has greatly reduced the cost of a small cold room that can be constructed from locally available insulating materials. In rural areas, these units have been operated on solar power. CoolBot-equipped cool rooms have been effectively used for storage of seed potatoes and sweat potatoes in Bangladesh. For vary short term storage on farms in low humidity environments, evaporative coolers such as the charcoal cooler or the zero energy cooler, can be affective, and provide a high humidity that will reduce water loss. Maintaining cool temperatures during transportation is also a challenge. Some creative solutions are being tested, but depend on the transportation options available to farmers and traders.

Adding Value to Produce During Periods of Over-Supply

It is very common to find a large percentage of farmers in a region growing the same crop at the same time leading to a glut of harvested high quality product on the market. Availability of cold storage could give more time to find available market, but there is a limit to how long products can be stored in fresh condition. Processing the product will greatly slow its deterioration. In fact, processing facilities can be available market for farmers if they can establish viable contracts for delivery of produce. Some simple processing methods can be done on farm. Solar drying is one such option, but can be limited by cloudy and rainy conditions. A new Chimney Dryer developed by the University of California will be described that increases the capacity and efficacy of solar drying, especially under poor weather conditions. After drying, products must be kept dry during storage and marketing. Exciting new options for removing moisture from the atmosphere include reusable ceramic drying beads and sachets of specific salts.

Market Access and Return on Investment

A requirement for adoption of good postharvest management practices is some assurance of a return on the investment of time or capability the farmer or trader. Most postharvest losses in the developing world occur after the produce leaves the farm. Smallholder farmers and traders generally do not have the resiliency to sustain loss of a product, especially after investments have been made. Linking smallholder farmers and traders to profitable markets can assist them in making improvements to postharvest handling practices. Successful examples will be discussed, including the use of participatory market chain assessment, linkage of farmers to local hotels and supermarkets, and creating market demand through production of sustainably produced and safer produce. Various microfinance schemes have been successfully used to assist farmer groups to raise the capital needed to invest in improved technologies that Increase their market access through improved postharvest handling practices.

Abstract # ADMI065

Behavioral Explanations for Barriers to Adoption of Postharvest Loss Technology

Pallavi Shukla and Kathy Baylis

University of Illinois at Urbana-Champaign, Illinois, USA

Corresponding Author: pshukla3@illinois.edu

Introduction: It may seem intuitive to many of us that given the lower prices of food grains immediately after harvest, it might be profitable for farmers to hold on to their produce and sell at a later date when the market offers a higher price. However, data suggest that in many countries, farmers sell low and buy high (Burke 2014). So what then, prevents farmers from exploiting these inter-temporal arbitrage opportunities? One of the many explanations for it could be lack of storage facilities and/or high postharvest storage losses (PHL). If this indeed is the case, we should see high willingness to pay and quick adoption of storage technology for reducing postharvest losses. However, experience tells us that the adoption of postharvest loss reducing storage technology, even when highly subsidized, is an uphill task in developing countries. Given the high returns to storage, why do farmers then forgo profits selling their produce immediately after harvest leading to the low adoption of postharvest loss reducing storage technology? This calls for further investigation into reasons why farmers do not store their crops even when given access to subsidized storage technology. Other explanations for this might include risk aversion related to uncertain future price or even the inability to sell, liquidity and/or credit constraints and time preferences. In an experimental setting in India, we examine these determinants of storage behavior among farmers.

Objectives: Our final objective is to promote the use of postharvest loss reducing storage technology among farmers, thereby increasing farm profits particularly for smallholders in India. With this end goal in mind, we aim to gain insights into why we see low adoption of storage technology among farmers, even when it is highly subsidized. In this paper, we use behavioral decision-making models and biases to explain the reasons for low storage among farmers. We posit that farmers may be inconsistent in their time preferences, i.e. present biased, leading to low storage and thus low adoption of storage technology. If this is the case, farmers might be making suboptimal selling decisions thereby reducing the profit they can make. This presents an opportunity for well-designed policy nudges to promote greater use of storage technology and increasing profits farmers can make.

Experiment Design/Approach: Recent evidence suggests that farmers in developing countries are stochastically present biased and not fully aware of this bias (Duflo et al. 2009). This bias has multiple implications for decision-making at both the input investment and output arbitrage levels. In other words, farmers might be making suboptimal selling decisions because of time inconsistencies or, a preference for present-day. Since farmers might prefer getting paid sooner than later, even if the late payment comes with a higher reward, they might be less willing to use any storage technology. However, other reasons like risk aversion and credit/liquidity constraints might impact the decision to store. To test this hypothesis, we use a choice experiment to understand farmers storage and marketing decisions for finger millet. Finger millet is widely grown in arid regions in Asia and Africa. Once harvested, the seeds keep very well and face little to no postharvest loss in storage. They are highly nutritious and comprise of micronutrients lacking in starchy staples like cassava, rice and maize. For these reasons, finger millet is promoted as a risk-avoidance cropping strategy and also as a nutritious addition to the diets of the poor. In the state of Andhra Pradesh in India, many districts grow finger millet, locally known as ragi. Our study is based in one such district called Anantapur. The local administration is considering the inclusion of ragi in the subsidized public food distribution system. In order to do so it is considering the feasibility of procuring ragi from farmers. However, matching demand and supply poses a problem while households demand ragi throughout the year, farmers may want to sell all of their produce right at harvest. If farmers are willing to store their crop and sell it at a preset, later date, this would allow the procurement agency to smooth supply. In this study we conduct a choice experiment with a random sample of ragi farmers in Anantapur to understand what drives a farmers decision to store. The results would also help design incentive structures that can promote storage behavior among farmers and allow them to gain from selling high. In the choice experiment farmers are offered a series of hypothetical pairs of options to choose from.

The choices offered vary along various critical dimensions. These include variation in the timing and price offered at procurement at different time periods after harvest, price premium available for various quality grade. Choices would also vary in terms of the contract offered-- upfront payment for later delivery, payments received in installments for sale in batches, full payment at date of delivery. The prices offered in these contracts would also vary in terms of their associated risk across choices. For example, one pair of hypothetical choices offered might be the following: (a) a contract for selling 500 kg of ragi at 1500 Rupees per quintal (the minimum support price announced by the government) at the time of harvest, or (b) a contract for selling 500 kg of ragi at 1700 rupees per quintal 1 month after the harvest. The design of the choices offered would allow us to estimate farmers willingness to accept various incentives for storage and procurement mechanisms. A farmer survey would also be administered along with the set of choice questions. The survey would collect data on landholding, cropping pattern, credit availability and other farmer characteristics. We would then relate farmers willingness to store, given the incentives, to individual farmer characteristics collected from the survey.

Concluding Remarks: With this paper, we aim to find the farmers willingness to store crops thereby smoothing sales, exploiting arbitrage opportunities and increasing farm profits. Regardless of whether we find evidence of time inconsistency among farmers or not, we would be able to highlight important implications for policies promoting the adoption of PHL reducing storage technology. If we find evidence of time inconsistency among farmers as we expect to, it would be indicative of a need to focus our PHL technology promotion strategies in a way to overcome these behavioral barriers. In that case, our strategy should include nudging and incentivizing farmers to store their crops long enough so as to make use of any future arbitrage opportunities and increase their profits. If we find no evidence for time inconsistencies, this study will help narrow down the reasons for low storage and low PHL storage technology adoption to risk aversion and/or credit constraints.

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Abstract # ADMI066

Aflatoxin biocontrol: Scaling-up a preharvest management tool to reduce postharvest losses in maize and groundnut

Ranajit Bandyopadhyay[1], Joseph Atehnkeng[2], Adebowale Akande[3], Lawrence Kaptoge[2], Charity Mutegi[4], Lamine Senghor[5], Peter J. Cotty[6]

[1]International Institute of Tropical Agriculture (IITA), Oyo Road, Ibadan, Nigeria,

[2]IITA, Oyo Road, Ibadan, Nigeria,

[3]IITA, Abuja farm, Kubwa Village, Abuja, Nigeria,

[4]IITA, c/o ILRI, Nairobi, Kenya,

[5]Direction de la Protection des Végétaux (DPV), Dakar, Senegal,

[6]USDA-ARS, University of Arizona, Tucson, Arizona, USA.

Corresponding Author: r.bandyopadhyay@cgiar.org

Food quality and safety issues resulting from aflatoxin contamination are significant obstacles for improving nutrition and agricultural production while linking smallholder farmers to markets. Aflatoxin exposure is frequent and widespread in most African countries where the key staples maize and groundnuts are particularly vulnerable to aflatoxin contamination. Aflatoxin poses a significant public health risk in many tropical developing countries and is also a barrier to the growth of domestic, regional and international markets for food and feed. The most documented health impact of chronic exposure to aflatoxins is liver cancer. Broader health effects such as child stunting and immune suppression with higher rates of illness have also been associated with aflatoxin exposure. Aflatoxin contaminated feed decrease livestock productivity. Aflatoxin contamination has also led to the destruction of hundreds of thousands of tons of grains, leading to huge losses of much-needed income, food, and trade with health and food security consequences.

An innovative scientific solution in the form of a natural biocontrol has been developed by USDA-ARS. This breakthrough technology, already in wide use in the United States, reduces aflatoxins during both crop development and post-harvest storage, and throughout the value chain. Atoxigenic-strain-based biological control is a natural, non-toxic technology that utilizes the ability of native atoxigenic Aspergillus flavus to naturally out-compete their aflatoxin-producing cousins. IITA and partners have successfully adapted this competitive displacement technology for use on maize and groundnut in various African countries using native micro-flora, developing biocontrol products called Aflasafe. We describe progress made with development of biocontrol of aflatoxins in Africa, the current status, and prospects for further scaling-up in maize and groundnut value chains.

Field testing of country-specific Aflasafe products in Burkina Faso, Kenya, Nigeria, Senegal and Zambia for several years has produced extremely positive results in reducing aflatoxin contamination of maize and groundnut, consistently by 80% to 90%, and even as high as 99%. The biocontrol strains carry over through the value chain, discouraging contamination in storage and transport even when conditions favor fungal growth. Positive influences of atoxigenic strain applications carry over between crops and provide multi- year benefits. A single application of atoxigenic strains may benefit not only the treated crop but also rotation crops and second season crops that miss a treatment. Additionally, because fungi can spread, as the safety of fungal communities within treated fields improves, so does the safety of fungal communities in areas

neighboring treated fields. The excellent efficacy of biocontrol in reducing aflatoxin in these countries has led to the expansion of the program to other countries in the East (Burundi, Rwanda, Tanzania and Uganda), West (Ghana and The Gambia) and Southern (Malawi, Mozambique and Zambia) Africa.

To make the biocontrol product available to farmers and other end-users, a manufacturing plant (capacity 5 tons/hour; See Figure) has begun to produce Aflasafe in Nigeria. A small-scale modular manufacturing plant is under construction in Kenya. A model for creating sustainable market demand for Aflasafe in maize value chain is being piloted under the AgResults Aflasafe Initiative in Nigeria where farmers have purchased Aflasafe to treat about 30,000 ha (application rate: 10 kg/ha; cost of product: $18.75/ha). The Kenyan government is providing the biocontrol product to smallholder farmers to treat almost 23,000 ha in aflatoxin-prone areas in as a public good in public health interest and to improve marketability of maize grains. A Senegalese agribusiness firm provided 8 tons of Aflasafe to its contract growers in 2014 to improve the safety and marketability of groundnuts procured from the farmers.

Smallholder farmers harvest, store and consume home-grown crops. The deployment of Aflasafe can profoundly improve safety of food of smallholder farm families and reduce postharvest losses since the technology dramatically reduces the source of contamination in the field before harvest, during storage and until maize/groundnut is consumed. Reduced crop contamination could also translate into improved food security and better access to domestic, regional and international markets that pay premium for aflatoxin standard abiding maize and groundnuts. Scaling-up of biocontrol has also the potential to revitalize exports and to increase smallholder’s opportunity to access premium export markets where the product is in demand. For health and income improvements to happen, the biocontrol technology must be scaled up to reach the various players in the maize and groundnut value chains by developing proper product manufacturing and delivery mechanisms.

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Abstract # ADMI067

Hermetic Wheat Storage for Small Holder Farmers in India

Pavel Somavat[1], Hiabo Huang[2], Sunil Kumar1, Mukesh Garg[1], Mary-Grace Danao[2], Vijay Singh[2], Marvin Paulsen[2], Kent rausch[2]

1CCS Haryana Agricultural University, India

2 University of Illinois at Urbana-Champaign, USA

Corresponding Author: krausch@illinois.edu

India is among the countries experiencing higher postharvest losses with farmers, governmental agencies and private sector players experiencing similar losses. Wheat and rice are major staple crops of India, which feed most of its 1.27 billion people. Estimates of postharvest losses for these crops range from 6 to 15% of the crop. Recent estimates have indicated that total postharvest losses in India cost US$41 billion. Approximately 60% of small holder farmers use either gunny bags or bulk storage (such as metallic bins) to store their crops. However, these methods are prone to losses due to insects, molds or rodents.

Hermetic storage is a technique that involves storing grains in airtight enclosures. As grain respires, carbon dioxide (CO_2) is evolved and oxygen (O_2) in the interstitial airspaces is consumed, reducing environmental conditions suitable for mold and insect growth. When O_2 decreases and CO_2 increases sufficiently, chemical fumigants are not required for safe storage making these hermetic bags an environmentally-friendly storage solution. These bags have been adopted increasingly in Latin America and Southeast Asia (Abalone et al., 2011; Villers et al., 2006). Insect respiration rates and metabolic activities usually are increased at an elevated temperature, causing more rapid depletion of O_2 in hermetic bags, and insect mortality is increased correspondingly (Jayas and Jeyamkondan, 2002). Although different insect species have varying levels of tolerance to a modified atmosphere (Navarro and Donahaye, 2005), 35% CO_2 concentration is lethal to test insects even when O_2 concentration is as high as 15%. In absence of CO_2, O_2 concentration below 3% is needed for effective control of insects but to obtain lethal gaseous atmosphere, an O_2 level of below 1% is desired (Banks and Annis, 1990). Hermetic bags have a synergistic effect of increased CO_2 concentration and decrease in O_2 concentration for achieving effective insect mortality (Calderon and Navarro, 1980). An increase in temperature within the insect growth range increases the respiration rate and metabolic activities of insects; and therefore, insect mortality is increased correspondingly (Jayas and Jeyamkondan, 2002).

We simulated real time Indian conditions to compare hermetic storage of wheat with two traditional methods, metallic bins and gunny bags. Four hermetic bags, two metallic bins and two gunny bag piles each containing one tonne of wheat were instrumented with temperature, relative humidity and carbon dioxide sensors. Four hermetic bags were purchased with each having a capacity of one metric tonne and dimensions of 1.2 x 1.2 x 1.9 m (L x W x H). These bags rested on metallic frames of 75 x 75 x 150 cm with rodent proof measures on each leg. Each hermetic bag had an outer propathene jacket to act as a strength member. The initial moisture content levels for wheat to be stored in the hermetic bags were 12 and 14% with replication. To test the effectiveness of hermetic bags, 80 adult specimens of the lesser

grain borer (*Rhyzopertha dominica*) were introduced into two of the bags. Two metallic bins each having 2 m height and 1 m diameter were purchased and filled with wheat with a moisture content of 12%. Forty 50 kg gunny bags were procured with dimensions of (84 x 50 x 20 cm). Two piles of twenty gunny bags each were stacked side by side with 12% initial moisture content. During storage, temperature, relative humidity and CO_2 concentration were measured at fixed intervals for each of the hermetic bags, metallic bins and gunny bag piles. Representative samples from each structure were collected every month and various qualitative tests for moisture, thousand kernel weight, germination, insect-bored grain, and milling yield were performed.

After nine months, wheat stored in hermetic bags had higher germination rates (87%) and lower insect-bored grain percentages (0.0 to 0.3%). Hermetic bags with deliberately introduced *Rhyzopertha dominica* successfully eliminated the pests. Gunny bags and metallic bins had 73 and 82% viability and 8 and 2% insect damaged kernels, respectively. We found that it would be necessary to use chemical fumigants to safely store wheat in gunny bags. Wheat moisture content in all structures varied depending upon ambient conditions; moisture variation was largest in gunny bag piles. Milling yields were lowest for gunny bag piles. Hermetic bags can be an effective and chemical free method of reducing storage losses of wheat in India.

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Abstract # ADMI068

Development of Tomato Value-added Products as an Alternative use for Oversupply in Costa Rica

Laura Brenes Peralta, María Fernanda Jiménez Morales, Marianella Gamboa Murillo

Agribusiness School, Tecnológico de Costa Rica

Corresponding Author: labrenes@itcr.ac.cr

Introduction: Projects have been executed to promote an alternative use of tomato oversupply in Costa Rica instead of causing market saturation and food losses, through the coordinated actions among the Agribusiness School (Tecnológico de Costa Rica-TEC), an Inter-institutional Tomato Board (PITTA Tomate), and the National Tomato Programme (Ministry of Agriculture and Livestock). This Programme previously determined that: i) tomato (Solanum Lycopersicum) is the most consumed vegetable in Costa Rica (18kg /person/ year), ii) there are peaks in production which lead to tomato losses (mass, market and competitiveness loss) and iii) there are challenges in value-adding abilities in this subsector (López, 2013). Prior research at TEC generated 4 processed products based on "salad-type" tomato -most common in Costa Rica. (Campos-Melendez, Brenes-Peralta, Gamboa-Murillo, Salazar-Díaz, & Robles-Rojas, 2014). This formulations originated a jam, a tomato & pineapple sauce, a paste, and dehydrated tomato; and they were considered after a secondary information review on consumer tendencies, experts' criteria on technology capabilities in the subsector, and small scale trials. (PITTA Tomate, 2014).

Objectives: During 2013-2014, two complementary projects were executed with TEC and FITTACORI funds, in order to "evaluate the mentioned formulations in terms of processing yield, cost and market acceptance as an option for the beneficiaries of the Programme, and consequently, as an aid in the use of the tomato oversupply and in the avoidance of losses".

Methods: The projects were part of a two-phase plan for National Tomato Programme: Phase I: research in product formulation, productive costs and market pre-feasibility. Basic processing technology at the Agro-Industry Processing Facility at TEC was used, with four different tomato varieties and two repetitions on each variety. Evaluated criteria involved yield (division of the obtained product mass by the initial mass), physic-chemical characterization (acidity, soluble solids content, lycopene content), and costs (cost per gram parting from raw tomato –market prices for 2°-type quality, additives, laboring costs, social security charges, and packaging costs for 2014), and it was presented as an average. A market study was conducted to infer on market pre-feasibility, through a study in 6 communities close to the main tomato production spots, suggesting a possible local market opportunity. The data were retrieved by surveying intermediate consumers (minimarkets and restaurants) and treated under normal distribution analysis for significant differences. Final consumers were surveyed as well, and the data were treated under non-parametric analysis through the Wilcoxon Test. There were six technology transference workshops, and results are currently being delivered to the National Programme. Phase II: technology adoption, once the results of phase I are socialized.

Results

Table 1. Summary of the obtained results from the product development and market study

Product	Yield	Production Cost	Market study results
Tomato & pineapple sauce	72,5%	$0,77 / 200g presentation	• 51% of the intermediate consumers would buy the product (78% of them were restaurants) • 61% of final consumers would buy it • A 200g presentation would be preferred at a $1,8 to $2,8price range.
Jam	52,0%	$1,75 / 250g presentation	• 67% of the intermediate consumers would buy the product (66% of them were minimarkets). • 70% of final consumers would buy it • The 250g presentation was preferred, in a possible price range of $1,8 to $2,4
Paste	24,9%	$2,63/ 200g presentation	• 53% of the intermediate consumers would buy the product (67% of them were restaurants). • 62% of the final consumers would buy it. • A 200g presentation would be preferred at a $0,6 to $1,2 price range.
Dehydrated tomato	4,4%	$27,87/ 200g presentation	• 32% of the intermediate consumers would buy the product (83% of them were restaurants) • 75% of final consumers would buy it • A 200g presentation would be preferred at $1,8 to $2,8 price range.

Source: (Brenes-Peralta & Gamboa-Murillo, 2015) , (Brenes-Peralta & Jiménez-Morales, 2015)

The physic-chemical characterization is not shown in this document, but acidity and soluble solids content were as expected for these processes, lycopene content is still under analysis by HPLC. As seen in table 1, the yield varies depending on the agro-industry process, and it is considered as acceptable on each case by the researcher's experience, even when "salad-type" and small caliber tomatoes were used. The yield is related to the formulation and the production scale on which the processes were done, and it influences the productive cost. The cost per gram was multiplied by the suggested unitary presentation from the market study, therefore it can be observed that some processes result very expensive at this scale and would present price-competitiveness challenges, while others would have the possibility to generate some profit after comparing the productive-cost and the price that potential consumers would be willing to pay for the suggested presentation. In terms of market pre-feasibility, the jam and the paste are the ones to present better acceptancy and commercial opportunity, closely followed by the tomato and pineapple sauce, over the dehydrated tomato. This is because of the acceptancy percentages shown in table 1, and the correspondence of the price range the consumer would be willing to pay and the processing cost.

Conclusions: The proposed formulations are technically viable, and products can be directed to different niches, for the jam was mostly accepted by minimarkets or convenience stores, and the sauce and paste were mostly accepted by restaurants. They showed a competitive production cost when compared to possible price. It is recommended to explore other market niches for the dehydrated tomato, since acceptance and cost were not satisfactory. Migration to Phase II has begun, showing that beneficiaries may consider value-adding strategies as a tool to avoid mass, economic, competitiveness and market losses. Trials will begin soon with a small processor to escalate a formulation of his interest, and achieve a market-ready product, using tomatoes that do not comply with commercial calibers. Further studies in the assessment of the impact of these strategies need to be carried out. The experience has been or will be replicated in blackberry and rambutan (Nephelium lappaceum) (Gamboa-Murillo, 2015), as well as in two small cooperatives which produce plum (Prunus domestica), avocado (Persea americana), apple (Malus spp) and guava (Psidium guajava) (Arnáez-Serrano, Moreira-González, Gamboa-Murillo, & Brenes-Peralta, 2015).

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Abstract # ADMI069

Blending maize and amaranth to control maize weevil during storage on smallholder farms

Carl J. Bern, Denis Bbosa, Thomas J. Brumm, Kurt A. Rosentrater, and Rashid A. Suleiman

Department of Agricultural and Biosystems Engineering, Iowa State University, Ames, Iowa 50011, USA

Corresponding Author: cjbern@iastate.edu

Amaranth (Amaranthus spp.) is used as a vegetable, food, forage and sometimes an ornamental. Grain amaranth has higher protein content compared to other cereals thus making it a good choice for human consumption and to help remedy world hunger and malnutrition (Tagwira et al., 2006). Maize is among the three most widely grown cereals in the world (CIMMYT and IITA, 2011). It plays a significant role in the lives of smallholder farmers, but experiences large post-harvest losses during storage and the maize weevil (Sitophillus zeamais) is the critical insect of stored maize in the tropics (Jacobs and Calvin, 2001; Longstaff, 1981, 1986). A possible method of controlling maize weevil is by storing maize mixed with amaranth, which we postulate will reduce interstitial spaces between kernels, overall void volume, and therefore, total oxygen available to weevils. In addition to limiting oxygen availability, filling the interstitial spaces leads to restricted movement of the weevils which in turn denies them access to kernels, making reproduction difficult. The combination of reduced access to maize and reduced oxygen may lead to reduced infestation. Laswai et al. (2013) observed varying degrees of control of maize weevils when they blended maize with crotalatia seeds, finger millet, or sorghum. The objective of this research was to determine the effects of blending maize with amaranth during storage on maize weevil mortality and maize quality compared to maize stored alone. Six 208-L (55-gallon) open head, unlined, steel barrels were used as storage containers. Maize weevils from infested commercially comingled maize were used as the source of infestation. Commercial comingled bulk maize used in this experiment was purchased from a local grain elevator with an initial moisture content of 13%. We used whole grain amaranth of variety Amaranthus Hypochondriacus with an initial moisture content of 11.7%. Three barrels were each loaded with 160 kg (353 lb) of weevil-free bulk maize three were loaded with this maize blended with amaranth (50:50 by volume). In total 84 kg (185 lb) of maize were blended with 96 kg (212 lb) of amaranth. Each barrel was seeded with 25 live adult weevils/kg of maize and placed upright in a 27 °C room. Once the barrels were loaded, tops were covered with screens to allow air circulation while preventing weevil escape. Representative samples were drawn every 40 days up to 160 days using a sampling probe inserted diagonally three times in each barrel. Weevil mortality was determined as described by Yakubu et al. (2010), and Gullan and Cranston (2010). Samples were analyzed for moisture content, test weight, visible mechanical damage, and broken corn and foreign material. Temperature and relative humidity of air inside barrels was recorded. Fig 1 shows the mean number of live maize weevils over time for the two treatments. The number of live weevils between the two treatments was not significantly different for 40, 80 and 120 d but it was significantly higher for maize stored alone at 160 d ($p = 0.0415$). On average, the maize-amaranth mixture reduced weevil population increase by 75%. There were many live weevils at the top with exposed kernels; a layer of amaranth may prevent this. There were no large differences in maize moisture or test weight between treatments. Visible mechanical damage, and broken corn and fine material were lower in barrels containing amaranth. After 160 days, the number of live weevils was significantly higher for maize stored alone. Differences in temperature and relative humidity were minor between treatments. Conclusion: Blending maize infested with maize weevils and amaranth (50/50 by volume) during 160 d

of storage reduced maize weevil population growth by 75% compared to maize stored alone. There were no major maize quality issues.

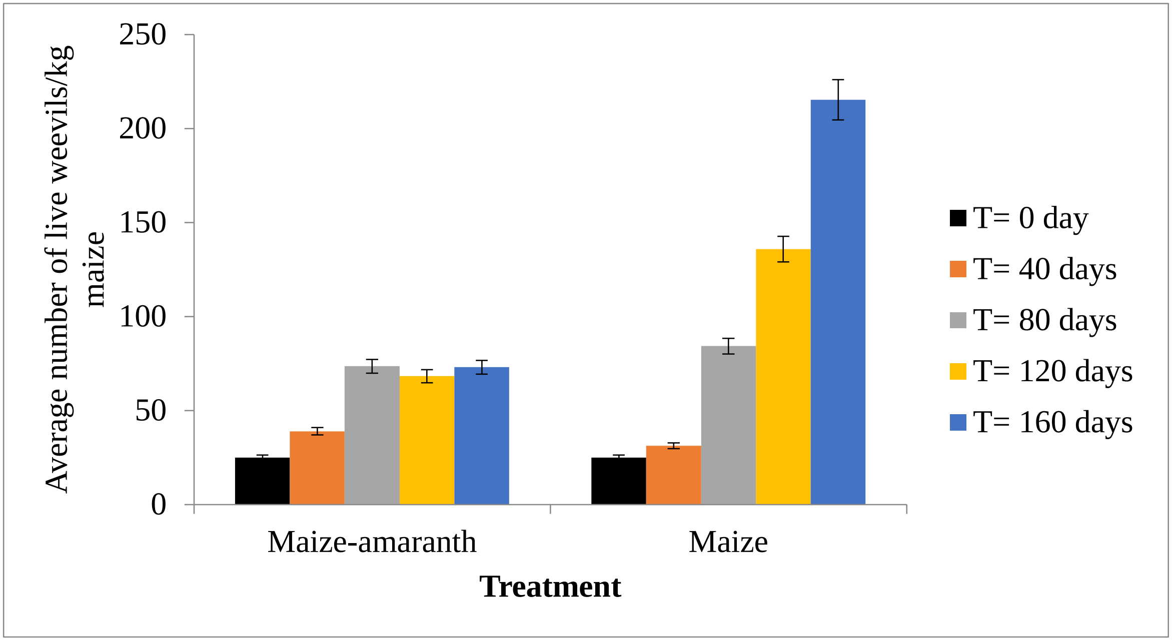

Figure 1. Live weevils/kg after different time periods for maize-amaranth mixture and maize stored alone. Average of three replications.

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Abstract # ADMI070

Hermetic Storage and Solar dryers Significantly Reduce Postharvest Losses

Philippe Villers

GrainPro, Inc., Concord, MA, USA

Corresponding Author: pvillers@grainpro.com

Millions of farmers with smallholdings in the developing world continue to have difficulty feeding their families. The double threat of high storage losses and growth of aflatoxin-producing molds create postharvest losses that can exceed 25% (1). By employing improved, ecologically sound drying methods and Ultra Hermetic™ storage, losses can be reduced to below 1%/year, even in tropical locations (2). The technology has been applied to a multiplicity of situations and in many different forms, but all rely on the same principle – the insects use up the available oxygen and die, molds cannot grow and moisture content stays constant. In addition, high seed germination percentage for both commercial and farmer seed can be preserved without refrigeration.

GrainPro Inc., as well as other companies has developed a variety of solutions to reduce postharvest losses using pesticide-free airtight storage and advanced solar drying technologies for a wide array of crops. These include rice, maize, pulses, coffee, cocoa, peanuts, and many types of seeds. GrainPro solutions are now used in 107 countries. Available forms of Ultra Hermetic storage range from the 25kg, portable SuperGrainbag™ to much larger, flexible storage units ranging from 250kg to 1000-tonnes (3, 4). Smallholder farmers also benefit from large-scale aggregators such as food reserve agencies that perform the critical function of leveling demand through the peak of harvest. This includes national food authorities such as the Tanzanian National Food Reserve Agency, National Food Authority of the Philippines. However, dry commodities intended for human consumption can be safely stored only if they are dried to at or below their critical moisture level. This varies by commodity and is defined as in equilibrium with 65% relative humidity. The high operating and capital costs of fossil fueled dryers are too expensive for much of the developing world. There is now increasing worldwide demand for efficient solar dryers and protection of commodities from the rain during drying. Such dryers include GrainPro's Collapsible Dryer Case™ solar dryers, and the Solar Bubble Dryer™, which leverages solar gain, uses forced convection and allows 24-hours/day drying to accelerate the drying process (5).

Ultra Hermetic™ storage is a chemical-free, organic way of creating an unbreatheable low-oxygen/high-carbon dioxide-rich storage atmosphere. An Ultra Hermetic storage environment is one where the rate of residual infiltration of air into the storage unit is less than the rate of respiration produced by insects, other microorganisms, or the stored commodity itself. These airtight conditions can be met by the use of specially manufactured modern flexible recyclable plastics, which, in their smaller sizes, can be 500 times more airtight than generally available single plastic compositions. For most commodities, low oxygen/high CO_2 conditions develop typically within 10-15 days at room temperature or above, and more slowly at lower temperatures. During that time, the storage atmosphere becomes unbreatheable with oxygen levels generally dropping below 3%, and carbon dioxide levels rising to around 15% or more, due to respiration alone. Under these conditions, all air-breathing life forms die naturally, without using any pesticides (6). In a few crops, such as peanuts, the process of achieving this reduced oxygen and high carbon dioxide condition takes much longer, sometimes as long as 30-days [7]. In such cases,

the injection of carbon dioxide or insertion of small oxygen-absorbing packets can accelerate the process.

By contrast, in the special case of green or parchment coffee, insect densities are too low to create low oxygen conditions. However, protection from humidity, and entrance of additional oxygen or outgassing of volatiles is prevented resulting in excellent preservation of quality for a year or more [8]. In many countries rodent protection is also an important issue to reduce postharvest losses. For this reason adequate protection techniques are needed, and accordingly rodent protection has been implemented in Ultra Hermetic containers. Growth of aflatoxin-producing molds is another major problem in many stored commodities including maize, rice and peanuts. Aflatoxin-producing molds affect public health by damaging the human immune system with serious consequences. When aflatoxin levels exceed 10 to 20 parts per billion (PPB) crops can be condemned and some customers, including the European Union, block imports. Dramatic increases in aflatoxin levels occur under conditions, suitable for mold growth, such as high humidity (over 65%) combined with high temperature, and long periods of unsafe storage. In the tropics, conventional commodity storage for more than two months causes rapid growth of aflatoxins, as shown in field studies by Icrisat in Mali, and Millennium Villages in Ruhira, Uganda [9-10]. Aflatoxin-producing and other molds do not die in Ultra Hermetic storage conditions, but they are denied both humidity and oxygen. As a result, their growth rates become negligible [11]. Low farm productivity starts with low seed germination rates. A significant problem in multi-month seed storage prior to planting, especially in hot, humid climates, is maintaining a high and predictable seed germination percentage. This is difficult whether the seeds are the farmers' own or high-performance hybrid commercial seeds. Seed germination can be protected by expensive and energy-consuming refrigerated storage, but it has been found that for a multiplicity of seeds equally good results are achieved by storing in airtight, Ultra Hermetic storage. Both local and regional seed producers in the Philippines, Kenya and Brazil now use this method on a commercial basis [12-13]. Hermetic seed storage is widely used with paddy, milled rice and rice seed and has been extensively studied by the International Rice Research Institute [14]. Pesticide-free Ultra Hermetic storage and solar drying units are effective in dramatically reducing postharvest losses. In an era of climate change, threatened crop yields and water shortages, storage loss reduction is essential. The use of Ultra Hermetic technology can reduce postharvest storage losses to less than 1% per year. Its widespread use in Africa, alone, would eliminate the continent's need for grain imports. Similarly, the public health hazard of excessive aflatoxin levels in tropical climates remains ubiquitous and yet is often preventable with proper drying and storage.

In conclusion, pesticide-free Ultra Hermetic storage plus improved solar drying are safe, environmentally responsible, energy-conserving technologies effective in protecting dry commodities, and therefore the income of smallholding farmers, both for the farmers' own family consumption, and for cash crops that small farmers need in the modern world.

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Abstract # ADMI071

Market Incentives for Food Safety and the Adoption of Post-harvest Technologies

Vivian Hoffmann and Kelley Jones

International Food Policy Research Institute, Washington D.C., USA

Corresponding Author: v.hoffmann@cgiar.org

Background: Post-harvest losses often include deterioration of food quality and safety, for example through fungal growth and contamination with mycotoxins (Magan and Aldred, 2007). Since food quality and safety may be unobservable to buyers, producers do not necessarily have incentives to invest in practices that would preserve their stored produce on these dimensions. Even when producers themselves are the ones to consume stored foodstuffs, lack of awareness of the health consequences associated with mycotoxins or other storage-related food safety problems, as well as resource constraints, may lead to poor post-harvest practices.

Objectives: This study documents the results of a randomized controlled trial testing two approaches to improving the post-harvest practices of smallholder maize farmers in eastern Kenya: subsidies for post-harvest technologies, and market incentives for maize that is free of the fungal contaminant, aflatoxin.

Design: The study sample consists of maize farmers in 30 villages in Meru and Tharaka-Nithi counties in Kenya, a region where aflatoxin contamination of maize leads to frequent and sometimes fatal outbreaks of aflatoxicosis (Daniel et. al, 2011). Maize farming households in 15 of the villages were randomly assigned to a technology treatment group. Farmers in the technology treatment group received access to a package of post-harvest technologies comprising use of a mobile maize dryer and hermetic storage bags. Within the technology treatment group, all households were randomly assigned to one of three discount treatments, which determined the price at which they could access the post-harvest technology: no subsidy, partial subsidy, or full subsidy (free provision). Farmers in the remaining 15 villages constituted the control group. Within each discount group, 50% of farmers were also assigned to a market incentive treatment. These farmers were told that they would be given the opportunity to sell up to 45 KG of maize at a premium of approximately 50% more than the market price, should this maize test below the regulatory standard for aflatoxin contamination. Researchers will visit households 3 months after harvest to purchase (in the incentive treatment) and sample stored maize. Both maize that the household plans to consume within the next two weeks, as well as home-grown maize the household plans to sell, will be collected from as all households who have such maize in store. The primary outcomes of interest are: 1) farmers take-up of the post-harvest technologies offered; 2) aflatoxin contamination of farmer's maize for home consumption and sale approximately three months after harvest.

Results: Results are not yet available; data on farmer's use of technologies has been collected but not yet analyzed; collection of maize samples for aflatoxin analysis is planned for May 2015. Discussion Post-harvest deterioration of food safety and quality more generally are not easily observable to farmers or downstream buyers. Encouraging adoption of practices to reduce such losses is challenging due to the absence of incentives at the individual or market level. Introducing market incentives for the supply of aflatoxin-safe foods has the potential to overcome these challenges. On the other hand, if market incentives are so strong that farmers achieve standards for their marketed produce through sorting â## this approach could lead to the concentration of less safe food in lower-value segments of the market. This study is the first to investigate the impact of market incentives, alone and jointly with technology

subsidies, on the safety of food sold and consumed by smallholder farmers in a developing country setting.

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Abstract # ADMI072

Reducing grain losses through the introduction of Mechanized Pearl Millet Threshing Tools in Senegal

Alexandra Spieldoch and Aliou Ndiaye

Compatible Technology International, St. Paul, MN, USA

Corresponding Author: Alexandra@compatibletechnology.org

Pearl millet is a nutritious, drought resistant grain with significant potential to contribute to greater food security in Senegal and throughout Sub-Saharan Africa. It is primarily produced by smallholder farmers at the household level and the hand harvesting, threshing, winnowing, and final preparation of the grain are performed almost exclusively by women. With over 230,000 millet farmers in Senegal, over 3.9 million millet farmers in West Africa, and over 95 percent of these farmers using the ancient mortar and pestle to thresh millet, the demand and need for an improved technology is immense.

The lack of improved postharvest technologies available to smallholders is a significant barrier to increasing pearl millet production, consumption and sale. Traditional methods of threshing pearl millet are tedious, inefficient, and produce low-quality, broken grain with limited market potential. Most modern, machine grain threshing technologies are designed for very large volume threshing and are expensive to purchase and inaccessible to many smallholders.

Typically, harvesting millet takes roughly 10 to 20 days per hectare. The manually harvested panicles (heads or ears) are sun dried for multiple weeks, then stored in thatch granaries, and when the pearl millet is needed, women thresh the panicles using a mortar and pestle or occasionally using sticks (beating-flailing). To reduce rancidity, care must be taken to avoid breaking or cracking the grain during threshing. The threshed grain is winnowed by tossing it in the air using shallow baskets, plastic tubs, or gourds. The postharvest processing is almost exclusively performed by women and girls.

Mechanized pearl millet thresher

Compatible Technology International (CTI) developed a mechanized pearl millet thresher designed specifically for smallholders. The CTI pearl millet thresher is a low-cost, manually operated device that significantly increases smallholder's millet production and grain quality while streamlining the pearl millet threshing process. The thresher was developed specifically for women smallholder farmers to reduce their drudgery and to improve their potential to generate income.

The thresher can process 20 kg of pearl millet an hour—roughly twice as fast as manual threshing with the mortar and pestle. The thresher is designed to be owned collectively by farmer organizations and women's groups to process their grain anytime and use it for local consumption, for storage or for sale at local markets.

Before introducing the tools in Senegal, CTI conducted baseline socioeconomic surveys with 179 rural households and 50 seed producers in Fattick, Kaffrine, and Kaolack—key pearl millet producing regions. In addition, Agricultural researchers and scientists at seed laboratories and the Institute of Food Technology were also interviewed to better understand the characteristics of the markets and gauge their interest in improved processing technologies.

During the 2014 processing season, CTI tested and measured the impact of the thresher in villages throughout Senegal, with support from Grand Challenges Award from the Bill & Melinda Gates Foundation. The research revealed several attributes commonly identified by clients:

- Better quality: Final millet is clean, unbroken, and free of both dirt and chaff reducing broken grain by 13% as compared to traditional methods
- Saves time: The thresher processes 20 kilos of grain in an hour—twice as fast as traditional methods and far less tedious
- Saves food: The thresher virtually eliminates millet losses during processing, reducing loss by less than one percent.

Launching distribution: In 2014, CTI launched the thresher in Senegal, with support from a USAID Feed the Future Partnering for Innovation award administered by FINTRAC. CTI established a technology showroom in Koalack, and local staff provided demonstrations, sales and training—targeting farmers' groups, women's groups, seed producers, and NGOs. Since launching, 105 threshers have been distributed. The majority of sales have gone to producer organizations, with 56% of sales to Farmers Groups and 33% of the sales to Women's Organizations. In addition, 4% of the sales went to Seed Producers (entrepreneurs who earn money selling high-quality seed grain for planting rather than consumption.), 4% to development organizations, and finally 2% to independent farmers.

Results: Farmers needs vary, and there's no one-size fits all technology. Since launching, sales to a mix of customer segments have demonstrated a strong demand for mechanized threshing. The field trials revealed that, at the household level, the CTI threshing technology immediately reduces food waste and boosts yields by 8%, in addition to improving smallholders' grain-quality and reducing women's drudgery. However, for many farmers, the opportunity to use the tools to earn income from the sale of high quality seed or rental of the tools was an important motivation. For these business purposes, a higher capacity, motorized thresher was a key request, as farmers were willing to pay more for the convenience, knowing they could see a return on their investment. As a result of this feedback, CTI has developed a new, motorized version of the thresher that is 20x more efficient than manual threshing, and affordable for small enterprises and village farmers' organizations to purchase and utilize as a group. For a next phase of research, CTI is adapting the equipment to thresh and winnow sorghum, in addition to pearl millet—another frequent request from smallholders.

Farmer training and local leadership are critical for strong developing country markets. CTI is providing the tools to farmers, working with women in particular as co-designers and customers. For example, CTI provides technical training and business training to farmer networks throughout the millet producing regions. CTI also works closely with public and private partners to develop local supply chains for manufacturing, distribution and repair of its tools, and to facilitate pricing and loans.

Conclusion

The launch of the pearl millet thresher confirmed a strong demand for mechanized threshing technologies and demonstrated farmers' willingness to purchase the equipment. In 2015 CTI launched a partnership with ANCAR, a Senegalese extension agency, to distribute the thresher to 100 farmers' organizations across the country over the next two years. In the next period, CTI is negotiating partnerships with Senegalese food processors to improve farmers' access to markets for high quality grain. And, CTI is working directly with women's groups to ensure that the thresher serves as a catalyst for leadership development, food security and gender equality.

Abstract # ADMI073

Lessons from Mitigation Post Harvest Losses in Tanzania

John Mwarai Macharia

Markets and Harvest management unit, Alliance for a green revolution in Africa-AGRA

Corresponding Author: jmacharia@agra.org

Introduction: In sub-Saharan Africa, post-harvest losses are estimated at 10-20% of total production for cereal crops, according to the Africa Post Harvest Loss Information System (APHLIS). Studies by various research and development agencies have shown varied results. For instance, the World Bank conducted a study in Uganda, Malawi and Tanzania and found national post-harvest losses for maize in these countries to be in the range of 1.4-5.9 %.

The use of hermetic technologies has been acclaimed as a way to tackle storage losses. Common hermetic storage solutions include metal silos, Purdue Improved Crop bags and hermetic cocoons. Among the benefits of these technologies is the generation of modified atmosphere in an environmentally safe and sustainable manner eliminating the need for chemical treatments, fumigants and climate control. Numerous research and development organizations have conducted adaptive research to test for the efficacy of these technologies, adapted for various crops and geographies. Limited studies have however focused research on the behavioral aspects that motivate and incentivise adoption of post-harvest technologies such as these.

In this regard, AGRA, in conjunction with the Rockefeller foundation are undertaking a participatory action research in Tanzania with the view of testing the efficacy of PICS bags, Metal silos and hermetic cocoons to solve the “good year” problem in Tanzania. The study also aims to establish the drivers of behaviour change in technology adoption. The study is being implemented with a view of providing answers to the following questions;

1. Adoption and behavior change: What techniques and approaches enable more rapid uptake of hermetic cocoons and post-harvest equipment?
2. Application: In what contexts are technologies appropriate?
3. Context: Are there specific village characteristics that cause the intervention to work more successfully in some locations than in others?

The study purposively selected 8 farmer cooperatives from areas that were experiencing a bumper harvest, from a frame of 63 cooperatives supported by AGRA Markets Unit in Tanzania. These cooperatives have a total membership of 4270 small holder farmers. The study also identified traders, non-governmental organization and government officials to participate in the study. All selected actors were trained on post-harvest management aspects relevant to various stages of loss and their roles in the value chain. All participants were trained on grain grades and standards approved by the East Africa Community (EAC). Hermetic technologies we introduced to the study participants and trainings on their effective use was also conducted. Technologies. Six appropriate test protocols were later established that included 6 hermetic cocoons, 10 metal silos and 315 PICS. Data was collected using qualitative methods. In particular focus group discussions were conducted for different actors using structured questionnaires. Data analysis took a deductive approach, grouping data and looking for similarities and differences.

Intermediate results from focus group discussion show that:

Adoption and behavior change: Farmers do not understand technical underpinnings of technologies and there is need to build their capacity in this area. There is need to combine capacity building with practical demonstrations that involve all actors in the setup of technologies and sharing of results. It is invaluable to provide farmers with options as their postharvest issues are not homogeneous. In the study, women preferred PICS bags as they fit well with daily cooking chores and don't require much space in the homestead. Men on the other hand prefer metal silos due to their durability .To improve uptake it is vital to involve government and private sector players as they can improve factors that encourage adoption. It is important to work out the economic costs of various technologies or practices with farmers. Having technologies readily available is important to farmers, as such it is important to work with local agrodealears or other private sector players that can keep promoting, distributing and making technologies available.

Application: PICS bags and Metal silos are more applicable for short term storage at the household level. Farmer organizations and traders prefer much larger solutions that are more suited to large volumes and duration of storage. When considering appropriate technologies for traders and aggregation centers, it is important to ascertain the approximate cost of current post harvest methods so as to ensure that proposed solutions actually provide a cost benefit. Metal silos are considered a good solution in areas with rats while PICS bags are considered appropriate against grain weevils.

Context. Various institutions have tried to introduce the hermetic storage solutions in Tanzania with little success. However when the same solutions were presented when the country was undergoing a bumper harvest and had shortage of storage facilities, participants readily accepted to test the technologies. The NFRA and government also accepted to test the efficacy of hermatic cocoons as short term and cheaper solutions compared to traditional silos and ware house (brick and motor).

Conclusion: The efficacy of hermetic technologies to solve post-harvest issues has been proven through this and many other studies. However for value chain actors to take them up, it is important to consider:

Produce market prices: Farmers aggregate for speculative purposes. In Tanzania, farmers store produce for an average of three months and sell produce when prices are much higher. Farmers only stored grain for two months and opted to sell produce when the price rose to US 530 per metric ton

Value chain Actors: For successful adoption of post-harvest solution, it is important to involve all value chain actors and policy makers. Private sector should be involved as they can manufacture, distribute and avail technologies at the local level.

Technology options: Different value chain actors handle different volumes and would require technologies that meet their volumetric needs. Actors also have different post-harvest problems. As such it is important to provide a range of solutions that solve different post-harvest issues and volumes.

Access to finance: value chain actors need access to finance to procure post-harvest technologies. Technology manufacturers need working capital to enhance production and distribution links to ensure technologies are easily accessible to farmers.

Economic benefits: It is important to undertake an economic analysis of the benefits of proposed solutions Vis a Vis current practices.

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Abstract # ADMI074

The Economics of Post-Harvest Loss: A Case Study of the New Large Soybean- Maize Producers in Tropical Brazil

Peter Goldsmith

University of Illinois at Urbana-Champaign, USA

Corresponding Author: pgoldsmi@illinois.edu

Introduction: Reducing post-harvest loss (PHL) of grains and oilseeds allows farmers to keep more of their crop and increases grain supplies, which is critical in a world where resources are scarce and rural developing economies struggle. The micro economics of loss reduction are not well understood, even though the policy goals are well documented. Little research focuses on the role the farm manager plays reducing loss. More specifically, why would a rational farmer accept loss? The research setting is the fast growing tropical maize and soybean region of Mato Grosso, Brazil, the largest agricultural state in the world. We focus on a new cultural practice in the tropics where farmers, using adapted soybean varieties plant and harvest early allowing the planting and harvesting of a maize succession crop. This new system, is called "safrinha", the Portuguese word for little or secondary crop. The safrinha system is unique to tropical farmers and allows significant improvements in land factor productivity (Goldsmith and Montesdeoca, 2015). The results also provide insights into the added complexities of tropical grain production where high moisture environments and poor infrastructure challenge the harvest, transport, and storage of grains and oilseeds, and as a result promote loss.

Objectives: Specifically in this research we seek to model and test a general model of PHL. In doing so a key objective is to introduce the concept of opportunity costs as rational farmer behavior that raises PHL. Specifically we seek to test the hypothesis that farmers willingly tradeoff higher soybean PHL in order to plant the succession maize crop. Testing this hypothesis allows for an understanding that PHL levels may include a significant component that is a function of opportunity costs. That is, managers rationally may elevate the level of PHL. The implication for policy makers and equipment manufacturers is that managers may not only face loss due to uncontrollable events, say weather, or technical inadequacies, say due to under development, but that there exists a third component, high opportunity costs, whereby managers explicitly allow PHL levels to raise.

Methods: First assume soybean output is Y_s, and there are only two inputs, X_1 and $\overline{X_2}$. X_1 is the level of soybean PHL mitigation, and $\bar{X}_2$ are all inputs to produce soybean, and for simplicity $\bar{X}_2$ is fixed. So $\bar{X}_2$ are positive inputs directly producing Y_s, and X_1, PHL mitigation, is an indirect input affecting Y_s. The production function is defined as:

$$Y = f(X_1 , \bar{X}_2) \quad (1)$$

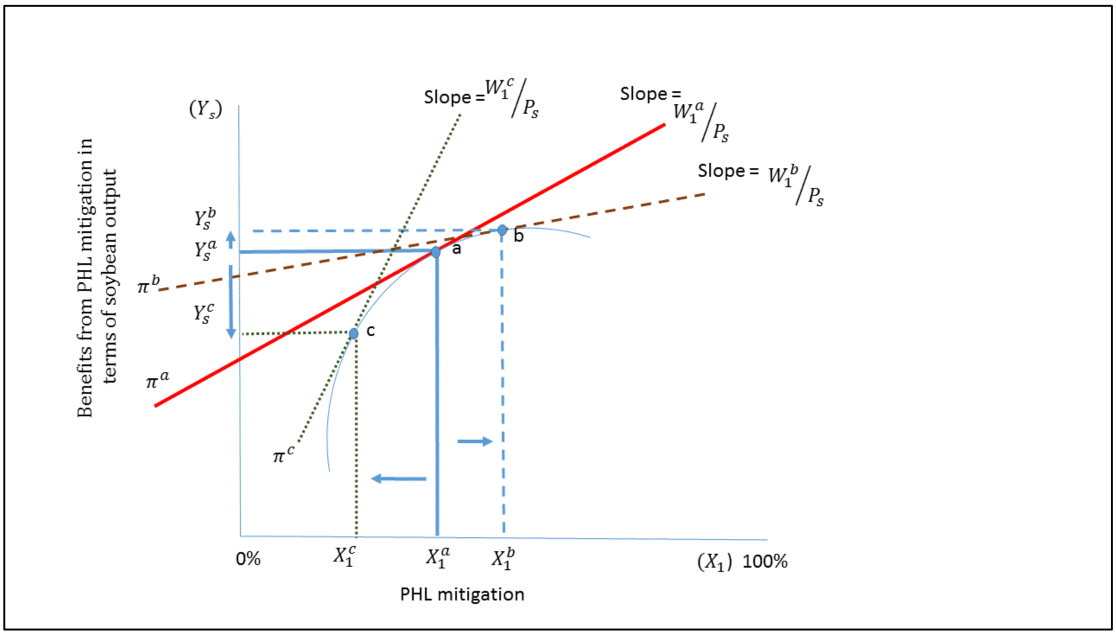
The manager then maximizes profit in the following manner:

$$Max_{X_1} \; P_s Y_s - (W_1 * X_1) - (W_2 * \bar{X}_2) \quad (2)$$

Where P_s reflects the soybean price. W_1 is the cost to reduce soybean PHL measured in maize opportunity costs, which is a function of maize revenue (yield and price). W_2 are the costs associated with all the other inputs. W_1 captures a variety of activities associated with PHL, for example; desiccating soybean, reducing combine reel or running speed, increasing combine maintenance and adjustment, using truck bed liners, employing on-farm storage, or training employees. So ceteris paribus, when W_1 rises, the opportunity costs measured in maize incent managers to increase soybean PHL, and when W_1 falls, say due to a fall in maize prices, smaller levels of soybean PHL occur. Solving the profit function for Y_s as a function of X_1 results in the following:

$$Y_s = \left({}^{\pi}/_{P_s}\right) + \left({}^{W_2}/_{P_s} * \bar{X}_2\right) + \left({}^{W_1}/_{P_s} * X_1\right) \quad (3)$$

Where, $\left({}^{\pi}/_{P_s}\right) + \left({}^{W_2}/_{P_s} * \bar{X}_2\right)$ depicts the Y_s intercept. ${}^{W_1}/_{P_s}$ reflects the slope of profit line (π), which is the marginal product of PHL mitigation in terms of Y_s and the tangency point with the production function $f(X_1, \bar{X}_2)$. The base level of PHL mitigation, X_1^a (point a), falls within the range of 0% and 100% as can be seen in figure below.



The research method involves five important steps in order to establish the validity of the case study of large producers operating in the tropics. First, in depth interviews were conducted with a focus group of seven farmers in Mato Grosso in June of 2012. Second, a survey instrument was developed with the aid of the results of focus group, and then individually administered to the focus group farmers. Third, researchers followed up the survey seeking comments about the survey from the focus group farmers. Fourth, these comments help produce version two of the survey, which was then pre-tested with a sub-sample of our population. Finally, with the results of the pre-test, a final online survey was administered in December 2012 to 1,902 producers of the soybean and maize association of Mato Grosso (Aprosoya). The survey queried producers across a number of PHL relevant topics. We specifically test a farmer's decision to accept soybean harvest losses. The following model estimates when farmers are more or less likely to accept soybean harvest losses in order to produce more maize:

$$ACCEPT\_PHL = \beta 0 + \beta 1Factor1 + \beta 2Factor2 + \beta 3Factor3 + \beta 4Factor4 + \beta 5On\_Farm\_Storage + \beta 6Combine + \beta 7Maize\_price + \beta 8Risk\_lover + \beta 9PHL + \beta 10Age + \beta 11Education + \beta 12Double\_crop + \varepsilon$$

Results: The conceptual and empirical models attempt to explain why PHL levels, in part, remain more than double the technical minimums and higher than societal expectations. Specifically the dependent variable reflects a manager's stated willingness or lack of willingness to accept higher levels of soybean PHL in order to plant a succession maize crop. Producers that hold weak (strong) demand to reduce loss, Factor 2, are significantly (.10 level) and positively willing to accept greater (lower) levels of loss. This coefficient suggests that higher scores for "My demand to reduce loss is weak" increases the probability of accepting soybean harvest loss. In terms of marginal effects, any point increase in Factor 2 increases the incentive to accept loss by 20%. The positive and significant relationship between the factor and the dependent variable makes sense as producers appear to differentially value loss, though they face the same grain prices. This result is consistent with the conceptual model's logic that a relatively high opportunity cost when valuing soybean mitigation, in terms of maize revenue, reduces PHL mitigation efforts.

The negative sign on the item, "Lack of training for operators is one important factor affecting PHL", may suggest that managers do not link operator training with loss reduction. At issue is a possible disconnect between weak private incentives to train employees about PHL mitigation and a policy imperative seeking lower levels of loss. Thus there might be benefits to public policies supporting curricula that include courses or modules on PHL mitigation, as the private sector appears to have weak incentives to do so. Factor 4 builds on the weak valuation of loss explored with Factor 2, by having respondents directly state if the benefits of reducing loss are lower than the benefits of maize production. The expected sign is positive and the results are significant at the .01 level. Higher scores for "The benefits of reducing loss are lower than the benefits of the safrinha" increase the probability of accepting soybean harvest losses. Any point increase in Factor 4 increases the chance to accept loss by 33%. The result provides evidence that producers are incented to produce positive losses, and these losses are rational. The finding also supports the proposition that positive loss is not only a function of uncontrollable events and technical inadequacies, which previous research shows, but opportunity costs as well.

Having on farm storage serves as the second largest driver to increase PHL in terms of marginal effects. The positive coefficient estimate on on-farm storage is positive, as expected, and significant at the .05 level. Farmers are more likely to accept PHL when producing a safrinha if they have on-farm storage. In terms of marginal effects, farmers who have on-farm storage are 42% more likely to accept an increment of soybean harvest loss.

Conclusion: Preventing loss and increasing food production are two feasible alternatives to meet the future worldwide demand for food. It is commonly thought that increased food production results from loss prevention. Our results present a counter factual setting, where the relationship does not hold. Farmers are rational profit maximizers and increasing PHL can be optimal in the case of double-crop systems in low latitude countries, where "time" is a critical variable and weather is uncertain. The results help explain the conundrum of why a manager accepts controllable loss.

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Abstract # ADMI075

Efficiency of the Scylla Serrata Crab Fishery Value Chain (Madagascar) Boosted by Simple Low Cost Interventions

Zbigniew Kasprzyk[1], Florence Wallemacq[2], Yann Yvergniaux[3]

[1] International consultant
[2] Indian Ocean Commission-SmartFish Programme
[3] Indian Ocean Commission-SmartFish Programme

Corresponding Author: Florence.Wallemacq@fao.org

Introduction: The Indian Ocean Commission SmartFish Programme is a regional fisheries programme managed by the Indian Ocean Commission, funded by the European Union and co-implemented by the Food and Agriculture Organization of the United Nations. Operating in twenty countries throughout the Indian Ocean Region, Southern and Eastern Africa, the project focuses on fisheries governance, management (UNFAO), monitoring control and surveillance, trade, and food security (UNFAO).

The mud crab fishery in Madagascar is an exclusively traditional/artisanal fishing activity, composed of on-foot or pirogue fishers using very simple fishing techniques and gears, such as hand lines or hooks mounted on sticks and with no proper storage and transport equipment. This is mainly due to the fact that Malagasy mangrove forests, the natural habitat of the Scylla serrata crab, are often in remote and difficult to access areas.

Over 80,000 people are estimated to be involved in crab collection in Madagascar. Recently, the high demand on the international market has pushed this traditional activity to become more export-oriented (over 75% of the production), which has led to the development of complex collection channels and constant increases in production.

Objectives: IOC-SmartFish has been, over the past years, supporting a series of interventions aimed at improving the value chain efficiency of the crab industry in Madagascar.

The initiative is based on the result of a Value Chain Analysis (2012) that highlighted the limited value chain efficiency due to the high mortality rate of crabs and identified the critical stages in the chain where this was happening: the storage points at village level and during transportation. A post-harvest loss assessment using the mobile-phone technology confirmed that poor handling practices and inadequate equipment are the main causes of crab mortality. Because it becomes toxic, the dead crabs cannot be eaten and are therefore discarded.

This results in high cumulative post-harvest losses of 23% on average with peaks of over 50% during rainy season. In financial terms, post-harvest losses are estimated at 4 500 000 euros per year. The highest mortality rates (16%) are observed at the stages of storage in collect places and delivery to factory/market on the coast. The findings of the analysis established baselines from which the stakeholders (fisheries officials, crab fishers and operators) set an improvement target for loss reduction, which was “a reduction by 1/3 by end of 2015”. This commitment was the basis for the programme’s interventions that have been targeting the West coast and Northern coast of Madagascar since 2013.

Approach: The analysis of the losses led to the selection of a few key interventions which proved profitable economically and sustainable hence providing impact in terms of loss reduction and increased income for beneficiary groups/fisheries operators.

A first set of interventions consisted of a combination of awareness raising activities and direct on-the-job capacity building of mud crab collectors and trade operators through the design and use of improved, but simple, crab storage and transport facilities that had been previously tested – the most effective, economically viable and socially accepted ones being selected to constitute the pillar of a larger field sensitization campaign. The campaign started in 2014 and continued in 2015. Activities were conducted in 73 villages (regions of: Antsimo Andrefana, Diana, Menabe and Sofia) and included the construction of fixed tanks and storage sheds using local materials; the enhancement of carts, utilizing boxes rather than fragile baskets to prevent damage to the crabs; the construction of storage shelves for canoes; and the introduction of a low cost innovative type of trap for harvesting the crabs, which is a viable alternative to the traditional hooks that cause physical damage to the crabs and their habitat (mangrove).

The heart of the campaign is the vulgarization of these techniques through the diffusion of a comprehensive technical manual, an educative comic strip for children, demonstration workshops in towns and a mobile campaign for demonstration in villages located in remote areas. A community fisheries-based competition on the theme of ‘Value addition for crabs’ was also organized to increase community involvement and gather new ideas for additional post-harvest losses reduction activities along the value chain.

Stage of the Value Chain	Intervention	PHL before intervention (%)	PHL after intervention (%)	Additional revenue per unit (USD)	Amortization period (months)
Storage (fishermen)	Construction of tidal cages and pens	5.5	1	3/week	7 weeks (2 months)
Storage (small collectors)	Construction of storage sheds	14,0	10,3	55/shipment	6 shipments (2 months)
	Construction of tidal shed	10,0	1,0	10/shipment	3 shipments (1 month)
Ground transportation (collectors)	Upgrading of carts	14.0	5.8	12/trip	11 trips (4 months)
Maritime transportation (collectors)	Construction of wooden boxes instead fragile baskets	25,0	11,0	60/trip	3 trips (1 month)

The complementarity of these interventions has been developed to reach the entire crab chain actors: from fishermen to exporters, all along with the fisheries authorities' collaboration. In addition, three crab markets of regional significance where rehabilitated for enhanced marketing environment and improved quality and hygiene conditions, which also contributed to reducing losses at retailer level.

Findings: The last post-harvest losses assessment recorded, in most pilot sites, a reduction of mortality rates from 22% (pre-project status) to an average of 17% within 12 months, hence very close to the target set. Moreover, some collectors who fully adopted the innovations have recorded losses below 15%.

Conclusion: The longer term aim is to reach a mortality rate that is below 10% by the end of 2017 as well as adapting the materials developed for Madagascar in order to make it widely available to other crab fishing countries where similar problems exist.

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Abstract # ADMI076

Scientific Animations Without Borders: High Throughput Global Development and Deployment of PHL Reduction Educational Content

Julia Bello-Bravo, Barry Robert Pittendrigh

University of Illinois at Urbana-Champaign

Corresponding Author: juliabb@illinois.edu

Cost-effective and locally appropriate Post Harvest Loss prevention technologies have and will continue to be developed in both academic and non- academic settings. Many of these approaches involve educating a population on a given set of techniques or how to develop or use a certain form of technology. The challenge emerges on how can we, as a global community, share this content in a cost-effective, systematic and highly efficient manner? This problem is further complicated by the fact that many of the people who could benefit the most from many of these PHL prevention innovations are low-literate learners that speak a multitude of different languages and come from many different cultural backgrounds. Scientific Animations Without Borders (SAWBO) is a University of Illinois at Urbana-Champaign program that addresses the academic and practical aspects of these aforementioned questions.

To this end, SAWBO has developed a “one step” approach, connecting global expert knowledge directly with in the field educators and low literate target audiences. SAWBO creates high quality animations on PHL prevention topics with global experts in a virtual, hyper-collaborative and highly cost effective manner. Animations are then placed into numerous languages from around the planet through a global volunteer network. Finally, all content is made freely available on a variety of on and offline platforms. All content can be shared using video-capable devices such as cell phones, tablets, computers, DVD players, TVs and projectors. Recently, SAWBO has released an App that allows global educators to easily access and share this content and in turn this App is allowing SAWBO to document global use of educational content.

Although SAWBO educational content is given out freely, essentially SAWBO represents a “wholesaler” of educational content that “retail educators” (those working directly with target audiences in developing nation countries) can simply use in their educational “retail” activities.SAWBO has and is routinely producing PHL educational content, with global experts on topics including, but not limited to, low-cost grain drying strategies, hermetic sealing of grains to prevent insect attack, safe storage and transportation of grains, simple tests for grain moisture levels. These animations have been placed into languages important both in Africa as well as in India and Bangladesh. Such content is then made available to any group wishing to use it directly in their educational programs. SAWBO is continuing to document the use and outcomes of the use of these educational materials by “retail groups”, e.g., NGOs, universities, government agencies, and local TV stations, in developing nation countries.

In parallel, SAWBO has continued to perform research studies on the acceptability of this educational content across diverse cultural settings, learning gain studies in low literate learners, viral cell phone animation spread experiments in rural settings in West Africa, and finally experiments comparing the effectiveness of cell phone animation education in technology adoption of PHL technologies as compared to traditional extension strategies. Here we present an overview of these studies and how their collective results have laid the foundation for a high throughput strategy, low cost and highly effective education deployment strategy for PHL technologies for farmers in developing nation counties.

The SAWBO strategy is now ready for scaling. Interestingly, the SAWBO system also has broad applications, as well, in the developed world content. We will also explain how these approaches are being tested in settings in Illinois as a highly cost effective alternative to traditional extension approaches.

Abstract # ADMI077

Global Partnerships for Global Solutions: An Agricultural and Biological Engineering Global Initiative

Mary Leigh Wolfe[1], Lalit Verma2, Terry A. Howell3, Ajit Srivastava4, K.C. Ting5, Sreekala G. Bajwa6, Dorota Haman7, Darrin Drollinger8

[1]Virginia Tech, Blacksburg, VA
[2] University of Arkansas, Fayetteville, AR
[3] McKee Foods Corporation, Collegedale, TN, USA
[4] Michigan State University, East Lansing, MI, USA
[5]University of Illinois at Urbana-Champaign, Urbana, IL, USA
[6] North Dakota State University, Fargo, ND, USA
[7] University of Florida, Gainesville, FL, USA
[8]ASABE, St. Joseph, MI, USA

Corresponding Author: mlwolfe@vt.edu

Agricultural and Biological Engineers (ABEs) strive to ensure that the necessities of life are provided in a sustainable manner. They apply engineering principles to processes associated with managing natural resources and producing agriculturally based goods. The American Society of Agricultural and Biological Engineers (ASABE) has a long history of providing resources to help its member engineers solve problems in food, agriculture, natural resources, and the environment. Recognizing the need to connect its members and partner societies to address emerging challenges as a global community, ASABE implemented an initiative in 2012 toward achieving its global vision: “ASABE will be among the global leaders that provide engineering and technological solutions toward creating a sustainable world with abundant food, water, and energy, and a healthy environment.” At the 2013 ASABE Annual International Meeting (AIM) in Kansas City, Missouri, an invited session was conducted during which members and colleagues from around the world shared critical needs in agricultural and biological engineering from their respective regions. The following year, Global Engagement Day activities at the 2014 ASABE AIM in Montreal, Quebec, Canada, began with invited remarks by internationally recognized thought leaders on the themes of sustainability, climate change, food security, energy security, and water security. The day concluded with an interactive session identifying global challenges and opportunities for agricultural and biological engineers in each of these five thematic areas. The ASABE Global Engagement Task Force synthesized the presentations and discussions to develop the following goals for the Agricultural and Biological Engineering Global Initiative: (1) Improve food productivity; (2) Reduce food losses and waste; (3) Enhance energy conservation and efficiency; (4) Develop adaptable renewable energy systems; (5) Improve water availability, conservation, and efficient use; and (6) Provide clean water for multiple uses (human consumption, agriculture, recreation, ecosystem services, biodiversity, etc.). Objectives (1) and (2) focus on food security, with objective (2) specifically including reduction of postharvest losses. Food security is comprised of four components: availability of a consistent food supply, access to sufficient resources to produce or purchase food, ability to store and preserve food for an adequate shelf life, and opportunity to make healthy, nutritious dietary choices. For many people in the world today, one or more of these four components are missing, and their food insecurity is a critical problem. As the global population grows toward nine billion people, the security of food systems will continue to be a challenge. ABEs play a critical role in addressing food security by providing solutions to improve food productivity. These efficient production systems must be extended beyond the developed world. The second major area in which ABEs will influence food security is in reducing postharvest losses and food waste. Postharvest losses in many

areas of the world result in up to 40% of food becoming unfit for consumption. Again, solutions developed by ABEs will be necessary to reduce these losses and preserve food. By increasing the productivity of available land and then extending the life of the food produced on the land, food security can be attained for the growing world. ASABE has identified three specific objectives that ABEs are pursuing toward reducing food losses and waste (goal 2 of the ABE Global Initiative): (1) Develop methods to quantify losses in production, processing, and distribution; (2) Develop real-time prediction and monitoring of product quality and safety; and (3) Design scalable, regionally appropriate harvesting, drying, storage, processing, and handling systems to minimize loss. ASABE is working with partners around the world, and developing new partnerships, to help achieve the objectives. ASABE publishes relevant information in different formats, provides venues for sharing information and networking, and develops relevant standards. ASABE is organizing an international conference on food security to be held in fall 2016 in Africa. The purpose is to bring together partners from around the world to share information on improving food productivity and reducing food losses and waste. ASABE has prepared a document entitled “Global Partnerships for Global Solutions: An Agricultural and Biological Engineering Global Initiative” that outlines the grand challenges that the world is facing, highlights the specific needs of the three “security” themes (food security, energy security, and water security) in the context of sustainability and climate change, and specifies how ASABE, its members, and its partners will address these grand challenges as the year 2050 approaches. The document includes specific objectives for each of the six goals listed earlier in this abstract. The Global Initiative document will assist ASABE in advancing the role, relevance, and importance of the agricultural and biological engineering profession to policy makers and funding agencies, as well as to potential partners and collaborators, with the goal of addressing food, energy, and water security challenges.

Abstract # ADMI078

Education platform for PHL, extension and implementation of technologies in fields in Latin America

Graciela Pereira and Nelson Avdalov

Centre for Marketing Information and Advisory Services for Fishery Products in Latin America, Montevideo, Uruguay.

Corresponding Author: Graciela.Pereira@infopesca.org

Postharvest loss (PHL) in fisheries can be among the highest for all the commodities in the entire food production system. There are three types of loss considered: physical loss, quality loss and market force loss. The physical loss of material is caused by poor handling and preservation or the discarding of by-catch. Economic losses occur when spoilage of wet fish results in a value-decrease or when there is a need to reprocess processed fish, raising the cost of the finished product. In addition, inadequate handling and processing methods can reduce nutrients, leading to nutritional loss. Similarly, the lowering of large quantities of fish catches into animal feeds can be considered under certain conditions as a "loss" for human food security.

The main PHL in Latin America (LA) are due to:

- Infrastructure and technology gaps
- Access to production inputs (improved processing equipment, ice…)
- Lack of knowledge and awareness
- Poor hygiene and handling practices
- Market dynamics

Since 1995, the Department of Projects of INFOPESCA has been developing several projects in LA with a component on PHL. 20 countries were trained and advised on implementation of different practices and technologies. All the projects aimed to develop tools for practical loss assessment in artisanal fisheries and seafood processing plants. INFOPESCA provided capacity building for fishery officers, fishermen, and personnel of seafood processing plants in qualitative and quantitative fish PHL methods.

The fieldwork indicates that PHL occur at all stages in the fish supply chain from capture to consumer. Huge physical and quality losses were found to occur in some supply chains assessed in all the countries. To try and reduce or prevent losses, various coping strategies are used by fishermen, processors and traders with varying degrees of success. Despite these, losses still occur, hence the need for careful and continued technical and policy initiatives by national authorities. Reducing spoilage requires improved fish handling on board, processing, preservation, transportation and commercialization all of which are particularly deficient in small-scale fisheries.

For many years, INFOPESCA has implemented a wide range of activities, including training of fishermen, authorities and fish technologists, in Latin American countries, to introduce appropriate technologies for lowering fish spoilage, especially for small-scale fisheries and seafood plants. INFOPESCA’s projects have also aimed to improve handling practices, especially in small-scale fish landing sites, and fish preservation methods such as smoking, drying and salting. INFOPESCA also provides consumer education about different fishery species and the benefits of seafood consumption.

Local food habits for local markets and sanitary requirements and marketing strategies for international trade are essential components that require adequate priority in product development. However, there is a change towards successful relocation of labour-intensive product value addition to developing countries. This is well illustrated by the salted anchovy industry in Latin America.

The combination of market signals (the gap between supply and demand) and environmental pressures (including ecolabelling and quality labelling schemes) are particularly favourable for bettering the current situation. There have been several successful improvements of fishing gear and practices in the past years that have reduced the catch of juvenile fish and non-target species. The growing awareness and involvement of the industry is a factor of success for the implementation of sustainable fishing technologies and practices in addition to increasing fish quality requirements in the main import markets.

Minimizing PHL is therefore one key to increasing revenues and food security, without intensifying the fishing effort. Improved processing techniques are a large part of the answer. Low-cost techniques have been developed by many fishing communities, most often by the women, who are mainly responsible for the fish after it is landed.

Abstract # ADMI079

Benefits of Training Stakeholders across the Grain Value Chain – A Capacity Building Effort in Nigeria

Klein E. Ileleji[1], George P. Opit[2], Samuel G. McNeill[3] and Harold V. Tarver[4]

[1]Purdue University, West Lafayette, IN

[2]Oklahoma State University, Stillwater, OK

[3]University of Kentucky, Princeton, KY

[4]USDA-Foreign Ag. Service, Washington DC

Corresponding Author: ileleji@purdue.edu

Introduction: Grain commodity demand in Nigeria is about 5.4 mil MT per annum and worth about NGN 600 billion (US$ 3.72 billion) (USAID MARKETS, 2013). The national storage policy of the Federal Government of Nigeria (FGN) stipulates that 5% of food production be stored by the federal government for strategic reserve purposes, 10% by the state government as buffer stock, and 85% stored on-farm by individual producers or by merchants in food warehouses (Ileleji et al., 2009). An in-country evaluation of Nigeria's commodity storage and management infrastructure by Ileleji et al. (2009) concluded that despite having up to 1.3 million tons of modern bulk storage capacity and more than 48 warehouse structures for its strategic grains reserves program (SGR), unsatisfactory management of stored grain by staff at these facilities resulted in huge post-harvest losses (up to 50% in some cases) (Fig. 1). Losses incurred were primarily due to the lack of adequate knowledge and implementation of sound stored grain management practices. Huge losses, estimated at 15-30%, both physical and quality losses, were also incurred along the value chain in on-farm and warehouse storage in the private sector.

Fig. 1. A view at one of the SGR facilities located in Akure, Ondo State (March 2010).

Objectives: The team of evaluators from three US land-grant universities (Purdue University, University of Kentucky, and Oklahoma State University) recommended developing training modules that addressed stored grain management at all three levels (strategic reserves, buffer storage and on-farm storage) of the commodity value-chain in Nigeria. The primary goal of this paper is to review the capacity building efforts that began in 2010 involving the training of stored grain managers, Extension agents, grain merchants and university faculty and students; this paper particularly highlights the benefits of training at all levels of the commodity value chain.

Approach: This work reviews the capacity building efforts in the stored grain commodity sector of Nigeria, which has been carried out since 2010 by faculty from three US land-grant universities. Approximately 371 personnel have already been trained in five workshops that were held in four different locations, namely, Makurdi, Akure, Abuja, and Ibadan in Nigeria. We review the efforts undertaken and outcomes achieved on the project based on reports submitted by the training team to the United States Department of Agriculture-Foreign Agricultural Service (USDA-FAS), feedback from the impact assessment conducted by the International Institute of Tropical Agriculture (IITA) in Ibadan, Nigeria and feedback from the program managers at USDA-FAS.

Results: Impact assessment conducted by the International Institute of Tropical Agriculture (IITA) in Ibadan and feedback from participants indicates that outcomes such as improved sanitation and reduced pesticide use, which reduce insect pest pressures and worker exposure to chemical insecticides, respectively, have been observed in facilities whose manager(s) took part in one or more of the trainings offered. Stakeholders who attended the courses on stored grain management included senior, mid and junior level managers of stored grain facilities, technicians, Extension agents, researchers, and university professors. The ultimate goal is to build capacity within Nigeria to sustain recurring training, post-harvest technology development/adoption and certification that will sustainably impact post-harvest losses across Nigerian grain value chains.

Conclusions: It is only when grains, which are tradable monetary instruments, can be safely secured and their value preserved in storage that farmers benefit from increased crop productivity. Our premise is that the security provided by reliable storage infrastructure is as important as stored grain management provided by the stored grain manager or farmer. Therefore, as we deploy resources toward appropriate and advanced technologies to reduce post-harvest losses, we must note that the first step in reducing losses is equipping farmers, grain merchants and stored grain managers with fundamental knowledge about best post-harvest management practices that would preserve the value of their commodity, even when simple storage systems are utilized.

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Abstract # ADMI080

Memorable Whiteboard Videos to Empower Postharvest Trainers

Nigel Banks

Postharvest.Co Limited, New Zealand

Corresponding Author: nigel@postharvest.co

Introduction: Do you ever wonder why the food systems you work with keep getting wrong-footed by variable product behaviour? It's true that food systems are inherently catastrophic because of the host of delicate balances involved in maintaining quality. But it seems that your system already has potential access to all of the technologies needed to achieve better results. What you don't have is a system built on people and processes that fully manage variable behaviours in both product and wider systems. How can you easily and effectively get best practice knowledge and concepts distributed to everyone throughout your system to mitigate losses?

Animated whiteboard videos are now well established as a medium for engaging, and enhancing learning in, diverse learning communities. They can also deliver information online and to learner groups through large numbers of sessions and to very large numbers of people with continued fidelity. On a recent training program in Thailand, extension workers from six Asian countries came together and translated and re-recorded the script of a postharvest training video. Each of them encountered the conceptual contents of the whiteboard video in an intense and powerful way - through word by word translation. When the new audio track was attached to the video, they were able to take home not just a set of notes but a high quality extension tool in their own language, their own words and their own voice, potentially establishing them as leaders in this area of knowledge.

I am excited by the potential for rapidly scaling up international collaboration and delivering whiteboard videos to communicate best practice postharvest technologies and mitigate postharvest losses. In this presentation, I summarise simple principles for engaging users with information and how I have used them to develop and deliver whiteboard videos that effectively communicate complex information.

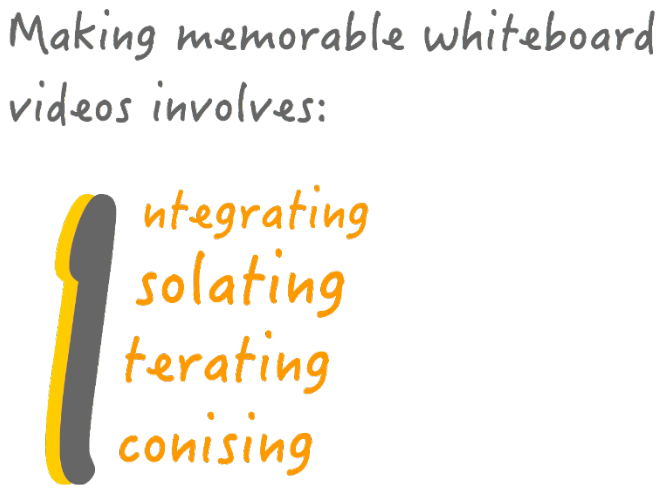
Principles: Your contents should be each of the following four things (synthesised from Berger (2014); Heath and Heath, 2007; LeFever, 2012; and Walter and Gioglio, 2015.).

Solid - Your users can more:

- Easily visualise, manipulate and master concepts in the mind's eye when they are concrete (tangible rather than abstract). This feature develops by default for those concepts that are converted to icons for visual explanation.
- Reliably provide attention, take contents seriously and give credence when contents are credible.

Simple - Your users can more readily integrate contents that are expressed simply. The fast moving pace of video content means that users benefit from your upfront investment of effort into simple representations. Elegant explanations demonstrate your respect for the energies and time of your users and your command of the conceptual territory of the content in hand. Presenting things of moment simply, even minimally, yet with conceptual beauty maximises mental bang for buck for your users.

Surprising - Surprising your users with something unexpected makes content more memorable and more likely to be passed on to others - it can provide the memory hook that triggers recollections of other elements of your content. When this relates to an insight about a core concept in your content, this provides a valuable “aha! moment” that your users will more readily recall. Likewise, the “aha! moment” of humour, based upon sudden shifts in perspective that generate a laughable new insight (Koestler, 1964), can make content particularly memorable.



Story-like - You are wired to engage with and communicate through stories. Casting your key messages in the context of a story that uses characters with whom your audience will empathise is a powerful way to open their minds to your content. Content that opens with: “Let me tell you a story ….” automatically places you into a receptive mode, ready to receive something that you are confident you will understand. Similarly, a voiceover that talks about “you” (by being worded in the “second person”) directly engages the “you” in the flow of the story. My clients have reported a good response to videos with a voiceover in which there is a dialogue that uses both first and second person perspectives as it neatly sidesteps overbearing / patronising didactic presentation of concepts such as best practice.

Your process will likely involve each of the following four things.

Iconising - Finding empathic, effective, explicit and economical visual metaphors in the characters, locations and props of your story is critical to engaging your users. Effective graphics work with a simple palette that is consistent with brand guidelines for your client / system.

Iterating - An “agile” like process (Sutherland, 2014), involving iterative cycles of developing the storyboard (key messages and visual, script and audio components of the video) is a great way to run a video project. Frequent meetings among learning designers and system stakeholders provides a rapid and economical way arrive at a high quality output.

Integrating - Whiteboard videos are at their most powerful when there is a strong sense of rhythm and flow to progression through the content, so that delivery of the visual content flows out onto the board in perfect synchronisation with the telling of the story, like liquid music.

Individuating - Breaking both graphics and script into chunks of linked content means that synchronisation can be kept tight even when the script is translated into languages with very different lexical densities (Anon., 2015).

Discussion: Several recent authors have reported on the effectiveness of visual presentation of sticky ideas for creating memorable and shareable content (Berger, 2014; Heath and Heath, 2007). The simple model outlined here (providing video and a script for translation) integrates the clarity, directness, engaging nature and accessibility of the whiteboard video medium with the power of insight provided by conceptual models and with the personal relevance and empowerment created by participants delivering their own tool.

Conclusion: As an all-round extension practice, using whiteboard videos together with translatable scripts looks likely to provide an effective and efficient medium for "train the trainers" programs aimed at widely disseminating best practice postharvest handling. I hope that the principles summarised here will contribute to the discussion of ways to best develop and realise the potential of this medium for equipping a new generation of food systems workers to reduce postharvest losses.

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Abstract # ADMI081

Learnings from Save Food Asia Pacific Campaign

Prabhat Kumar, Abha Mishra

Asian Center of Innovation for Sustainable Agriculture Intensification, Asian Institute of Technology, Thailand

Corresponding Author: pkipm@ait.asia

Background: The Food and Agriculture Organisation of the United Nations (FAO) has started "The Save Food Asia-Pacific Campaign". The Campaign seeks to raise awareness about the high levels of food losses - particularly post-harvest losses - and the growing problem of food waste in the region. ACISAI, AIT under a Letter of Agreement established and hosted secretariat of Save Food Asia Pacific (SFAP) Campaign with a multiple objectives. Under this collaboration a range of activities were supported by ACISAI like, a) Save Food Asia Pacific webpage, b) social media sites, c) campaign materials like notebooks, caps, and pens, and, e) co-hosted a high level regional consultation from Asia Pacific countries to seek a common and coherent national and regional action plan.

Objective: Create awareness on food loss and waste issues through campaign leading to a high level regional consultation to develop national and regional action plans.

Methods: A multi-facet approach of campaign first began with creating awareness among various stakeholders ranging from students, government officials, and media fraternity leading to a High-Level Multi-Stakeholder Consultation on Food Losses and Food Waste in Asia and the Pacific Region (27-28 August 2013). The programme of the Consultation included three technical presentations, country presentations, two parallel round table sessions, four thematic working group sessions, plenary presentations and discussions on strategic issues and actions to address food loss and food waste.

Results: Apart from sensitizing the students, government officials and households on the issues of food loss and waste through a website, mass media etc. the high level consultation arrived at many important outputs with far reaching results. The result could be summarised in two parts, one strategic actions and government recommendations. In the strategic action part all participating countries realised that awareness and advocacy are critical to act against food loses and waste, private sector is key stakeholder in this effort, and support mechanism must be ensured by governments to facilitate smallholder organizations and to support private sector initiates geared towards reducing waste and losses. On other hand a set of recommendations were mooted for actions from government. Those included, the strategic importance of food loss and waste in addressing overall food security issues, prioritization of reduction of food losses-particularly post-harvest losses and waste and their inclusion on agriculture development plan, and, creation of an enabling environment supportive of food loss reduction and a better climate to stimulate the private sector to invest in the food industry for food loss reduction. Policy objectives to meet that end must integrate consideration for the development of basic and post-harvest specific infrastructure and food safety and quality regulations.

Conclusion: A draft joint communiqué was discussed, amended and endorsed by participants to the Consultation. Following endorsement of the Joint Communiqué, the document was read in its entirety and the Save Food Campaign was officially launched by Mr Hiroyuki Konuma, Assistant Director-General and Regional Representative of the FAO Regional Office for Asia and the Pacific. As a follow-up of this ACISAI, AIT is undertaking a research study inside its campus on quantifying the amount of

food losses and at the same time creating awareness to reduce food waste among AIT residents, which is a 1500 plus population representing all major Asian countries.

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Abstract # ADMI082

Do Farmers Benefit from Increased Access to Credit? Evidence from Rural India

Tisorn Songsermsawas, Kathy Baylis, Mindy Mallory

Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign

Corresponding Author: songser2@illinois.edu

Small-scale farmers in the developing world face largely incomplete agricultural markets when they try to sell their crops. One notable signal of market incompleteness is price fluctuations, both spatially and temporally. Regular seasonal price variation is a common feature of staple grain markets in many parts of the world. Grain crop prices are usually at their lowest right at harvest, and gradually increase after that. This is of particular interest to small-scale farmers growing grain crops because the price variation opens up opportunities to arbitrage; holding on to crops to sell when prices are high. In our dataset from rural India, farmers in the same village who sell the same crop receive different levels of price even if they sell in the same month. Throughout the year, the prices received by different farmers selling the same type of cash crops within the same village fluctuate as much as 100% in our setting, depending on the crop and the region. While the substantial variation in prices might be beneficial for farmers if they could hold on to their crops and sell when their prices rise after harvest, several obstacles usually prevent them from doing so. Credit constraints may force farmers to sell their crops right after harvest to pay back their agricultural loans. The absence or insufficient access to agricultural credit creates a major obstacle for small-scale farmers seeking financial capital needed for their agricultural investments and other uses and could result in displaced distortion. This terminology refers to a phenomenon in which economic agents allocate resources inefficiently in the absence of failures in financial markets. Instead, without a working financial system in place, farmers are forced to sell their crops (either to trader or directly to the regulated market) when cash is needed for less than desirable prices, and buy food grains back at a later date even at higher prices. Exogenous factors including sudden illnesses and extreme weather shocks further exacerbate need for cash, which necessitate farmers to immediately sell their crops at lower prices than what they had anticipated. Another source of marketing constraints facing small-scale farmers is crop storage. Storing grain crops after harvest without safe and secure facilities might involve substantial losses due to pest and rodent infestation. Even if these constraints are solved, farmers might still face great difficulty in accessing the agricultural market. In this study, we ask to what extent access to credit, on- farm storage space and market access associate with the ability for farmers to hold back and sell their crops after harvest, hoping to receive higher prices. Higher crop prices are particularly important for policy implications because subsistent farmers earn a considerable amount of their revenues from selling cash crops. While we acknowledge that other factors such as marketing strategies, negotiation skills and farm practices may help explain the variation in crop prices farmers receive, we do not consider them in this study. To investigate the factors that prevent rural Indian farmers from accessing price arbitrage opportunities, we use the longitudinal household survey from ICRISAT and official price information reported by the Indian Ministry of Agriculture, AgMarkNet between 2009 and 2014. We seek to test three hypotheses in this study. First, we explore the extent to which state-level elections associate with an increase in agricultural loans to farmers. Particularly, we compare if agricultural loans obtained in election years are higher than those made outside election years. Further, we test for two additional factors that could affect the farmers' capability to hold on to their crops after the harvest season. We test whether the absence of on-farm storage capabilities also prevent farmers from taking advantage of price arbitrage. And finally, we ask whether the lack of access

to open, nearby agricultural markets is associated with the differences in local market prices and prices received by farmers. We see three major contributions of this study to the literature. First, this study complements the broad literature on the effects of credit on farm management and agricultural marketing. Existing evidence of the returns to credit provision are mixed. In our study, we focus our analysis on one source of a potential shock to credit provision: political elections. Within the Indian context, previous studies on the topic use district-level data and document a positive and significant relationship between election schedule and credit supply. To our knowledge, ours is the first to use a household-level dataset to explore the relationship between the plausibly exogenous variation in the state-level election schedule and agricultural credit levels in rural India. Another aspect of agricultural marketing constraint faced by small-scale farmers is market access. Commonly, market access measures only emphasize the role of geographical distance on market participation but not on the temporal component of market opening times. In this study, we create a market access index that contains both distance and time components to explore whether its variation affects the opportunities of small-scale farmers in rural India for price arbitrage. A number of studies point out potentially significant improvements in efficiency gain from having a more direct access to the agricultural supply chain for small-scale farmers in developing countries. Therefore, the second contribution of this study is to supplement this existing literature by also extending to test for two other factors such as access to nearby and open agricultural markets and secure storage space on market outcomes. Third, this study seeks to understand the role of multiple factors that might affect access to arbitrage. Although market intermediaries such as traders can help farmers enter the supply chain, farmers also have to face substantial mark-up from selling through traders, resulting in lower profits.

Abstract # ADMI083

Training small scale handlers on solar drying fruits and vegetables to mitigate postharvest losses

Odette F. Ngulu[1], Bertha Mjawa[2], Mary Mdachi[1], January Mafuru[1], Angela Kidunda[3]

[1]Selian Agricultural Research Institute Arusha, Tanzania

[2]Prime ministers –office, MIVAF programme, Tanzania

[3]Private business development trainer, Tanzania

Corresponding Author:

Background: Fruits and vegetables are vital part of our diet. They provide vitamins, dietary fiber and antioxidants to keep us healthy. *(Thompson and Kader, 2009)* In Northern Tanzania, fruits and vegetables production is dominated by smallholder farmers. Productivity is to a large extent influenced by rainfall pattern. Production gluts are common during cropping seasons with adequately distributed rainfall. Under such situations, farmers have low bargaining power, are compelled to sell at low prices, knowing quite well the perishable nature of fruits and vegetables. Many handlers unknowingly contribute to postharvest losses by using common practices or by not using certain practices known to reduce losses and help maintain produce quality and safety *(Kitinoja 2002).* Estimated losses ranging between 40 -80% occur on the farm, during postharvest handling, food processing, storage, and distribution. This translates into low returns on investment and disincentive to growers, particularly women and the youth. The production glut is usually followed by dry period with food shortage especially in rural areas where the main production depends on rainfall. This scenario underscores the essence of value addition; firstly to mitigate losses associated with perishability of fresh produce, and secondly to enhance household income earnings from sale of processed products throughout the season.

Solar drying technology is not totally new in most parts of Tanzania. It has been a traditional food preservation method for vegetables, wild mushrooms, bananas, sweet potatoes, cassava, cereals, fish and meat. Despite of its contribution to reduction of postharvest losses during gluts and extended shelf life that guaranteed year round availability, "sun dried food products the traditional way" are not that popular today because of food safety risks associated with inappropriate handling and storage practices. When it comes to commercialization, they are simply non-competitive.

The training on solar drying technology was conducted in response to long term demand for improved solar drying practices which fulfill food safety standards; for household consumption as well as competitive markets requirements.

Objectives: *Main Objective:* (i) To train small scale handlers on solar drying fruits and vegetables for household food security, nutrition and mitigation of postharvest losses.

Specific objectives: (i) To reduce postharvest losses especially during glut periods (ii) To impart participants with knowledge of value addition for longer shelf life of fruits and vegetables and income generation. (iii) To promote food diversity in response to expanding demand for fruits and vegetables in domestic markets, enhancing farm gate price stability of fresh produce leading to improved returns on investment, therefore creating an increased employment opportunities to the smallholder community especially to women and the youth.

Methodology: Training small scale handlers on solar drying technology was conducted at the Postharvest Training and Services Center (PTSC) in Arusha, Tanzania. A total of 75 participants were trained including 65 women and 10 men. All trainees were individual small scale entrepreneurs working on a variety of small scale farming, selling fresh vegetables, drying of vegetables at a micro scale and other petty businesses related to fruits and vegetables.

Training materials, tools and equipment: *Training Materials used:* Flip charts, maker pens, note books, handouts and posters. Basic food processing kitchen utensils, solar drier and raw material. Sanitation processing and preservation chemicals, packaging and labeling material.

Tools: Rapid base line survey: Shortly before conducting the training, the trainers administered a short questionnaire to establish baseline status of available technologies and pertinent skills most practiced in food processing; particularly focused in solar drying for value addition at household levels. The survey was meant to establish technology gaps and also to serve as future reference point for impact assessment related to the training.

Group formation: To enhance training efficiency in terms of practical skills, theoretical knowledge and active participation of each trainee, small groups were formed and each assigned a different commodity to work on. Each group was urged to move around at times during the course to learn what others were doing. The objective was to expose trainees to processing skills and gain experience on what it takes to process good quality safe food products.

Modules: Core modules included principles of food processing, food hygiene and safety, theory and practice of solar drying, entrepreneurship skills - cost and pricing, breakeven point, packaging and labeling. These modules were meant to provide participants an insight of solar drying technology contribution to value addition to fruits and vegetables, Cost and benefits analysis was also covered. Both theory and practical skills were taught for each module.

Findings: *Participants' positive perception on the training:*

- The training was quite useful but needed more practice to perfect skills for preparing products with comparable quality standards similar to those produced during the training.
- Participants commented that they were going to practice the gained knowledge immediately.
- They indicated a need for onsite follow up to advice when they start processing
- To create wide impact in mitigation of postharvest losses, such training should be expanded to other famer groups.
- The entrepreneurship skills module was very useful for them since they wish to use the knowledge of food processing for business.

Challenges encountered in this intervention:

- Financial concern: Majority of the trainees were individuals with low income which makes them view the process as too costly and hence deem purchasing a solar dryer at the household level unaffordable
- Time management factor: Some of the participants have multiple roles associated with family and or community responsibilities. At times this interferes with training schedules.
- Some of the trainees were operating on individual basis and have not yet formed groups or associations that would enable them to operate jointly and fulfill market requirements.

- Lack of knowledge on improved solar drying technology contributes to low adoption of solar drying for value addition as business.
- Early deterioration of products due to lack of food grade packaging.

Conclusion: The decline of fresh produce quality during postharvest handling, storage and distribution results in significant economic losses. In this respect, promotion of improved solar drying technology that considers food hygiene and safety can greatly contribute to reduction of the losses and enhancement of higher returns to investment along the value chain, food security and nutrition. All trainees expressed enthusiasm and interest in this subject thus implying high acceptance of the technology.

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Abstract # ADMI084

Private sector-led Solutions to Reduce Post-harvest Loss in Sub-Saharan Africa

Helen Mant

Initiative for Global Development

Corresponding Author: hmant@igdleaders.org

Private sector-led solutions to reduce post-harvest loss in Sub-Saharan Africa Introduction Over the past two years, the Initiative for Global Development (IGD) conducted extensive primary research with private sector actors to identify scalable interventions to mitigate post-harvest loss (PHL) with a specific focus on several agricultural value chains in Nigeria, Ghana, Kenya, and Tanzania. IGDs research contributes to addressing the increasingly urgent problem of food waste and loss in Sub-Saharan Africa, which has the most pronounced per capita food losses, resulting in reduced incomes for millions of smallholder farmers (SHFs) and downstream value chain actors. For the sustainability of any solution to reduce loss, it is critical to pursue PHL prevention strategies that are market- led and demand-driven. Both large and small commercial food and beverage retailers and wholesalers can apply technology, infrastructure, and management discipline to the problem of PHL for developing cost-efficient, scalable, and economically accessible solutions. IGDs research has demonstrated the importance of creating an integrated business-led value chain approach to addressing PHL whereby all players along the value chain are benefitting and shared value is created. IGD will present the findings of our research and bring the private sector perspective to the PHL conversation at the First International Congress on Postharvest Loss Prevention. Objectives The findings of IGDs research will bring insights from extensive primary research through engagement with over 60 companies ranging from large international retailers to small local agro processors, and will: Increase awareness around PHL. Demonstrate how to leverage the private sector by identifying critical success factors for engagement. Highlight key opportunities to reduce PHL and enhance SHF livelihoods for specific commodities in particular markets. Call key stakeholders to action, including funders (foundations/development agencies) and the private sector. Approach IGDs approach draws on expertise in African agriculture, corporate impact assessment, and inclusive business models. IGD conducted structured interviews and surveys with more than 60 companies to gather primary evidence on company perceptions of PHL and identified potential intervention opportunities. Particular areas of focus included activities to increase local sourcing, promote value-added processing, enhance efficiency and value conservation, and reduce upstream waste and spoilage. IGD explored these potential interventions with companies to clarify where the most impactful and scalable opportunities exist for leveraging. To evaluate the effectiveness of current and proposed interventions on reducing PHL and enhancing SHF livelihoods, IGD tailored the igdIMPACT agribusiness impact assessment framework which looks at impact across four key business drivers: achieving growth; achieving operational efficiency; being a responsible business; and enhancing the operating environment. Key findings: IGDs work to date has led to greater clarity around the conditions under which more private sector players would engage in tackling PHL, the impediments to business involvement to date, and solutions to unlock private sector resources to reduce PHL, and achieve impact at scale. Companies interviewed, regardless of their position in the value chain, demonstrated a significant commitment to initiatives that reduce PHL and improve SHF livelihoods and see these activities as being critical to enhancing the sustainability of their business operations in key markets. Additionally, companies recognize the value in engaging with SHFs and see several benefits in sourcing locally, such as having more control over quality and consistency of supply and benefiting from tax and

tariff reductions. While many companies have already incorporated such activities into their business models, IGD identified opportunities to leverage company resources and optimize practices currently in place to enhance income and economic opportunities of SHFs and reduce food loss in the target crop value chains. These include: Value chain conservation: Increasing SHF access to, and adoption of, low-cost storage solutions and other PHL technologies by leveraging established agro dealer networks. Value addition: Improving efficiencies in the supply chain by creating greater collaboration amongst key companies and transforming supply chains through deployment of on- or near- farm processing technologies and improving aggregation models. Innovative finance: Expanding the range of innovative access to finance models for SHFs by working with leading banks to test and explore alternative financing models. Impact measurement: Developing a standardized approach to measuring, assessing, and reporting on the impact of company sourcing models on SHFs. To achieve success in the pursuit of any intervention to reduce PHL, the following factors should be considered: Capitalize on companies existing and planned initiatives to address PHL; Maintain a market- led focus, focusing on commodities with growing market demand; Establish collaborative solutions between large multi-national corporations (MNCs), local processors, and lower value chain actors to achieve scale and potential cost-savings; Learn from results-driven, commercial performance measurement techniques; and Utilize the collective voice of business to influence government policy and/or commodity development plans. Conclusion IGD has extensive knowledge on the opportunities, risks, impacts, market consequences, and viability of successful private sector-led initiatives that can be pursued to reduce PHL and positively impact SHFs in key value chains. IGD sees significant opportunity to engage with the private sector to implement transformational and scalable interventions. Our presentation will discuss the importance of leveraging the private sector to tackle PHL across different supply chains, citing examples of current company initiatives and intervention areas. IGD will also outline the most effective incentives across the private sector to address PHL and discuss the importance of establishing impact metrics for PHL interventions that can be widely used. IGD would be honored to have the opportunity to present our findings at the First International Congress on Postharvest Loss Prevention. We appreciate your consideration for this role.

Abstract # ADMI085

Empowerment of Rural Youth through Income and Knowledge Generation by Mechanization and Implement Banking

Satish Kumar, Sanoj Kumar, Ashok Kumar, Mahendra Kumar Sharma

Bihar Agricultural College, Sabour, Bhagalpur, India

Corresponding Author: skumarbau@gmail.com

This study provides strategies to empower rural youth in India and enhance the role of implement banking. Based on survey data it was reported that about 70 percent of the Indian population lives in rural areas with agriculture as the main source of livelihood. Agricultural mechanization implies the use of various power sources and improved farm tools and equipment to reduce the drudgery of the human beings and draught animals, enhance the cropping intensity, precision and timelines of efficiency of utilization of various crop inputs, and reduce the losses at different stages of crop production. The end objective of farm mechanization is to enhance overall productivity and production using the lowest cost of production. The contribution of agricultural mechanization has been well recognized in enhancing production, together with irrigation, biological and chemical inputs of high yielding seed varieties, fertilizers, pesticides, and mechanical energy. Several studies have been conducted on the impact of agricultural mechanization on production, productivity, cropping intensity, and human labour employment, as well as income generation. Introduction of implement banking helped a farmer or group of farmers to enhance their income as well as their production and productivity of different crops due to timeliness of operations, better quality of operations, and precision in the application of the inputs. To sum up, agricultural mechanization and implement banking studies have shown that farm mechanization leads to an increase in inputs due to higher average cropping intensity, larger area, and increased productivity of farm labour. Undoubtedly, farm mechanization and implement banking displaced animal power from 60 to 100 percent but resulted in less time for farm work. Also, mechanization led to an increase in the human labour employment for the on-farm and off-farm activities as a result of the manufacture, repair, servicing, and sales of tractors and improved farm equipment. Rural youth generate income from agricultural activities and/or from employment in rural non-farm activities which are in most cases linked to the agriculture sector (including the production of inputs, repairs of agricultural implements and output processing).

Success Story of a Farmer

Mr. Amitabh Anand, S/O – Mr. Anandi Prasad Singh, resident of Vill: Mohanpur, Panchayat-Gobrain, Block: Sahkund District: Bhagalpur (India) received the first position in "Krishi Samrat Samman (East Zone)" in the category of 5-20 acre area agriculture land of the prestigious Mahindra Samridhi India Agri Award of 2015. He also received a check of Rs. 51,000/=, a memento, and a recognition certificate.

He cultivates his paddy using a paddy transplanter. He uses Cono Weeder after 15-20 days to control the weeds, resulting in more production. Previous farmers in his area were used to low productivity of a paddy due to lack of labor, untimely planting, lack of proper irrigation, weeds, mites, and soil related problems. Use of a paddy transplanter minimizes such constraints and increases the productivity. Preparation of seedlings for one acre of land requires an area of 28-32 square meters of land and 15 days. The established method requires 200 square meters of land for seedling preparation and 25 days. More tillers are coming with the use of a paddy transplanter in comparison to conventional methods, which results in more production and reduced expenditure. It is economical also in comparison to conventional methods, as it requires only an amount of Rs. 1000/= per acre in comparison to Rs. 1600/= per acre required for the conventional method. It can also plant five to six acres of land in a day. The productivity of a paddy transplanter is around 21 quintal /acre. It is only 16 quintal/acre with conventional methods, which is five quintal/acre less than the paddy transplanter technique.

The use of machines for harvesting and winnowing is also beneficial in comparison to the manual methods, as it requires Rs. 2400/= per acre in comparison to Rs. 4200/= per acre with the conventional manual methods, resulting in a saving of Rs. 1800/= per acre with the use of machines. So the use of machinery reduces the cost of production and increases the productivity. By using machines, Sri Amitabh Anand saved Rs. 10,300/= per acre. He also has agricultural implements like the Zero Till Seed Drill, which reduces the irrigation need up to 40 percent, allows timely sowing of wheat, and results in more production as well as more financial gains.

Mr. Amitabh Anand also operates a Farm Machine Bank and provides machines on a custom hiring basis to local farmers. By custom hiring he receives around Rs. 3 lakh/year and encourages the local farmers to move towards farm machines for their agricultural work.

Previously he was adopting a conventional method of agriculture, which resulted in low production as well as smaller financial gains for him. Keeping this in mind, he thought to adopt the “Adhabattai” system, but then he came in contact with the Krishi Vigyan Kendra, Sabour, and scientists for the Kendra convinced him to approach agriculture in a modern way by using machines. Now he uses machines for his agricultural needs and has become financially independent.

Abstract # ADMI086

E-Granary: Reducing Post Harvest Losses Through a Vertical Integration Platform

Stephen Muchiri[1], Paul Thangata[2]

[1]Eastern Africa Farmer Federation

[2]FAO

Corresponding Author:

Previous studies by the Eastern African Farmers' Federation (EAFF) and FAO have shown that farmers participation in East Africa regional trade is negligible (<1%). Yet, agriculture and agriculture trade forms the backbone of our economies contributing 24-40% of GDP. Additionally, several studies conducted by EAFF and FAO found that large produce buyers in the region face challenges when procuring grain. Some of the challenges include grading for aroma, colour, and breakages. The buyers asked EAFF to build the capacity of farmers to produce for the markets and grade their produce accordingly as a means to minimize market related losses. Better links between farmers and buyers would help to overcome these obstacles, but they are difficult to form. Mistrust between farmers and buyers runs deep. Buyers fail to honor purchasing agreements or do not pay the agreed price at harvest. Farmers abandon purchasing agreements and sell their produce to another buyer or on the spot market if they can get a more favorable price.

After consultations with stakeholders, EAFF requested for support form FAO for a web based platform where market information can be passed from farmers to buyers and vice versa. With FAO support, EAFF's experience with another project involved in aggregation was the breakthrough.

There are many agriculture related applications now emerging and showing great promise for smallholders. Recent increases in ICT affordability, accessibility, and adaptability have resulted in their use even within impoverished rural homesteads relying on agriculture. Today, ICTs such as mobile phones and management information systems facilitate communication between parties and help to track large numbers of smallholders, their farming activities, delivering loans cost-effectively, ensuring that funds are properly used, and collecting payments.

The egranary

To improve aggregation and linkages to markets, an innovative e-agriculture platform became the most plausible aggregation method. The virtual platform EAFF was looking for would meet the following criteria:

- An innovative way to aggregate the grains as well as an easier way to cause physical collection.
- A platform that would allow farmers to use simple mobile technology.
- A platform that allows multiple data entry by individual farmers, allowing them to enter grain grade parameters presented by the buyers.
- A system that provides market information and extension information between the farmers and buyers from a regional perspective

Now, the e-granary is a reality. It is an ICT Mobile Driven Platform that engages with farmers to provide market information, implement virtual warehouse, create an all-inclusive market place, monitor and track their progress. It is an innovative way of reducing post harvest loses:

- Is a farmer based virtual warehouse receipt system

- A solution that enables the farmer to keep auditable farm records, capable of assisting the farmer to obtain microfinance assistance – value chain financing
- A solution scalable to incorporate other business streams and not only agricultural products – e.g. inputs

The main aim of the virtual platform is to help farmers aggregate farm produce and in the process help link them to national and regional buyers. In the short term, the e-granary will be scaled up to more farmers in East Africa, and in the long term, to other commodities. The e-granary will also generate requisite data to inform the EAC food balance sheet and improve cross border trading policy processes and improvements in value addition investments. A demo for the e-granary allows farmers to enter individual or group related production data variables. The virtual aggregation is done according to location, crop type, quantity of seed used, quantities harvested by grades. This information can easily be linked to markets such as the Eastern Africa Grain Council (EAGC)'s G-soko. The E-granary envisions moving 20% of EAFF members from farm gate to aggregation by 2020.

Partnerships

Recognizing the importance of partnerships in e-agriculture, under a TCP, EAFF sought collaboration with FAO East Africa Office. The two organizations came into partnership with MoDE, a commercial private company, in developing a digital platform, called e-granary. The idea behind the e-granary is to support EAFF members to virtually aggregate farm produce. The e-granary information would be matched with possible buyers based on demanded quantities, quality, price and time of delivery.

Partnerships with ICT specialized companies in e-agriculture will ensure affordable rural access to infrastructure, devices, and services. It is the key to improving access and affordability by rural people. Market information in the form of text messages to mobile phones can therefore reach large numbers of farmers and give them a stronger negotiating position with traders.

eGranary's competitive advantage

The platform will allow farmers to get data to EAFF central database via SMS using any cheap hand-held mobile. The eGranary will allow for farmer registration over SMS, capturing farmers' stock and integration to mobile payment gateway systems, Automated SIM/SMS /Mobile App based registration. The platform will enable a prospective buyer (individual or corporate) to search for existing produce based on location, product type, availability lead time etc. It will support searches via the web and through an SMS service. It will allow farmers aggregate their produce (several farmers willing to sell their produce can be pooled together to supply required sales volume), manage bidding for farmers produce by the buyers, manage farmer produce suppliers who would wish to engage with the farmers and provide for order reconciliation (payment vs stock purchased). It shall also provide for access to the mobile pay gateway services. Like the WRS, using egranary Information will allow farmer get a loan. The e-granary platform will support all financial transactions and communications. Farmers will be able to transmit data/information during the crop cycle, primarily via SMS. When operational, the egranary will allow, for the first time, farmers to generate evidence that they can use to engage in the regional integration process/ markets. It will be able to track a farmer's progress over time developing his/her risk profile useful in micro insurance and financial transactions; creating a market place that brings together key players in a self-sustainable manner – service providers, governments etc. More importantly, it will generate data and information will be useful for policy & advocacy + planning additional investments – processing/ finance/ inputs.

Abstract # ADMI087

Applying Farmer-centered Design to Alleviate Women's Drudgery and Reduce Quality Losses in Groundnut

Alexandra Spieldoch

Compatible Technology International, USA

Corresponding Author:

Introduction: Groundnut is a nutritious and valuable crop with immense untapped potential to improve food security, nutrition, and raise incomes among smallholders around the world. 95% of the groundnut crop produced worldwide originates in developing countries, where it can provide an important source of protein, fats, vitamins, and minerals for communities that struggle with malnutrition. Groundnut is a valuable commodity, and known as an excellent rotation crop that enriches the soil with nitrogen and greatly increases farmers' yields. For its numerous attributes, governments in Malawi, Zambia, and numerous other countries in Sub-Saharan Africa have established national policies encouraging farmers to increase their production of groundnut. Of the global land area cultivating groundnut, nearly half—46%—is in Africa, where it's grown mostly by smallholders with little access to agricultural resources and technologies. As a result of these limitations, Africa only accounts for 28% of global production of groundnut. There are a number of constraints that limit the yields, quality, and value of smallholders' groundnut harvest, including access to high-yielding seed varieties and other important inputs. Another key barrier—and one that's often noted in research but has seen little investment historically—is the lack of mechanization among smallholders. Women in particular work under incredibly labor-intensive, traditional methods of harvesting and processing groundnuts by hand. They have poor storage and their wet shelling methods render nuts susceptible to aflatoxin, negatively impacting health and their ability to produce a high value crop for a good price.

Farmer-centered design: Compatible Technology International (CTI) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) partnered together to develop affordable, mechanized tools that address smallholder farmers' constraints. The team worked over four years, engaging farmer leaders to identify the problems and the solutions based on their experiences and perceptions. In Malawi, the team investigated the groundnut postharvest value chain—from harvest to consumption and sale. 248 households located in the center of the country's groundnut belt were surveyed to understand the basic socio-economic and agricultural context, and in particular the harvest and post-harvest (HPH) groundnut technology potential. In conjunction, separate market-level research was conducted with groundnut merchants, processors, exporters and well-informed local scientists and agricultural professionals. In individual interviews, family surveys, and group discussions, the communities named harvesting, stripping, and shelling groundnuts as among the most difficult, labor demanding and time consuming processes.

Traditionally, smallholders harvest their crop by first using a small hoe to dig into the ground, then lifting the plant by hand. After harvesting, the plants are dried and the pods are stripped, primarily by women and children, who tediously pluck groundnut pods from the plant by hand, one-by one. Shelling is also typically performed by women, by hand, and was the largest cross- cutting problem named across villages as both difficult and time consuming.

Based on the survey findings, CTI established basic design parameters to develop prototypes. The team incorporated smallholders as co-designers of three mechanized technologies for lifting, stripping, and shelling groundnut. The prototypes were evaluated by women and men smallholders in Malawi and neighboring Tanzania in dozens of field tests to assess the performance of the equipment and enable farmers to inform design changes. After successive testing and demonstrations, the technologies were left with farmers for familiarization, and in 2014 ICRISAT conducted a socioeconomic survey of nearly 100 farmers in an effort to study their perceived value of tools, as well as the potential implications of their adoption, both positive and negative.

Results

Reduced drudgery for women: The research had a significant, positive impact on reducing the time and labor that women spent harvesting and processing nuts.

- Oxen-Powered Lifter: An animal-drawn technology that harvests groundnuts 4x faster than the traditional method of digging with a hand hoe.
- Stripper: An A-frame tabletop stripper that removes groundnut pods from the plant 3x faster than hand stripping, on average.
- Disc Sheller is a hand cranked tool 24x more efficient than hand shelling, on average.

Strong demand and willingness to pay: In terms of the machines' acceptability, results from the farmers surveyed during field tests indicate 100% willingness to advise other farmers to use the technologies. 98.8% of the farmers from individual interviews expressed that they will continue using the machines and most stated they would also pay a fee to rent the tools if given the opportunity. The majority (97%) of farmers in the research study indicated a willingness to increase groundnut production area if the HPH problems could be minimized. About 45% of the farmers reported that they could increase their production area by 50% while 42% indicated a 100% increase in groundnut production area. In addition, farmers suggested that the project will provide them with increased cash income (49.7%), enough time for other socio-economic activities and resting which will improve their quality of life (38.7%), improved nutrition and also provide cash for buying farm inputs such as seed and fertilizer.

Improved quality: Quality has a direct impact on the marketability and price of groundnut, and aflatoxin contamination is a key impediment preventing export of groundnuts from developing countries. Storage and shelling are crucial in aflatoxin management. Because it's such difficult work, before shelling large quantities for market sale, it's common for farmers to wet their pods to soften their shells. This practice makes the groundnuts much more susceptible to spoilage and waste, and causes considerable risk of aflatoxin contamination. Mechanized dry shelling makes the process of shelling high-value whole nuts for market sale much more accessible to smallholders. It makes the practice of soaking nuts to soften the shells obsolete, greatly reducing the risk of aflatoxin contamination. And, it reduces women's drudgery and frees up their time.

Strengthened access to markets: The research has proven that mechanized groundnut tools can help farmers (i) reduce HPH drudgery and time requirements, and (ii) improve crop quality. However, these benefits don't necessarily immediately translate to higher incomes and access to new markets. Most smallholders surveyed through the project ranked groundnut as their most important cash crop,and over 85% were already regularly selling their groundnuts at market. To ensure farmers' were receiving a fair price for their higher quality groundnut, ICRISAT negotiated partnerships with four groundnut buyers. Participating villages sold their nuts collectively, and received a price 15% higher than in other markets. In addition, participating villages had far less rejection of their nuts (4%) compared to other communities, whose nuts were rejected due to either poor grading or wet nuts (18% on average).

This shows the potential of the project interventions for changing farmer behavior with regard to groundnut marketing. Without support to negotiate with buyers and collectively market their nuts, it would be difficult for smallholders to achieve the full potential of the opportunities that mechanization can present. It is clear there are a number of barriers and challenges that limit smallholders production and access to markets, therefore, the introduction of mechanized tools should be integrated in a wider value-chain approach that includes access to credit and inputs, connection to fair markets, and business training, for those interested in providing service processing.

Shifting gender roles: In Malawi, groundnut has historically been regarded as a feminine crop, and women have been responsible for most HPH operations historically. In interviews with the farmers, 97.6% suggested that mechanization of groundnut postharvest operations encourage men to participate more than ever before, implying that these technologies have in away shifted the gender stereotype about the legume crops particularly groundnut. 64.5% of the respondents suggested that women use the saved labor for household chores or for starting small businesses (19.5%). In addition to this a small percentage of the respondents suggested that the women's saved labor could be used for production diversification, participation in clubs and cooperatives (0.6%), and finally women/village community group meetings (0.6%). This suggests that the machines could help women engage in other activities using the saved labor and probably time.

Conclusion: This farmer centered design project highlights the fact that the best technology solutions are not created in a void, but are based on responding to farmer preferences and needs. In 2015 and beyond, CTI is expanding its work to strengthen groundnut markets with tools and services that strengthen farmer empowerment and gender equality.

Abstract # ADMI088

Food loss assessments: Causes and solutions Case studies on small scale fisheries in Indonesia

Singgih Wibowo[1], B.S.B. Utomo[1], D. Ikasari[1]; R. Kusumawati[1]; A.H. Purnomo[1], Wudianto, A.A. Utama[2], R.A. Ward[3] and Diei-Ouadi Yvette [4]

[1] Research and Development Center for Marine and Fisheries Product Processing and Biotechnology, The Ministry of Marine Affairs and Fishery, The Republic of Indonesia

[2] Research Center for Fisheries Management and Conservation, The Ministry of Marine Affairs and Fishery, The Republic of Indonesia

[3] Fisheries Development Specialist, FAO, Rome, Italy

[4] Fishery Industry Officer, FAO, Rome, Italy

Corresponding Author: yvette.dieiouadi@fao.org

It has been quoted that about 30% losses occur during post-harvest fisheries process in Indonesia. However, a quantitative study has not been done to support this quotation. The main objective of the study is to find out the actual picture of post-harvest losses on small scale fisheries in Indonesia as well as to find the causes and the potential solutions to reduce the loss. In order to answer the objective, three case studies have been designed. The first case study is focused on assessing post-harvest fish loss of dominant fish product in an important and large fishing center (fishing port, fresh fish market, processing center, and processed fish market in the same area). Second study is focused on assessing post-harvest fish loss of gillnet fisheries, while third case study is focused on assessing post-harvest fish loss of small pelagic fisheries. Four locations of important fishing ports in Indonesia were chosen, namely Muara Angke (North Jakarta) for case study 1, Tegal (Northern Coastal of Central Java and Yogyakarta (Southern Coastal of Java) for case study 2, and Brondong (Northern Coastal of East Java) for case study 3. In addition, for the location of Yogyakarta (case study 2), the study is also directed to the issue of ghost fishing. A series of steps for post-harvest fish loss assessment were employed, which consisted of preliminary screening, exploratory fish loss assessment method (EFLAM), load tracking (LT) and solution finding. The EFLAM was carried out through group discussion (large and small), individual discussion and field observation. A fish species is selected in each location as a focus based on the dominant quantity of fish. Squid which is processed into boiled salted product is selected for case study 1, skipjack fish is selected for case study 2, and scads fish is selected for case study 3. Once an idea of where losses are occurring based on EFLAM results, then the LT is designed to measure the quantitative loss identified by EFLAM. The LT is designed in terms of what to measure, how to measure and sample size etc. For the LT, three processors in each location were selected regarding to specific selected fish. In Muara Angke, the major fish landed in fishing port and processed was squid which was further processed into boiled salted squid without drying. The possibility of losses may occur at any steps throughout the supply chain, starting from fish capture, fish landing to consumption. However, the actor of the food supply chain seemed to be aware of this possibility of losses and has found strategies to overcome them. It was recorded that the losses occurred only less than 5%. This result can be used as a good example for fish loss reduction in any other food supply chain in Indonesia. Post-harvest fish loss study in Tegal (Northern Coastal of Central Java and Yogyakarta (Southern Coastal of Java)) was focussed on gillnet capture fisheries. The result showed that fish loss may take place at any step throughout the supply chain, starting from capture to processing, mainly in the capture activity. The loss assessment at other locations is planned on September 2015. The results of all the case studies then will be disseminated to the public as an example of solution finding for food loss reduction through National workshop that will be held on November 2015.

Abstract # ADMI089

Effective Agricultural Extension Programs Can Prevent Post-harvest Losses

Lola Gaparova

USAID Farmer Advisory Services, Tajikistan

Corresponding Author:

Poverty and malnutrition are substantial economic development and health problems affecting a very large number of children under 5 years old and women, in Khatlon province of Tajikistan. Anemia, iodine deficiency disorders and other micronutrient deficiencies are prevalent among children and among women of childbearing age. Tajikistan is the poorest country in Central Asia, with 49 percent of its rural population living below the poverty line. Approximately 73 percent of the country's 8.2 million citizens live in rural areas, where paid jobs are scarce and the average amount of arable land held per person is 0.11 hectares. While 46.5 percent of the overall population was employed in agriculture, productivity in the sector is low and represents only 25 percent of national GDP. The 2012 Tajikistan Demographic and Health Survey indicates 26 percent of children below the age of 5 were stunted, 10 percent were wasted, and 12 percent were underweight. Food availability and accessibility could be increased by increasing production, improving distribution, and reducing post-harvest losses. Thus, establishing an effective agricultural extension system can substantially reduce of post-harvest food losses as a critical component of ensuring future global food security. According to Foreign Agricultural Office (FAO) research, the postharvest loss rate for cereals equals 15% in Tajikistan. The USAID grantee, Farmer Advisory Services in Tajikistan (FAST) program, under the Feed the Future initiative, aims to reduce poverty through improved nutrition and increasing family income through increased and improved agricultural production primarily for women and their children in the 12 districts of Khatlon Province, Tajikistan. Women in southern Tajikistan, as in many places in the developing world, have become the de facto heads of farms because of male out-migration. That is why the FAST program focus is on women in agriculture and their small (0.01 ha) household farm plots. Small household farms, primarily worked and managed by women, are the principal source of subsistence and income for three-quarters of the population of the Republic of Tajikistan. Household farms of less than one-half hectare (one acre) in size produce more than half of the country's potatoes, more than 60 % of its vegetables and almost all its livestock products. Since the country became independent in 1991, these women farmers have had no access to information about or training on agricultural production, group organization or marketing. The agriculture extension conducted in 12 target districts in Khatlon province under the FAST program was designed to increase, improve the yield and prevent PHL using the latest technology and extension approaches. Training and resources provided through FAST are spreading much needed agricultural production information, high quality seeds, composting, preparation of local pesticides, group strengthening, and marketing advice to support increased household farm production and reduction of post-harvest losses. Farmers using compost and improved vegetable seed with support from Feed the Future have increased yields 15-20 percent during their first year of production. FAST trainings help farmers understand their common objectives and assist the groups of women (146 groups totaling 3,758 women and 140 male) in planning and achieving their objectives. These approaches are based on factors allow a comprehensive application of using agricultural information systems and facilitate a simple simulation scenarios in areas with limited resources data. The study showed that prevention of PHL and improved nutrition in agricultural areas requires the integration of effective Extension

Advisory Services. Seminars and trainings on the latest technologies of cultivation of agricultural crops by provides a good basis to increase and improve the productivity and income of the rural economy.

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Abstract # ADMI090

Vegetable postharvest loss Intervention strategies in developing Asian countries

Antonio Jr. Acedo[1], Ngonl Nenguwo[2], Arusha, Tanzania3, Shrlniwas Gautam[3], Peter Hanson[4], Ray-yu Yang[4], Srinivasan Ramasamy[4], Warwick Easdown[5], Jacqueline d'Arros Hughes[4]

[1]AVRDC -The Wortd Vegetable Center

[2]AVRDC Eastern and Southern Africa

[3] AVRDC East and Southeast Asia. Bangkok, Thailand

[4]AVRDC Headquarters, Shanhua, Taiwan

[5] AVRDC South Asia, Hyderabad, India

Corresponding Author: jun.acedo@worldveg.org

Reducing postharvest losses of vegetables in developing countries contributes to achieving food security and reducing poverty, but it is a formidable challenge. Vegetables are highly perishable; appropriate postharvest practices and facilities are inadequate if not lacking; dedicated support entities have inadequate capacity and resources; and smallholders dominate vegetable industries. Smallholders are usually engaged in subsistence farming with limited economies of scale, technical capacity, and market access. They are also drawn into traditional supply chains, which are fragmented, supply driven, trader-controlled, and with long lead times from harvest to market. There is no quality reputation, and high postharvest loss. The postharvest program of The World Vegetable Canter (AVRDC) is primarily designed to build the capacity of smallholders to engage in commercial market-led production for better income opportunities. The program follows a value chain approach to minimize losses, preserve quality, maintain nutritional content, and contribute to year-round availability and affordability of global and traditional vegetables in developing countries. Our postharvest research and development (R&D) work is multidisciplinary and integrated, harnessing value chain analysis to direct technical interventions, which include breeding for desired postharvest traits; production methods for improved quality, shelf life and food safety; and fresh produce handling and processing techniques. The postharvest program effectively connects with AVRDCs four global themes: Germplasm, Breeding, Production and Consumption. AVRDCs postharvest program started in 2005 when a Southeast Asia postharvest initiative funded by the Asian Development Bank was launched. The value chain approach to postharvest loss reduction had three main activities: value chain surveys, technology generation, and technology promotion/capacity building. National project teams went capacitated through postharvest facility upgrading, conduct of training-workshops on postharvest research and training techniques participation in scientific conferences, symposia and study missions, and facilitation of PhD studies. These programs expanded the postharvest network and promoted national and international cooperation and collaboration. The current United States Agency for International Development (USAID)-funded global postharvest program targeting Feed the Future countries in Africa and Asia pursues a strengthened value chain approach by integrating nutritional quality and food safety aspects, developing new safe postharvest treatments and non-invasive quality evaluation, expanding capacity building and technology promotion activities, and forging collaboration and partnership with the USAID Horticulture Innovation Lab and related initiatives. National programs, such as the AVRDC-USAID Agriculture Innovation Promotion (AlP) program in Pakistan, AVRDC Bhoo Samruddhl Project in India, and AVRDC-SNV Netherlands Development Organization, Cambodia Horticulture Advancing Income and Nutrition (CHAIN) project, have also benefited from AVRDCs Southeast Asia experience. In Africa, linkages with partners have been an important strategy for the research and development of suitable

technologies where AVRDC Is active In Tanzania, Kenya and Ghana under the USAID Postharvest project. Value chain surveys covering smallholder growers and value chain partners quantify postharvest loss, assess needs and opportunities, and identify strategies for improvement (results of recent surveys In Bangladesh, Cambodia and Nepal are reported in a separate paper.) In Africa, studies on postharvest loss assessments in selected vegetable value chains have been undertaken for tomato, which Is a commercially important crop, as well as for traditional vegetables, which have high nutrient content and thus play an important role in improving the nutritional wellbeing of African consumers. Based on value chain analyses, R&D priorities and protocols have been formulated. Technologies developed previously in Southeast Asia included simple solar dryers, simple evaporative coolers, low-cost hydro-coolers, use of preservative pastes for cabbage soft rot control, modified atmosphere packaging, fermentation techniques, and small scale tomato sauce and chill-tomato sauce processing; these continue to be disseminated. On-going R&D activities include postharvest loss and needs assessment studies; country variety trials for long shelf life and processing tomatoes using AVRDC promising lines; fresh produce handling and processing options for tomato, traditional vegetables, leaf mustard and cauliflower; and non-invasive quality evaluation using the differential absorbance matter and hardness tester. Investigations Into the benefits of using improved packaging materials have shown positive results for tomatoes in places such as Tanzania, Ghana and Kenya, where traders are still using low quality boxes that damage produce during transportation. In addition, low cost cooling methods such as the brick and sand evaporative coolers developed in Asia have been adapted for producers and traders in Africa. To support the country trials, AVRDC scientists at headquarters and regional centers have conducted breeding and postharvest trials. To disseminate postharvest technologies and best practices, hands-on training of trainers (TOT) and training of end-users (TEU) programs are conducted and supplemented with training manuals and technology posters in local languages. In addition, a small-scale enterprise model was developed to showcase vegetable postharvest technologies in an actual enterprise setting and to assist smallholders in linking with markets to gain better bargaining positions. In the current projects, technology promotion has been expanded to include farmers' field days, techno-demo programs, and the establishment of a model pack house with basic postharvest facilities. University students have been supported to work on some project-related research topics. The postharvest sector heavily involves women but many African and Asian societies are male-dominated. Building the capacity of women in postharvest operations could improve their socioeconomic position and influence and promote gender equality. Thus, the projects emphasize women's participation in various activities. A recent impact study revealed the benefits of adopting postharvest technologies to reduce postharvest loss in vegetables. There is scope and potential to expand the limited postharvest and value-adding activities that characterize vegetable sectors in developing countries and contribute to enhanced livelihoods and well-being of millions of poor farm households.

Abstract # ADMI091

PHL Best practices in developing countries

Joseph Kabogoza

Action Line for Development, Uganda

Corresponding Author:

Introduction: Over the past six decades world agriculture has become considerably more efficient. Improvements in production systems and crop and livestock breeding programmes have resulted in a doubling of food production while increasing the amount of agricultural land by just 10 percent. However, climate change is expected to exacerbate the existing challenges faced by agriculture and hence post-harvest loss.

Approach:

Considerations for climate-smart production systems

The production, processing and marketing of agricultural goods are central to food security and economic growth. Products derived from plants and animals include foods (such as cereals, vegetables, fruits, fish and meat), fibers (such as cotton, wool, hemp and silk), fuels (such as dung, charcoal and biofuels from crops and residues) and other raw materials (including medicines, building materials, resins, etc.). Production has been achieved through a number of production systems which range from smallholder mixed cropping and livestock systems to intensive farming practices such as large monocultures and intensive livestock rearing. The sustainable intensification of production, especially in developing countries, can ensure food security and contribute to mitigating climate change by reducing deforestation and the encroachment of agriculture into natural ecosystems (Burney et al, 2010 and Bellassen, 2010).

The overall efficiency, resilience, adaptive capacity and mitigation potential of the production systems can be enhanced through improving its various components, some of the key ones are highlighted below.

Soil and nutrient management: the availability of nitrogen and other nutrients is essential to increase yields. This can be done through composting manure and crop residues, more precise matching of nutrients with plant needs, controlled release and deep placement technologies or using legumes for natural nitrogen fixation.

Water harvesting and use: Improved water harvesting and retention (such as pools, dams, pits, retaining ridges, etc.) and water-use efficiency (irrigation systems) are fundamental for increasing production and addressing increasing irregularity of rainfall patterns. Today, irrigation is practiced on 20 percent of the agricultural land in developing countries but can generate 130 percent more yields than rain-fed systems.

Pest and disease control: There is evidence that climate change is altering the distribution, incidence and intensity of animal and plant pests and diseases as well as invasive and alien species. The recent emergence in several regions of multi-virulent, aggressive strains of wheat yellow rust adapted to high temperatures is a good indication of the risks associated with pathogen adaptation to climate change.

Resilient ecosystems: Improving ecosystem management and biodiversity can provide a number of ecosystem services, which can lead to more resilient, productive and sustainable systems that may also contribute to reducing or removing greenhouse gases.

Harvesting, processing and supply chains: Efficient harvesting and early transformation of agricultural produce can reduce post-harvest losses (PHL) and preserve food quantity, quality and nutritional value of the product. It also ensures better use of co-products and by-products, either as feed for livestock, to produce renewable energy in integrated systems or to improve soil fertility.

Findings: Estimates show that world population will grow from the current 6.7 billion to 9 billion by 2050 with most of the increase occurring in South Asia and sub-Saharan Africa. Taking into account the changes in the composition and level of consumption associated with growing household incomes, FAO estimates that feeding the world population will require a 70 percent increase in total agricultural production (Bruinsma, 2009).

At the same time, climate change threatens production's stability and productivity. In many areas of the world where agricultural productivity is already low and the means of coping with adverse events are limited, climate change is expected to reduce productivity to even lower levels and make production more erratic (Stern Review 2006; Cline 2007; Fisher et al. 2002; IPCC 2007). Long term changes in the patterns of temperature and precipitation, that are part of climate change, are expected to shift production seasons, pest and disease patterns, and modify the set of feasible crops affecting production, prices, incomes and ultimately, livelihoods and lives. Preserving and enhancing food security requires agricultural production systems to change in the direction of higher productivity and also, essentially, lower output variability in the face of climate risk and risks of an agro-ecological and socio-economic nature.

Conclusion: Modern technologies and advances in the agriculture sector, such as inorganic fertilizers, pesticides, feeds, supplements, high yielding varieties, and land management and irrigation techniques have considerably increased production. This has been fundamental in meeting the food needs of a growing population and in generating economic growth needed for poverty reduction. However in certain circumstances these practices and techniques have caused ecological damage, degradation of soils, unsustainable use of resources; outbreak of pests and diseases and have caused health problems to both livestock and humans.

Abstract # ADMI092

Local knowledge for food security in Uganda; Postharvest practices in homegardens of the Ugandan Southwest

Cory Whitney

Faculty of Organic Agriculture, University of Kassel, Witzenhausen

Corresponding Author: acory.whitney@hsrw.eu

Introduction: Postharvest Losses (PHL) in East Africa destroy 20-60% of the food production (FAO 2011); in Uganda PHL are 35% for fruits and vegetables (Mulumba 2015), with up to 60% losses of more vulnerable crops such as tomatoes (Ogang 2011) primarily due to mold and rot (Kaaya et al. 2005; Kaaya & Kyamuhangire 2006). In seeking solutions to the overwhelming problems of food insecurity in East Africa, reducing PHL may be more effective than increasing yields or farming area (Lotze-Campen et al. 2008; RockstrÃm et al. 2009) with a greater impact than improved cultivation methods (Goletti & Wolff 1999) to sustainably increase the volume of available food, without adverse effects on the regional ecological and economic situation (Hensel 2011). A study of botanical diversity and associated specific cultural practices of Ugandan homegardens in the Greater Bushenyi found many potential endogenous solutions to PHL. Methods Data collection took place around Rubirizi, Sheema, and Ishaka within the Greater Bushenyi Region of the southwest of Uganda, to assess plant use, and to understand related cultural and socio-economic factors. It sought to learn the plant diversity and associated traditional knowledge of farmers in 102 homegardens within 3 distinct geographic areas (forest edge, savannah, wetland). The study was guided, but not constrained (c.f. Vayda 1983), by the hypotheses that the three different biodiversity zones would contain distinct species and traditional knowledge. Villages were randomly selected from groupings of those that fell within the three pre-determined distinct biodiversity locations across the greater Bushenyi region. 11-12 households were randomly selected from each of 3 villages in the forest-edge communities of the far western highlands near Rutoto town in Rubirizi district (Kinoko-A, Kinoko-B, and Remitagu), 3 villages (cells) in the savannah and semi-urban areas of Bushenyi center around Ishaka town (Buhuma, Buramba, and Fort Jesus), and 3 villages in the wetlands of Sheema in the southeast near the town of Bugongi Kyarykunda, Rwabizi, and Nakashambya). Data collection followed a systematic approach fitting to the local culture and included three interviews, in February to April of 2015, based on semi-structured questionnaires about the uses for plants and postharvest practices. Cited species were recorded and identified by Ankole, Luganda, Lukiga, and Latin names with the help of farmers, local botanists, and botanical guidebooks. Specimens were conserved in a field press and are now part of the Makerere botany collection. All data was recorded and uploaded digitally in the field using Microsoft Excel (14.1.0, 2011). Names, uses, and postharvest treatments of recorded species were digitized and subsequently imported into the statistical package R (R version 3.1.1 Copyright (C) 2014 The R Foundation for Statistical Computing). Multiple linear regression analysis was performed using the “lm” function of the R package “psych”. Independent 2- group Mann-Whitney U Tests were performed using the R function “fisher.test” and “wilcox.test”. Results Local knowledge on postharvest practices for plants was a common factor to all gardens in the sample. By order of importance: farmers commonly processed millet (Eleusine coracana), dried and pounded to make a traditional sweet and sour fermented drink known as Bushera and a wet loaf known as Kalo; peanut (Arachis hypogea) was the next most important, sun-dried or roasted for cooking with meat or as a porridge; beans (Phaseolus spp.), peas (Pisum sativum), and soybeans (Glycine max), were commonly sundried and stored to be cooked as porridge or sold; cassava (Manihot esculenta), was often

sundried and powdered; sweet potatoes (Ipomoea batatas), and potatoes (Solanum tuberosum), were stored for longer periods after harvest; coffee (Coffea canephora), was sundried, as was sorghum (Sorghum bicolor), maize (Zea mays), and tobacco (Nicotiana tobaccum). Fisher's Exact Test for Count Data found significant differences in the number of different postharvest treatments between those homegardens found in swamps of Sheema and those in the forests of Rubirizi. Also important for PHL in the gardens is growing plants that have a flexible year-round harvest. Important plants belonging to this category included three plants eaten as tubers, fourteen used as herbs and five used as spices. Tubers included, arrowleaf elephant ear (Xanthosoma sagittifolium), cassava (M. esculenta), and yam (Dioscorea cayenensis). Herbs included african spiderflower (Gynandropsis gynandra), amaranth (Amaranthus spp.), cranberry hibiscus (Hibiscus acetosella), little mallow (Malva parviflora), rosemary (Rosmarinus officinalis), and tea (Camellia sinensis). Spices included chili (Capsicum frutescens), ginger (Zingiber officinale), lemongrass (Cymbopogon citratus), mlelgueta pepper (Aframomum angustifolium), and sugarcane (Saccharum officinarum). Plants kept in the homegardens that offered a flexible year-round harvest were grown mostly in older gardens; multiple regression analysis showed a positive influence of garden age on the presence of these plants. Farmers manage their homegardens as intercropped banana plantations (Musa spp.) under constant harvest, with banana plants at various stages of maturity. The Musa cultivars Kayinja/Kivuvu and Kisubi are used for making alcohol, representing the only way that bananas are preserved in the gardens. These are harvested green and rot in one week. Sweet Musa cultivars Bogoya and Kabaragara can last for 2 weeks if harvested very young. Whereas Musa cultivars used for cooking Bukumu, Embire, Embwaziruma, Entaragaze, Entukura, Enyeru, Enzagata, Enzirabahima, Eshakara, Gonze, Kibuzi, and Muzuba can last longer than one week after harvest with the exceptional case of the Gonze cultivar which, if harvested young, can last up to 1 month. Regression analysis revealed a significant positive effect of the richness of sales (different plant products sold) on the practice of postharvest preservation on farm. Furthermore, regression revealed an effect of the number of days that a homegarden was used a year on the same process, the more days a garden was used the less postharvest preservation was practiced. In homes with very elderly heads, there is evidence that there exists special traditional knowledge of fermentation techniques and other special postharvest practices to keep food longer for household consumption. Discussion and conclusions Traditional Ugandan foods and crop choices are important mechanisms not only of PHL but also for conservation of traditional culture in Greater Bushenyi. This study is an early step in recording the local knowledge to compare their economic, ecological, and socio-cultural significance. It aims to contribute to a neo-gastronomy (Tencati & Zsolnai 2012), to regard indigenous plants as traditional food and nutrition, to encourage farmers to plant and utilize indigenous plants (Tabuti et al. 2011). That no special food preservation techniques would be found was a widely supported null hypothesis (FAO 2011; Ogang 2011). The actual case was rather that few special conservation or preservation techniques were present in the sample. However, there were many traditional, naturalized, and introduced plants kept in the homegardens that offer year round harvest. Future investigations should explore these traditional knowledge systems expressly using en ethnographic approach. Acknowledgements This project (031A247B) is financially supported by the Federal Ministry of Education and Research (BMBF) within the collaborative research project GlobE-RELOAD.

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Abstract # ADMI093

Economic Consequences of Post-Harvest Losses in Rwandan Common Bean Markets

Michael S. Jones[1], Corinne E. Alexander[2], and Bruce Smith[3]

[1]North Carolina State University Department of Economics

[2]Purdue University Department of Agricultural Economics

[3]Former Advisor to the Rwandan Minister of Agriculture and Animal Resources

Corresponding Author:

Introduction/Background: Post-harvest losses have major economic consequences for smallholders in sub-Saharan Africa (SSA). Storage insects in particular cause significant losses for grain and legume producers (Affognon et al., 2015). Economic losses through insect damage result from reduced quantity and quality of food for home consumption and a reduction in grain value for market sale. For marketing producers in particular, price discounts for insect damage can be a stronger driver than quantity losses in total economic (value) loss in storage (Jones, Alexander, and Lowenberg-DeBoer, 2014). While retail level (consumer) discounts have received moderate attention in SSA, there is currently a severe lack of data on farm-gate level (trader) discounts which are most directly relevant to smallholders.

We investigate this subject through the lens of maize (Zea mays) and common bean (Phaseolus vulgaris) markets in the Republic of Rwanda. Mvumi et al. (2012) conducted a post-harvest bean survey in Rwanda and found that insect damage is the greatest factor in farmers' frequent market rejection for poor quality beans. Therefore, understanding the economic implications of insect damage is important to provide evidence-based information to farmers regarding marketing strategies as well as assessing the value of grain and legume storage technologies.

Objectives: In light of these concerns, this study seeks to understand how insect damage affects smallholder farmers in rural market transactions. Specifically, we investigate farm-gate level discounts demanded by rural Rwandan bean and maize traders for insect-damage. A second objective was to develop a method for quantifying farm-gate price discounts that the Rwandan Ministry of Agriculture and Animal Resources (MINAGRI) can implement in the future as part of ongoing monitoring efforts. In doing so, we also attempt to provide a methodological road-map for policy makers seeking to assess market implications of grain and legume insect damage as part of broader post-harvest economic loss measurement and evaluation.

Method/Designs/Approach: Based on the literature, we decided the most effective and reproducible way to approach Rwandan common bean discounts for insect damage would be:

1. At the farm-gate level (discounts demanded by traders purchasing from farmers)
2. Using physical grain samples
3. Conducted in actual grain markets on market days
4. With individual grain traders
5. At multiple time periods to contrast discounts in immediate post-harvest months (1-2 months of storage) with discounts in times of greater grain scarcity ("lean season" after 4-5 months of storage – Rwanda has two major agricultural seasons). (see: Compton et al., 1998)
6. An analytically simple contingent valuation method to facilitate local institutional replication.

We constructed physical samples in clear, airtight 0.5L plastic water bottles to display graduated insect damage levels. The damage levels utilized were 0, 5, 10, 20, and 30% of beans with visible signs of insect emergence holes, with sample presentation randomly ordered for each trader. Three trained Rwandan MINAGRI enumerators interviewed 270 bean traders and 126 maize traders in 25 regionally-diverse rural markets. Traders were first asked if they would currently purchase beans of the sample's quality from farmers. If responding no, traders were simply presented the next sample. If responding yes, then traders were asked what they considered their "fair" final purchase price for beans of that quality. Results are reported as percentage deviations from the 0% damage quoted price.

Results/Findings: In common beans, lean season descriptive results indicate that while levels of 5-10% insect damage can generally be sold with a moderate discount, beans with 20-30% insect damage are largely unmarketable. Some threshold effects are found, as about 36% and 7.4% of traders would buy 5% and 10% insect-damaged beans without a discount, respectively. Lean season discounting averages 0.76% (±0.06%) per 1% seeds damaged, translating to a 0.36% (± 0.03%) discount for each hole in 100 beans. Immediate post-harvest season discounts average 1.28% (±0.06%) per 1% beans damaged, translating to a 0.61% (± 0.03%) discount for each hole in 100 beans. These are significantly lower than the annual average 2.6% retail level discount (per hole in 100 beans) demanded by consumers in Tanzanian bean markets (Mishili et al., 2011).

In maize, the marginal discount intensity is much higher, with a 1.13% (±0.07%) and 1.89% (±0.11%) discount for each 1% damaged grain in the Lean and Immediate Post-Harvest Seasons, respectively. Maize is frequently consumed as whole kernels and newer to the Rwandan diet, possibly contributing to this disparity. While marginal discounting in maize is more severe, the lower value of maize (per kg) results in largely similar revenue loss. Figure 1 presents a graduated revenue loss from price discounts for a 100 kg bag of common beans and maize1

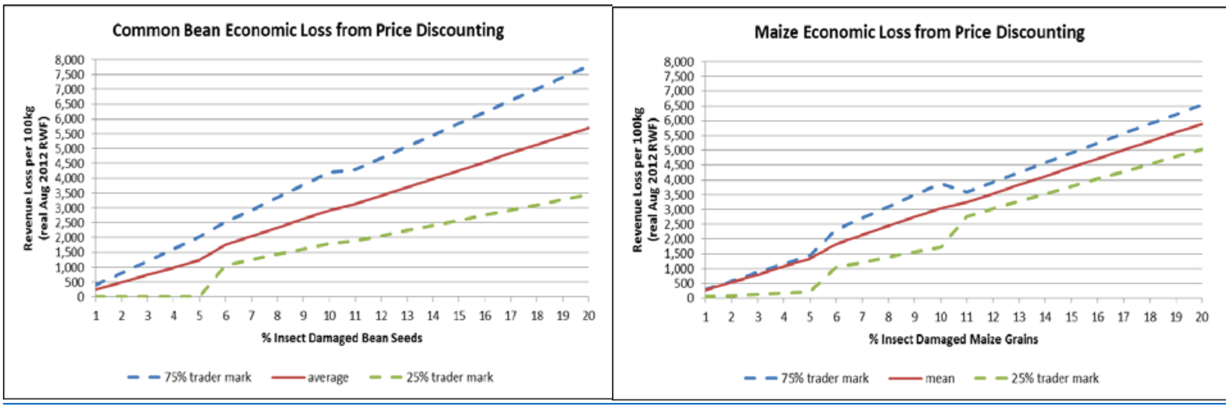

Figure 1: National Average and Interquartile Range of Revenue Loss from Price Discounts in 100kg Bag of Insect-Damaged Beans and Maize (Lean Season, Season B, after 4-5 Months Storage) [RWF:USD at 605:1]

[1]Based on survey average of non-damaged prices of 357 RWF/kg for beans and 252 RWF/kg for maize. Damage under 5% was not measured in this survey, but we extend the discount parameter estimate down to 0% damage for illustration purposes. Below 5% damage, these losses may be an overestimate since thresholds before discounting may be more widespread.

We additionally use a two-stage model to investigate physical and non-physical drivers of buying insect-damaged maize and beans and, if purchased, the demanded discount intensity. Results indicate that while insect damage levels play a central role, large volume traders penalize damage less while traders in the seed market, storing before re-sale, or purchasing heavily from farmers (vs. other traders) penalize damage significantly more. More educated traders are both more likely to purchase damaged grains and demand higher discounts. This may indicate that more knowledgeable traders understand how to blend poor quality beans with clean beans to arrive at sample which does not exceed a damage threshold for their future customers, as is common practice in developed country grain markets.

Conclusions: Findings have helped develop more evidence-based extension programming for the Post-Harvest Task Force of the Rwandan Ministry of Agriculture and could be adapted as an easily implemented and potentially insightful model for other developing-country policy makers. Additionally, derived discount coefficients help evaluate the cost-effectiveness of technologies throughout the region which prevent post-harvest damage.

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Abstract # ADMI094

Food Losses and Food Security Training for Georgian Farmers

Kakha Nadrirazea, Nana Phirosmanashvili, Mariam Goginashvili

Association for Farmers Rights Defense, AFRD

Corresponding Author: foodsafetyge@gmail.com

Georgian Agriculture is rapidly transforming into a modernized, productive and competitive force by the State Support in the last three years, a wide ranging, highly effective set of policy reforms focused on enabling private-sector led modernization of the Ag Cooperatives to sustainable agribusiness community. Smallholder farmers in some selected communities of Georgia have been trained by the Experts of the Association for Farmers Rights Defense, AFRD how to reduce Post-Harvest Losses using the small bags and vehicles for collecting post harvest crops for moving to storage. This enables Georgian farmers to store different crop variety grains including maize, millet, sorghum, beans, wheat among others for more than one year after harvest. One hundred and fifty benefited from the training, which helps to improve food availability and increase income of smallholder farmers. Postharvest technologies can contribute to food security in multiple ways and can reduce PHL, thereby increasing the amount of food available for consumption by local farmers and poor rural and urban consumers. The benefits to consumers of reducing losses include lower prices and improved food security. In addition, postharvest activities such as processing and marketing can create employment and thus income and better food security in the agricultural sector. Therefore, reducing PHL clearly complements other efforts to enhance food security through improved farm- level productivity and will generate incomes. The economic estimations have been restricted to weight losses; however, the size of the economic value of total losses could be substantially higher if the losses associated with missed market opportunities were considered. Although opportunity losses are more difficult to estimate than weight losses, there is a need to better understand their importance. The establishment of post harvest weight loss baseline data, as well as a better understanding of the magnitude of the opportunities lost, are both critical to better inform development experts, policy makers, and industry stakeholders of the options offered by the systematic adopting of PHL-reduction strategies. The exercise presented here on PHL estimations also suggests the need for an approach that balances the costs and benefits of producing more food to cover the losses caused by the lack of appropriate PHL reduction technologies and practices.

Abstract # ADMI095

Global Variations in Micro-nutrient Losses in the Fruit and Vegetables Supply Chains

Mauro Serafini[1,2], Warren T K Lee[1], Elisabetta Toti[2], Camelia Bucatariu[3], Jorge M Fonseca[3], Robert van Otterdijk[3] and Divine Njie[3]

[1]Nutrition Division, Food and Agriculture Organization of the United Nations. 00155 Rome, Italy.

[2]Functional Foods and Metabolic Stress Prevention Laboratory, Research Council on Agriculture, Center of Nutrition (CRA-NUT), 00178 Rome, Italy.

[3]Rural Infrastructure and Ago-Industries Division, Food and Agriculture Organization of the United Nations, 00155 Rome, Italy

Corresponding Author:

Introduction: Today, 795 million people are chronically undernourished and over two billion people are micronutrient deficient worldwide. At the same time, approximately one-third of global food production is lost and wasted. Massive food losses and waste (FLW) represent a missed opportunity to improve food security and nutrition of people in the world. However, research to investigate the extent of micro-nutrient losses from foods is limited.

Objectives: To investigate losses of vitamins A and C associated with fruit and vegetables losses along the food supply chains in seven regions of the world during 2009.

Methods: Global Food Losses and Food Waste Report (Gustavsson et al. 2011) and FAOSTAT's food balance sheets were used to estimate volumes of FLW in 7 world regions [Europe; North America and Oceania (NAO); Industrialized Asia (IA); Sub-Saharan Africa (SAA); North Africa, West & Central Asia (NAWCA); South & Southeast Asia (SSEA); and Latin America (LA)]. Vitamins A and C contents in fruits and vegetables were determined using the USDA National Nutrient Database.

Results: The highest per capita vitamins A and C in FLW in fruit and vegetables were found in IA (China, Japan and South Korea): vitamin A: 784 RE/person/day and vitamin C: 90 mg/person/day, the lowest were found in SSA (vitamin A: 135 RE/person/day; vitamin C: 26 mg/person/day).

Across the seven regions, agricultural production, post-harvest and consumption accounted for the majority of vitamins FLW along the food supply chains, while food processing accounted for the lowest FLW. Agricultural production in IA and NAO had the highest vitamins A and C FLW respectively (Vitamin A: 228 RE/person/day; vitamin C 33mg/person/day). IA was also the lead region in the world with the highest vitamin A FLW among fruits and vegetables across different steps of the food supply chain apart from food processing. Regarding vitamins A and C waste in fruit and vegetables at consumer end, IA produced the highest waste, followed by NAO, Europe, NAWCA, SSEA, LA, while the lowest was in SSA.

Conclusions and Discussions: Vitamins A and C losses and waste in fruits and vegetables due to FLW across the entire food supply chains are alarmingly high in the world, especially during agricultural production, post-harvest and consumption. Reduction in FLW could avail more micro-nutrients for human consumption, thereby contributing to the alleviation of micro-nutrient deficiencies in the world's vulnerable populations. Regions in the world having the highest nutrient losses in FLW warrant further research to formulate better policies and strategies to revert the trend.

The methods used in the present study to estimate nutrient losses in FLW of fruit and vegetables had some limitations: The global databases on FLW are based on seven food categories without disaggregated food items. Hence, assumptions had to be made to estimate nutrient contents in fruits and vegetables, because most food composition databases express nutrient contents per food item. Furthermore, information on global FLW is not grouped by country but by geographical regions (n=7). In order to estimate precisely micro-nutrient losses and waste in FLW, empirical country specific FLW data based on disaggregated food items are needed.

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Abstract # ADMI096

POST-HARVEST FISH LOSS EVALUATION: CASE STUDY OF BOILED SALTED FISH IN PATI, CENTRAL JAVA, INDONESIA

Syamdidi; B.S.B. Utomo, Badarudin, S. Wibowo

Research and Development Center for Marine and Fisheries Product Processing and Biotechnology, INDONESIA

Corresponding Author: mcnamar1@illinois.edu

Background: Boiled salted fish, locally named “pindang”, is one of the most popular processed fish in Indonesia which is commonly consumed by low to middle income society. Mostly, boiled salted fish is processed from small pelagic fish. It has lower salt content compared to dried salted fish. This product is mainly produced by small-medium scale (SMS) processing units, in which losses becomes a major issue in the supply chain. Post-harvest fish losses are often caused by biochemical and microbiological spoilage changes that occur in fish after death (Diei-Ouadi & Mgawe, 2011). Some physical treatment also caused loss during the supply chain including processing stage.

Unfortunately, currently there was no study conducted to measure the quantitative loss of boiled salted fish. In Indonesia, post-harvest fish losses including boiled salted fish processing have been quoted as much as 30%. This figure is still quoted regardless of the many efforts that have been undertaken to improve fish handling practices. Moreover, there is no explanation of how this figure of 30% has been derived (Utomo, 2014; Wibowo, et al. 2014)

Objectives: This study aimed is to identify and quantify the main causes of fish losses in the selected fish supply chains, and to analyze how to reduce fish losses of boiled salted fish production.

Methods: This research was taken place at Pati District located in northern coastal of Central Java, around 500 km from Jakarta, Capital City of Indonesia. Pati is known as one of the largest boiled salted fish processing center in Indonesia with total raw material processed around 100 ton/day. There were three main fish species processed into boiled salted fish, namely scad fish (*Decapterus* sp.), pacific mackerel (*Scomber sp*), and small skipjack (*Euthynnus affinis*).

Fig 1. Boiled salted fish unit processing (a) Boiled salted fish product (b)

The study was initiated with preliminary screening which was done based on secondary data, documentation and reports, and expert consultations (by phone and in person), discussion with key person, individual discussion and field observation (EFLAM). A method of questionnaire loss assessment method (QLAM) developed by Ward and Jeffries (2000) was applied to measure the loss along the selected supply chain from fish landing, handling, processing, packaging, distribution, and marketing.

The processing of boiled salted fish was similar with dried salted fish. Fish was soaked in dry salt for 10 minutes to prevent the quality. Then fish was sorted based on the quality and arranged in small bamboo tray for boiling in saturated saline solution for 15-20 minutes. Fish then let cooled at room temperature before packaging.

Results: The result showed that all 10 respondents interviewed during study experienced post-harvest fish loss. It was recorded that the fish loss was very low, namely 0.31% for scad fish, 0.09% for pacific mackerel, and 0.36% for small skipjack (Table 1).

Table 1. Percentage of loss of boiled salted fish

No	Small Scale Enterprises (SME)	Fish species	Fish loss (%)
1	Adiputra	Scad fish Pacific Mackerel	0.46 0.14
2	PS	Scad fish Pacific Mackerel	0.32 0.12
3	Puspita Sari	Scad fish Pacific Mackerel	0.27 0.07
4	Samudera Jaya	Scad fish Small Skipjack	0.21 0.30
5	UPI 1	Scad fish	0.33
6	UPI 2	Scad fish	0.29
7	UPI 3	Scad fish	0.37
8	UPI 4	Scad fish Pacific Mackerel	0.24 0.04
9	UPI 5	Scad fish Pacific Mackerel	0.35 0.10
10	Anak Nelayan	Scad fish Small Skipjack	0.23 0.26
AVERAGE		Scad fish Pacific Mackerel	0.31 0.09

The highest Small Scale Enterprises (SME) experienced with loss was Adipura about 0.46% for scad fish and 0.64% for pacific mackerel. The lowest SME experienced with loss was PS about 0.32% for scad fish and 0.12% for pacific mackerel. The main cause of fish loss was identified to be physical loss (damage) due to inappropriate handling. Fish loss of boiled salted fish was occurred due to bad handling prior and along processing stages started from unloading fish from truck, thawing stages in open air, sortation and packaging. Unloading fish from the truck contributed the highest loss. Because of this, the brittle frozen fish used as raw material for boiled salted fish will break down into pieces which will not be processed into boiled salted fish but will go for fish feed instead.

Conclusion: In summary, fish loss of boiled salted fish was occurred due to bad handling prior and along processing stages. Bad handling was the most factor causing loss along the processing supply chain so an intervention of good handling is urgently needed to reduce the loss.

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Abstract # ADMI097

Principals of Designing and Implementing Extension Programs for Post-harvest Loss Prevention

Paul McNamara and Joyous Tata

University of Illinois at Urbana-Champaign, Illinois, USA

Corresponding Author: mcnamar1@illinois.edu

Post-harvest losses represent a significant threat to food security and farmer incomes worldwide. It is an inefficiency in the global food production system that is avoidable using appropriate technology. In designing interventions to reduce post-harvest losses, valuable lessons can be gleaned from other major agricultural technological change initiatives. Utilizing such previous experiences and distilling them into a form useful for Informing post-harvest loss prevention programs Is Itself an efficient way to arrive at solutions to this problem. Some important elements of the post-harvest challenge from an extension perspective Include: multiple points of Intervention, multiple value chains, multiple technologies a dimensionality problem in terms of the technology; relevant value chains embedded in weak and poorly developed systems overall; these agricultural-enabling environments face policy challenges as well as institutional capacity constraints, and in some cases, weaknesses in the investment and private sector business operating climate. When considering efforts to reduce post-harvest loss significantly in the developing countries of SSA and South and Southeast Asia, what dimensions of the phenomenon shape how we think about the challenge of large-scale programs? Especially, what dimensions of the problem are relevant to utilizing insights from extension programs? A first relevant aspect of the post-harvest loss challenge in these countries is its dimensionality. It involves linkages up and down the supply chain, though some experts feel that post-harvest loss challenges are greatest in the developing countries at the farmer-producer end of the supply chain (IMECHE 2013,p.17). Many different actors have decision-making power that affects the level of post-harvest loss in these chains: farmers, processors, importers and suppliers, machine and tractor service providers, millers, distributors and storage businesses, marketing channel actors, input dealers, as well as institutions such as credit markets, labor markets, output markets, and academic and commercial researchers. Another layer of dimensionality is on the technical side where multiple approaches, techniques, and products most to help reduce post-harvest losses. Given scarce resources, donors or policy makers may need to make choices about where to target their education, training and research, and demonstration and extension funds fora post-harvest loss reduction program. Policy makers may face a difficult task in identifying the critical and most productive post-harvest loss reduction investments to support. Viewed from the extension programs and systems lens, this aspect of dimensionality becomes important for several reasons. First, even technologically sound innovations may fall to take off and become widely adopted if other aspects of the supply chain or value chain are inhibiting or reducing the ability of adopters to increase net incomes through the technological improvement. For example, if distortions or significant gaps or bottlenecks occur at the milling stage, even if post-harvest losses can be prevented on the farm, it may not make sense for the farmer to invest in those loss- reducing technologies. Similarly, if a great technological advance in post-harvest loss is available but credit is highly constrained, it is unlikely that smallholder producers would benefit from the advancement Secondly, an extension challenge that displays multiple dimensions may indicate that a multi-pronged extension approach is needed in order to reach the various decision-makers and actors involved in the most important components of the system. The challenge of identifying and prioritizing post-harvest loss reduction interventions and products becomes another aspect of the process. Extension programs that achieve significant impacts in terms of behavior and

practice changes, as well as agricultural productivity increases, succeed as a result of good program designs and effective implementation management They succeed because they provide a platform and avenue for desired change with their participants and because the program elements that support this change at the household, farm, firm or community level are present and vibrant. Making this happen is challenging in many environments because it involves mobilizing multiple actors, significant institutional capacity and human resources, as well as a sound suite of technical or practice innovations. By considering the experiences of well-functioning extension programs, post-harvest loss prevention program designers will increase their likelihood for significant program impacts. This paper surveys key principles from effective agricultural extension programs operating in developing countries to inform post-harvest loss prevention. This paper aims to contribute to the design of post-harvest loss reduction efforts in developing nations. The paper focuses on the crafting of strategies for large-scale efforts in the countries of Sub-Saharan Africa (SSA) as well as South and Southeast Asia. Data was collected through project document review, and field experience gathered during the implementation of the Modernizing Extension and Advisory Services (MEAS) program.

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Abstract # ADMI098

Mobile for Postharvest Management: Investigating the opportunity of low-cost communication technologies for professional warehouse management

Jan Priebe

University of Greenwich, UK

Corresponding Author: j.s.h.priebe@gre.ac.uk

Mobile for Postharvest Management: Investigating the opportunity of low-cost communication technologies for professional warehouse management Warehouse administration is important for effective management of food reserves and food stores, and is crucial to setting up warehouse certification systems. It creates the information flows necessary to provide warehouse managers with more accurate information about current stock levels, their age and quality, aiding decision making processes. Damaged stores can be identified faster and can be more easily traced throughout the system and eliminated, improving the overall quality of stores. Furthermore, professional warehouse administration and certification is a vital step to establishing a warehouse receipt system. The administrative systems currently used are paper-based and were often developed over time, becoming unnecessarily complex and time consuming. They often use rudimentary manual reporting systems making them inefficient to operate and, because of the errors and delays incurred in filling the forms and in transporting them to where they are collated and used, they often provide only outdated and unreliable data. Computer-based administration systems, on the other hand, can be costly and require extensive trainings to use, especially when they rely on computers and proprietary software packages. While they are increasingly being adopted for cash crops, they are often unsuitable for food security crops due to their associated high costs and required organisational skillsets. The rapid spread of mobile technology in Africa over the past 10 years means that relatively low-cost devices and software platforms are becoming increasingly available that could provide much needed information transparency in post-harvest logistics and warehousing. These are driven by developments in cloud-based storage (1) eliminating the need to invest in server infrastructure and software-as-service (2) business models which make software more accessible to organisations by reducing access costs. Moreover, due to the steady development of open-source (3) software packages, simple data collection and management software can be implemented at little or no cost. These low-cost and increasingly mobile systems can contribute to effective storage management by drastically reducing administrative costs and increasing the speed with which information is shared between actors in a system. However, although their potential benefits are considered to be significant, adoption of these systems has been relatively low, and little research has been done to understand whether these systems may contribute to the professional administration of warehouses. This study explores the capacity for mobile ICTs to facilitate information transparency in logistics and warehouse management. It reviews relevant case studies from the literature and incorporates first-hand experiences from projects conducted by the Natural Resources Institute in Zambia, Tanzania and Uganda. These cover the use of tablets to record warehouse receipts for the Zambian Food Reserve Agency, and the use of smartphones and tablets to support the implementation of a warehouse certification system by the Tanzanian Warehouse Licensing Board. It is argued that low-cost ICTs represent an appropriate technology for supporting the professional warehouse administration of staple commodities, and can provide an important first step on the technology ladder allowing users to experience many of the benefits of ICTs without having to submit to all its burdens.

The main benefits are to allow warehousing organizations to simultaneously increase the internal transparency of information, while reducing the time and costs associated with collecting it. However, as experiences show, the choice of technology plays a key role as does providing the appropriate trainings and incentives to staff at all levels of the organisation to ensure data is collected accurately and continuously. (1) Cloud-based storage refers to data storage that is provided by a third party, which is accessible through data connections such as mobile data networks and fixed internet lines. Data is often protected through encrypted data connections and restricting access to the database. (2) Software as a service business models provide access to software that are hosted by a vendor and can be used via internet connections, eliminating the need to purchase and install software packages. Remuneration is typically done via periodic subscriptions. (3) Open-source software is computer software that is made available with a license in which the copyright holder provides the rights to study, change, and distribute the software to anyone and for any purpose.

Abstract # ADMI99

Establishing a Trade -by-Barter Food Network with Dried Foods

Chukwudike Abraham

Society Against Poverty and Hunger

Corresponding Author: societyagainstpovertyandhunger@yahoo.com

In Agriculture, the postharvest stage must be managed carefully in order to have minimum amount of losses from the production and to deliver the greater amount of product for consumption. This stage will determine the profitability of a farmer"s work of the week or months and the efficiency in the use of resources such as land, water and soil fertility. Since agriculture alone is responsible for 18% of global GHGs emission, and the World food losses produces year 3.5 gigation of GHGs, better post-harvest practices would also reduce global warming.

The improvement of post-harvest practices, however, faces several challenges, including inadequate transportation, lack of cooling system, poor storage and difficulties in accessing markets. These problems are higher and more difficult to tackle for smallholders in developing Countries. In Countries like Nigeria and other developing nation, where losses are quantified and the losses after transport to be selling point are on average 16% of the load, feasible solution are required.

The Sun - Solar Barter system aims to provide rural Communities in tropical and Sub-tropical Countries with low cost solar dryers, managed by farmers" Cooperatives or similar community "hubs" farmers are encouraged to process the surplus of seasonally abundant fruits and vegetables into dried products and to trade the product by Barter or sell it through and interactive SMS service. The SMS- system rather than app-based network circumvents dependence or internet service and smartphones.

The solar driers model was selected to tolerate different sorts of available construction materials, and to respond to the climatic characteristics of the regions selected for the project.

We target areas where infrastructure and the preservation model of fruits and vegetable are bad, and because of the mentioned reasons, at the seasonal peak, +45% of fruits and vegetable products is lost after harvest(mainly during transportation) or near the harvesting stage.

Drying fruits and vegetables, together with the barter system through a mobile phone platform, has the potential to prevent food losses, create a value added product in the place of waste, and positively impact seasonal food insecurity while meeting local food preferences.

An exchange between groups tackles also the problem of seasonal availability of the products in rural areas, and potentially improves household nutrition. Combining existing solutions might result in one greater solution.

Our greatest target is to create pilot projects, to assert the actual impact and feasibility of the idea across selected locations. Upon success, we scale up the reach of the project to cover the different countries with special focus on Nigeria, Mali, Kenya and Egypt and Asia.

Abstract # ADMI100

Economic Assessment for Sustainability of Post-harvest Technologies

Alex Augusto Gonçalves

Laboratory of Seafood Technology and Quality Control (LAPESC), Animal Sciences Department (DCAn), Federal Rural University of Semi-Arid (UFERSA), Mossoró, RN, Brazil

Corresponding Author:

The expansion in demand for fish products in recent decades has been accompanied by growing interest in food quality and safety, nutritional aspects, and mainly in wastage reduction. In the interests of food safety and consumer protection, increasingly stringent hygiene measures have been adopted at national and international trade levels. Fish is highly perishable and, unless correctly treated after harvesting, can soon become unfit to eat and possibly dangerous to health through microbial growth, chemical change and breakdown by endogenous enzymes. Proper handling, processing, preservation, packaging and storage measures are essential to improve its shelf life, ensure its safety, maintain its quality and nutritional attributes and avoid waste and losses. In the last two decades, there has been a global trend of growing awareness about the economic, social and environmental aspects of optimal use of fishery resources, and of the importance of reducing discards and losses in post-harvest phases (storage, processing and distribution). Globally fish losses are estimated to be ten to twelve million tons per year, accounting for around ten percent of the total production of capture fisheries and aquaculture.

The total global capture fishery production in 2011 reached 93.7 million tons. The inland waters production reached 11.6 million tons in 2012, and aquaculture production reached 90.4 million tons (in 2012). It has been estimated that 20 million tons (or more) of fish per year is discarded at sea, another form of post-harvest loss. The FAO estimates fish losses for fisheries among the highest. This is also accompanied by financial loss since the spoiled or poorly processed fish is discarded or sold at a low price. Global demand for fish is growing and reduction in post-harvest losses would make a major contribution to satisfy this demand by improving the quality and the quantity for consumers and increasing the income for producers. Appropriate preservation methods can significantly reduce this loss when the processing, distribution and marketing systems cannot cope with the exceptional quantity of fish landed due to seasonal or inter-annual variations of availability or abundance. Despite the extensive research and promotion of remedial techniques, uptake of recommended control measures has been limited. There is very little published information directed at aspects concerning post-harvest loss reduction.

Fish and others seafood is known a very perishable commodity and hence susceptible to high post-harvest losses. Generally, there are three types of losses that are considered mainly in small-scale fishery:

I. Physical - fish not used after capture/harvest or landing, and totally lost from the supply chain and not consumed or utilized;
II. Quality - products that are spoiled or damaged but not to the extent that they are thrown away, the nutritional value may or may not be affected, i.e. products of lower quality; and
III. Market force - loss due to market reaction affecting the selling price to such an extent that, irrespective of quality, the fish sells for a lower price.

Both physical and quality losses are high in the fisheries sector and these translate into losses in nutritional contribution of fish to the total diet and health of populations. Studies on post-harvest losses

in several countries indicate high levels of losses both in quantity (material or physical losses), and quality (mostly due to downgrading) of fishery products. The "total global food losses" in small-scale fishery have been estimated at 1.3 billion tons per year, which is about one-third of the total world food production for human consumption. This situation includes post-harvest fish losses, which are reductions in the quantity, quality or monetary value of fish in the supply chain. Greater attention is focusing on the loss in the monetary value of fish (not necessarily a result of loss of fish as food, but a downgrading in value irrespective of quality) because it is a key target of the rural poverty elimination goal.

There is an increasing interest in effective intervention for post-harvest loss reduction. The investment required to reduce fish post-harvest losses is relatively modest and the return on that investment rises rapidly as the price of the commodity increases. Post-harvest fish losses occur globally in all fisheries, from the point of production to the final sale to the consumer, but the magnitudes and types vary.

As in any food system, losses of fish affect the four dimensions of food security: availability, access, stability and utilization. The socio-economic impact of post-harvest losses is significant because the post-harvest domain comprises several activities at all stages of the supply chain, including handling fish on board, unloading, processing, storage and distribution. Losses also affect resource sustainability. Estimates of post-harvest fish losses range between 20 and 75 percent.

Traditionally processed fish is a nutritionally and economically important commodity in many tropical developing countries; however, the major losses that occur are due to traditional processing methods. Then, the technology used and emerging (or innovation) technologies should be crucial factor in reducing losses.

Regarding to economic assessment for sustainability of post-harvest technologies, it is necessary to evaluate the main causes of fish post-harvest losses, i.e. if they are related to harvesting techniques, storage, transportation, processing, cooling facilities, infrastructure, packaging and market systems. Nowadays, interventions in fish post-harvest loss reduction are seen as an important component of the efforts of many agencies to reduce food insecurity. Various studies on postharvest food losses support the view that interventions for the sustainable reduction of these losses have to be planned within the context of the relevant value chains.

Based on this information, some questions remain:

I. How supply chains in economically developing countries can be strengthened and improved to enable food production in an economically, environmentally and socially sustainable way so that food losses will be decreased to a minimum?
II. How to analyze the economic impact of post- harvest loss of the fishery?
III. Which suggestions of strategies for reducing post- harvest loss of the fishery would be effective?
IV. How to conduct a cost and benefit study to assess the net economic benefit of the proposed strategy?

Several initiatives in fisheries have echoed the concerns about post-harvest losses in small-scale fishery. Given that there may be multiple root causes, whether technical, technological, financial, managerial, policy or behavioral, it would be unrealistic to generalize from one fishery to another or even within the same fishery. The situation is further complicated in small-scale fishery because many fisheries, particularly tropical ones, are multispecies and catches lack uniformity in terms of composition, weight and shape. In addition, spoilage rates vary under different conditions for different fish, and value chains can have fragmented distribution systems involving many stakeholders. Moreover, landing sites and markets often use non-standardized units of measurement for trading and pricing purposes.

Reducing post-harvest loss requires wiser use of resources, reducing spoilage and discards and converting low-value resources, which are available on a sustainable basis, into products for direct human consumption. Reducing spoilage requires improved fish handling on board, processing, preservation, and transportation, all of which are particularly deficient in small-scale fisheries.

Conclusion: There is a necessity to propose a cost effective management strategy to reduce post-harvest losses in fishery chains around the world, for economic and nutritional benefit to the people.

Reducing post-harvest losses in artisanal and commercial/industrial fisheries will increase productivity, profitability and secure access of fishery to rewarding local and regional markets.

Government and development agencies should set a comprehensive post-harvest loss intervention fisheries related policy that covers the future development of the fishery.

Education is an important part of the loss reduction process.

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Abstract # ADMI101

Assessing Responses to Food Loss Reduction of Public Investments in Postharvest Facilities

Nerlita M. Manalili[1], Kevin F. Yaptengco[2], and Alessandro Manilay[3]

[1] NEXUS Agribusiness Solutions, Managing Director

[2] University of the Philippines at Los Banos, College of Engineering and Agro industrial Technology, Associate Professor

[3] University of the Philippines at Los Banos, College of Economics and Management, Assistant Professor

Corresponding Author:

Introduction: Majority of postharvest facility (PHF) investments in developing countries are government (public) initiated. The Philippines is no exception, given government PH program investments across the value chain such as in on-farm postharvest activities, processing, logistics, marketing and trading. As these programs entail significant government investment in manpower, facilities and equipment, it is but proper to assess their performance. Thus, In aid of policy formulation and investment planning, the Philippine Institute for Development Studies (PIDS) of the National Economic and Development Authority commissioned NEXUS Agribusiness Solutions to undertake the "Rapid Appraisal of Selected Postharvest Facilities in the Philippines" which is the basis of this paper.

Objectives: This rapid appraisal (RA) evaluated selected PHFs in the context of upgrading value chains and improving economic outcomes for small farmers. Specific objectives were: (1) characterization of PHF project identification, beneficiary and site selection, expenditures, assets, and impacts, (2) assessment of PHF projects (quality, utilization, and management) and (3) identification of strengths and weaknesses in the PHF project cycle.

Methodology: Selection of PHF for evaluation ensured technical and geographical representation by including at least one each for the following PHF categories:

1. Equipment and facilities required immediately after harvest (e.g. threshers, dryers)
2. Processing and storage facilities (e.g. milling equipment, ice plants)
3. Market infrastructure and transport facilities (e.g. food terminals, tramlines) and for the country's major island grouping, Luzon, Visayas and Mindanao.

The RA centered on four Rice Processing Centers (RPC), established from the Korean International Cooperation Agency (KOICA) grant and are located in Sta. Barbara, Pangasinan, Matanao, Davao Del Sur, Pilar, Bohol, and Pototan, Iloilo. Using these sites as the hub, other postharvest facilities such as food terminals (FT), flatbed dryers (FBD) and threshers were included for evaluation. An initial assessment of the status of various PHFs was undertaken, then an in-depth assessment of the shortlisted PHFs. In-depth assessment include site visits and interviews with farmer-respondents (table 1) and key informants (KI) which include representatives of institutions involved in the planning/operation of a PHF, [officers of local government units (LGU), Department of Agriculture (DA) and PHF facilities]. Information on status of PHFs was also obtained from the Philippine Center for Postharvest Development and Mechanization (PHILMECH), the DA, and LGUs.

Findings:

The KOICA-RPCs were found underutilized, for lack of capital for paddy procurement and limited availability of paddy. The Php20 Million working capital provided by the DA is inadequate relative to the RPC's design capacities, to service 1,000 ha of production area and a PhP80 Million capital

requirement to operate on full capacity. RPCs reduced postharvest losses in rice (Table A). Drying and milling using RPC equipment resulted in a loss reduction valued at PhP236.93 Million.

Table 1. Number and type of respondents by postharvest facility per province

Province/ Institution	Rice Processing Center			Municipal Food Terminal			Barangay Food Terminal			Flatbed Dryer	Thresher	Key Informant
	A	B	C	D	E	C	D	E	C			
Pangasinan	35	35	1	0	0	0	0	5	1	4	4	27
Davao del Sur	31	32	1	0	0	0	30	33	3	4	6	34
Iloilo	32	30	1	21	13	2	4	8	1	6	10	23
Bohol	31	30	1	11	11	1	20	20	2	6	5	22
PHILMECH												11
Total	129	127	4	32	24	3	54	66	7	20	25	117

A = User of facility; B = non-user; C = manager; D = supplier of food terminal; E = customer of food terminal
Source: Impact Evaluation Terminal Report

Table A. Value of Reduced Losses from proper grain drying and milling using KOICA Rice Processing Centers

Parameter	**Value (PHP)**
Value loss (delay in drying)	37,485,829
Quantitative loss (improper drying)	82,876,528
Quantitative loss (milling)	116,567,668
Total	**236,930,025**

The RPCs higher buying prices (than private traders/millers) afforded farmers higher income (PhP0.79 to 1.11 per kg.), especially during wet season, while total gain in farmers' income reached 13.9 Million. With new equipment and trained personnel, RPCs are able to produce properly dried paddy and good-quality milled rice, and provide a safety net for farmers during periods of oversupply.

Flatbed Dryers and Threshers: While FBD, reduce grain deterioration during rainy season at farm level, the aggregate capacity of drying facilities is not enough to accommodate all farmers. During dry season, FBDs impact is less pronounced since farmers prefer selling wet paddy or sun drying. For this RA, the volume of threshed paddy from 20 key informants was about 141,320 kg. The quality loss eliminated by timely threshing was PhP190,000 (PhP9,500 per famer).

Food Terminals: Barangay Food Terminals (BFT) and Municipal Food Terminals (MFTs) function as food depots and distribution systems. Usually located around farming or fishing areas, they directly link suppliers and consumers and reduce transport cost (BFT), with savings from PhP7.50 to PhP275 per trip depending on commodity. MFTs serve as trading centers where growers can bring produce in large volumes for direct trading with wholesalers, thus reducing middlemen' involvement and improving growers' income. Location is very important in ensuring a successful and sustained MFT operation; when the presence of pre-existing trading centers has not been adequately considered, this has resulted in an under-utilized facility.

Conclusion: The assessed PHF are responsive to farmers' needs, covered key areas (production, postharvest, processing and marketing), and generally met pre-set objectives and post positive impacts.

- RPCs’ are able to increase farmers’ income, produce good quality milled rice, reduce postharvest loss, improve distribution system, and maximize utilization of by-products. Continued government support until a beneficiary can take over the RPC is needed.
- FBD/thresher distribution programs preserve grain quality and reduce volume of postharvest losses. Increased productivity has come with rice mechanization, but programs must ensure benefits accrue to farmers, the target beneficiary.
- FTs provide agri-suppliers with access to markets, improve availability of commodities and basic goods, create employment, enable operators to become entrepreneurs, and strengthen LGU – private sector partnership. Proper management, comparable product prices (to nearest market) as well as entrepreneurial skill of beneficiaries were key to successful FT operations.

The following are recommended:

PROJECT PLANNING AND IMPLEMENTATION

1. Project proposal should be well developed; flawed designs cannot be offset by good implementation strategies.
2. Involve project beneficiaries/stakeholders as early as possible: Identify individuals to champion projects’ cause.
3. Strictly adhere to project implementation guidelines; guard against political interference.
4. Verify/take actions on non Compliance of RPC products with NFA standards for milled rice

ENHANCING UTILIZATION

RPCs - Increase operating capital to Php 40-80 Million to allow RPCs to scale up procurement and undertake operational efficiency enhancing moves: credit provision (reduce dependence on high interest charging traders) proper scheduling of planting/harvesting matched with appropriate logistical support and spare part replacement fund allocation.

FBDs - To recover public investment in the form of reduced losses and improved product quality,need close monitoring of accredited fabricators to ensure quality of disseminated units, thorough evaluation of recipients and proper site selection to maximize utilization of dryers.

FTs - Success and failures of MFT/BFT be documented, compiled and disseminated for learning insights. For technical improvement of existing FTs, better lighting and unitized handling will help reduce mechanical damage to produce, reduce labor requirements and lessen worker strain. Hygienic handling should also be put in place to improve food safety.

Survey existing food terminals and wet markets, prior to project implementation as their status are indicators of whether an additional MFT facility is needed, in what size and where to establish. All evaluated government PHF programs are still ongoing (even expanded). In-depth review of these programs is needed to determine intervention impact. Selection of sites and beneficiaries should be based on a set of suitable criteria, rather than using a “divide-by-N” approach that disregards the possibility of duplicate functions and overlapping coverage of a growing or trading area (HDN 2013). Such facilities established and maintained with scarce government funds points to poor and short-sighted planning.

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Abstract # ADMI102

A Qualitative Discussion about the Utility of Staple Grain Logistical Platforms in Ghana, West Africa

W. Lanier[1], W. Salifu1, D. Parker[2]

[1] NeverIdle Farms Consulting, Ghana

[2] Flat Pack Silos Australia

Corresponding Author: neveridlefarms@gmail.com

Introduction: It is hard to understand why the spread of sms texting, commodity exchanges, microfinance, mechanization, improved seed, fertilizer, pest management and increased gross yields in the world's poorest places has been heralded as breakthroughs with the potential to "double the agricultural productivity and incomes of small-scale food producers." When the reality is, significant Postharvest and related input loss (PHL) needlessly limits higher yields from increasing the wellbeing not just of smallholders but of entire developing countries.

Staple grain, pulse and oilseed storage programs have been proven by farmers, agronomists and stored grain researchers to guarantee Food security against PHL. However, Sub-Saharan African (SSA) institutional sack storage and "warehouse receipt systems will likely fail when support is withdrawn. These are typically multimillion projects that do not work, as the marketing environment is not sufficiently developed to support them. Even if they did work, they would not help smallholders, which they are often claimed to do" (World Bank/Ferris, 2013).

Background: Let's try to imagine the plight of a woman farmer in SSA, growing grain to feed her family without staple grain utility storage. She will suffer "significant Postharvest loss" (Lipinski, 2013), because practically she does not have the right to benefit from her harvest. If she sells for a low price during peak harvest, her labor and other production inputs (that are often micro-financed) will be wasted. If she attempts to own the right to the value of assets like Land tenure, she may "increase the risk of violence in the short run, by challenging traditional gender roles and increasing conflict in the household" (Bott, 2005). The combined result is she may experience "market failure" (Jones, 2011) after selling low, and then buying back at a higher price. In this sense, the PHL risk undermines a mother's ability to feed her children quality, high calorie grain or improve farm income.

Objectives: Simplify PHL into "after the plate" and "before the plate" topics and by setting aside wet, low calorie fruit/vegetable PHL, because for example, "Encouragingly, though, tackling [grain] post-harvest loss is not rocket science. It does not require technological breakthroughs or years of high level scientific research as do some of the other challenges we face" (Cousins, 2015).

1. To evaluate the utility of various Ghana grain grower storage options by organizing and reviewing literature including lifecycle assessments, popular press and personal observation of adaptive learning in low investment, tenure-less SSA agriculture.
2. To implement mobile utility storage at 4 locations to demonstrate this approach.
3. Identify any potential institutional roadblocks to adoption of mobile storage systems.

Approach: Approach Ghana growers with assessments of: sack, metal cans, hermetic or ZeroFly® bag, warehouse, silo and mobile utility (See Image 1.) storage. Perform due diligence by inspecting storage systems. Design, test and refine mobile utility storage at 4 locations. Investigate potential roadblocks by asking "Global PHL Prevention: Fundamentals, Technologies, and Actors" (Kalita, 2015), SSA

Governments, production oriented pre-harvest forums, PHL training groups, United Nation Food Security conferences and International PHL congress "Why mobile utility is not already a storage option?"

Fig. 1. Example Mobile utility storage

Results: PHL caused grain quality deterioration is a needless waste of nutritional high calorie food. For the minority world grain value chains are effective "before the plate", because producers know that PHL is expensive. However, most SSA grain value chains are based on stationary primitive and institutional storage. Primitive and institutional storage is closely related to low investment, market failure, hungry months and "Farmers whose scale of operation is too small to be able to produce SAFE FOOD" (Cardwell, 2015). Environmentally, PHL means soil is less resilient and plants are less likely to survive drought, pests, sustain yields and or resist Aflatoxin. Incentives to produce safe higher yields lack meaning because either PHL or stationary storage remove net benefits from rural communities and eco-system services that bear the cost of production.

Discussion: SSA growers still do not have access to mobile utility storage options because the facts are ignored, or as has been said "the value of knowledge is not always equal to the exposure it gets" (SIANA, 2015).

Research and Extension is needed to

- correct life cycle assessments that suggest after support ends, mobile utility storage will significantly increase net yield / tonne hired or purchased to harvest, dry, aggregate, store, monitor, process and market;
- refute how significant increases in SSA net grain yields will have the desired effect of increased research in the area of wet, low calorie fruit/vegetable PHL;
- expose tenure-less growers to "the benefits of owning mobile assets that guarantee Food security" (Lanier, pending) so net yields will alter reality.

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Abstract # ADMI103

Effect of hydrocooling and packaging on shelf life of cold stored litchis

Roop Soodha Munbodh

Food and Agricultural Rersearch and Extension Institute (FAREI)

Corresponding Author: soomunbodh@yahoo.com

Introduction: Litchi fruits are swee, acid, juicy and soft but have a crisp pulp with a bright red color. These fruits have a high commercial value on the international market (Nakasone et al., 1998). After harvest the fruits are very perishable and rapidly lose their bright red skin color, turning brown within 1-2 days at ambient temperature (Nip, 1988. Ray, 1998.). Emphasis is now being laid on temperature management and non chemical disease control.(Kaiser,1994; Lichter et al., 2000) In Mauritius, the method most commonly used to increase shelf life of litchi for export is through the fumigation of fruits using sulphur dioxide (produced by burning sulphur), a few hours after harvesting. However, the use of Sulphur dioxide is a risk to health, especially for people suffering from allergies. To-day, SO2 treatments have totally ceased in the U.S.A, except for treating table grapes. European legislation authorizes residue levels of 10 ppm in litchi pulp and 250 ppm in the skin. Alternatives to sulphur have to be found in order to enable exporters from Mauritius to secure international markets. There is therefore the need locally to devise methods of treating litchis non-chemically so as to satisfy the demands of the GLOBALPGAP and maintain the export markets. The main objective of study carried out was therefore to assess the shelf life of hydro cooled and non- hydro cooled fresh destalked litchis when packed in LDPE plastic bags, clip-on barquettes , opaque polypropylene plastic bags70 micron thickness and stored at 5 °C, in terms of, weight loss ,color change, brix, acidity and any post harvest disease incidence.

Materials and methods: Litchi fruits variety Taiso were harvested at full red color stage from a commercial litchi orchard .Fruits were destalked and selected for uniformity of shape, color and size and for absence of physical damage, insect's injury or fungal infection. The selected fruits were either dipped in a stainless steel water bath and hydrocooled at 0-1 °C for 15 minutes until the core pulp temperature was 5°C or not treated, air dried prior to packing. Both hydro cooled and non hydro cooled selected destalked fruits were then packed in in in (a) clip-on barquettes, (b) polypropylene opaque plastic bags of 70 micron thickness (c) LDPE bags 30 micron thick and stored at 5 °C. Statistical design used was randomized complete block, 15 replicates per treatment was used with each replicate containing 20 fruits.

Parameters recorded from ramdomly selected pack of each treatment were as follows:

(a) Pericarp browning, level of pericarp browning was visually assessed by estimating the % of fruit peel browned over storage time. Fruit peel browned were graded as follows: 0-5 %, 5-10 %, 10-25 % & > 25%. The number of fruits browned and % browning reached were recorded.(b) Disease incidence, level of disease development was measured by counting the number of fruits in the pack showing any fungal or bacterial growth and calculating the percentage number of fruits diseased over storage time, (c) Percentage weight loss was calculated by subtracting the actual weight from the initial weight of fruits per pack and dividing it by the initial weight and multiplying by 100, (d) Peel color, color acceptability index is determined by visual assessment of fruits in the pack and they were graded as excellent:5,good:4, fair:3, poor:2, very poor:1, (e) Brix was determined by the mean of three values of juice readings from 5 fruits in stored pack taken by the Atago refractometer, (f) Acidity was determined by titrating 10 ml diluted pure fruit juice against standard 0.1N Sodium Hydroxide solution. The acidity is expressed as gram of citric acid per 100 mL of fruit pulp using the equation: 1 mLof 0.1 N NaOH = 0.0064g of citric acid.

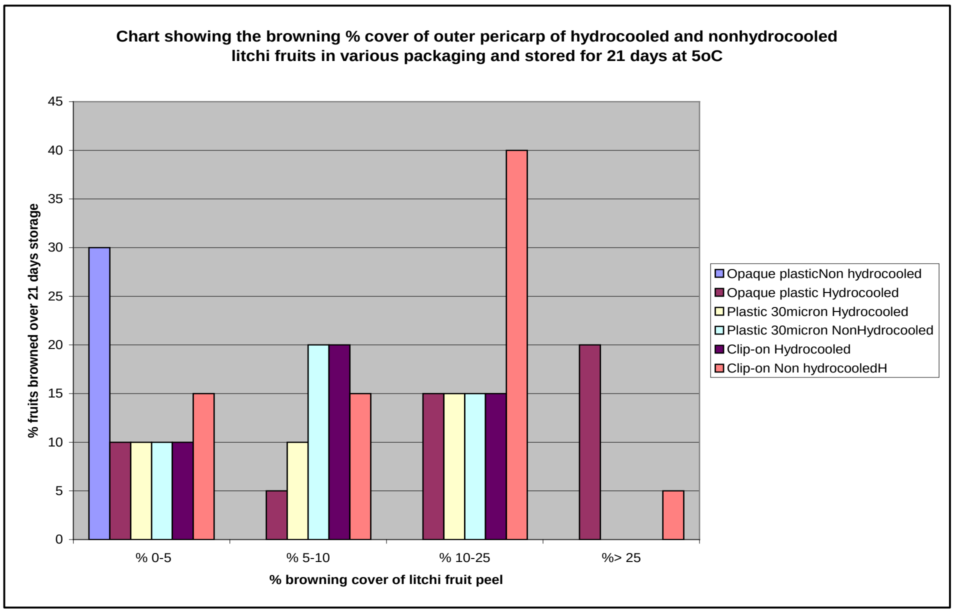
Results and discussion:

Weight loss

There was very slight significant difference in cumulative % weight loss over storage time for the packaging treatments for hydro cooled and non- hydro cooled fruits. Hydro cooled litchis stored in opaque plastic bags had the least % cumulative weight loss (0.833 % +- S.E 0.06) over 30 days storage compared to the other packaging treatments. There is also a significant difference over the storage time, fruits stored over 30 days having a slightly higher cumulative % weight loss than those stored over 21 days (S.E +_ 0.06). Packaging and refrigeration therefore successfully slows the rate of water loss from the fruits by reducing the water holding capacity of the surrounding air, slowing rates of diffusion and providing a physical barrier to air currents. For 21 days, both hydro cooled and non hydro cooled litchis did not lose more than 1 % moisture, irrespective of packaging material. Rate of moisture loss increased thereafter except in hydro cooled litchis in opaque plastic bags which did not lose more than 1 % moisture even after 30 days.

Pericarp Browning

Pericarp browning is related to water loss or dessication from the pericarp (Scott et al 1982).). It was observed that the % of pericarp browning on the fruit peel increased with storage time. At 3 weeks storage the hydrocooled fruits packed in LDPE plastic 30 micron and in clip-on barquettes had a 0 % of fruits browned >25%. But 5% browning (>25%) of fruits occurred in non hydrocooled fruits stored in clip-on barquettes. This may be explained by the fact that clip-on barquettes are more permeable to water loss from the fruits. Hydrocooled fruits packed in polypropylene opaque plastic 70 micron thickness had more than 20% fruits browned by > 25% in the stored pack.



Opaque plastic 70 micron compared to other packaging types has accumulated excessive moisture and water condensation in stored pack which can also enhance tissue decay and browning and cellular breakdown. Cool temperature storage slows browning (Paul and Chen 1987), slows evaporation, respiration and tissue senescence (Tongdee, 1998).

Brix and acidity

Total soluble solids, titratable acidity are important factors in flavor and nutritive quality of litchi fruit. (Jiang and Fu, 1998). Brix and acidity values remained stable throughout the storage period of 3 weeks but decreased significantly after 26 days storage for all the treatments as fruit quality gradually declined after 26 days storage

Peel color

At 3 weeks storage excellent peel color was maintained at 5 ºC for hydro cooled fruits stored in clip-on barquettes and plastic pack of 30 micron thickness plastic compared to non hydro cooled fruits where the peel color retention was graded as fair. Hydro cooled and non hydro cooled fruits stored in opaque plastic 70 micron thickness retained peel color good-fair for 2 weeks after which due to low permeability of plastic material to gases and moisture, there tends to be excessive humidity in stored pack leading to tissue expansion and fruit cracking.

Disease incidence

No fungal growth was observed on the hydro cooled and non hydro cooled fruits at 3 weeks storage at 5 ºC in irrespective of packaging type. Low temperature storage is most successful means for slowing rot development. Johnson et al (2002) found that fruit stored at 22 ºC rotted three times more quickly than fruit stored at 5 ºC.

Conclusion: It is recommended to pack hydrocooled excellent fresh destalked litchi fruits in clip-on or LDPE plastic 30 micron and store it at 5 °C as the fruits maintain their quality, peel color and market value for three weeks with a minimum cumulative weight loss percentage, low browning percentage and no disease incidence.

Acknowledgements: Grateful to the CEO and colleagues Fruit division of FAREI for their help and cooperation.

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Abstract # ADMI104

Losses in the transportation of fruits and vegetables: revisiting a Brazilian case study model

José Vicente Caixeta-Filho, Augusto Hauber Gameiro, Thiago Guilherme Péra.

Group of Research and Extension in Agro-industrial Logistics (ESALQ-LOG), University of Sao Paulo, Brazil.

Corresponding Author: jvcaixet@esalq.usp.br

Introduction: According to Caixeta-Filho (1999), there are several transportation models applied to Brazil, documented by the international literature. The two pioneering ones (Lave et al., 1966, for the Northeast region; and Whitman, 1968, for the Southeast region), were inspired under normative approaches, and had as the main objective the identification of feasible transport projects, as well the evaluation for an entire mode or sector through the application of a formal network model. Linear programming was the technique used to basically determine for each commodity the pattern of shipments from sources to sinks that results in the lowest total transportation cost. Both of them do not pay attention to the eventual losses in the transportation, except for the treatment given by Whitman (1968) to the increase on vehicle operating costs due to the variations of road surface type, vertical profile, horizontal alignment and side clearances.

Also according to Caixeta-Filho (1999), the majority of Brazilian goods flow through the country by road transport, with the occurrence in some years of more than 90% of the agricultural production being transported by trucks. The statistics about losses vary, according to the source, to the cause and to the eventual methodology to measure them. According to Borges (1992), the Brazilian situation, in terms of losses, is not different from the other developing or less developed countries. They account, in general terms, for something around 30%, achieving rates between 80 and 100% for the more perishable products, such as some fruits and vegetables.

Objectives: The purpose of this abstract is to revisit the model proposed by Caixeta-Filho (1999) and to discuss the potential for its replication to other situations and other agricultural products. The model was originally proposed for the logistics of fruits and vegetables. However, we believe that the model can be adapted to different situations and agricultural segments.

Methods: To model the problem of losses in the transportation of fruits and vegetables, two basic aspects have to be taken into consideration by Caixeta-Filho (1999): it is not a very clear phenomenon, either under the logistic or the biological and chemical view; and that there is no consensus in the pertinent literature that those losses have to be minimized.

Thus, the treatment to be given to losses in the transportation in his study considers that: a) the road conditions are fundamental when considering the distance to be driven. Therefore, adjustment factors are assumed as a mean of homogenizing distance values for different types of road surface, by vehicle type; b) the level of losses varies according to the logistic option to be utilized. Caixeta-Filho (1999) stated that there were also distinct costs associated to each of those logistic options. These functions and the respective costs for them were therefore incorporated in his analysis.

In view of that, a normative approach was apparently demanded and it seems that the use of mathematical programming techniques was the most appropriate one for the treatment of the problem. The problem was formulated as one of maximizing the wholesalers' surplus observed in the trade of each specific product, taking into consideration the possibility of having available supplies of technological options for diminishing losses. This would then imply the determination of: shipment patterns between supply and demand regions for agricultural products; prices to be paid to the producers; pertinent consumers' prices; and damage prediction during the transportation of each type of product. The required data were basically associated to: supply and demand functions; transport cost functions; loss functions; and the distances between the regions. Thus, the following mathematical structure, of quadratic complexity, was proposed as shown in Figure 1:

$$Max\ \mu = \sum_{i=1}^{n}\sum_{j=1}^{o}\sum_{k=1}^{p}\sum_{l=1}^{q}\sum_{m=1}^{r}\left(DP_{jk}Y_{ijklm} - SP_{ik}X_{ijklm} - c_{ijklm}X_{ijklm}W_{ijl} - e_{ijklm}X_{ijklm}\right) \quad (1)$$

subject to:

$$\sum_{j=1}^{o}\sum_{l=1}^{q}\sum_{m=1}^{r}Y_{ijklm} \le S_{ik}\ , \qquad for\ i = 1, 2, \ldots, n;\ k = 1, 2, \ldots, p \qquad (2)$$

$$\sum_{i=1}^{n}\sum_{l=1}^{q}\sum_{m=1}^{r}Y_{ijklm} \ge D_{jk}\ , \qquad for\ j = 1, 2, \ldots, o;\ k = 1, 2, \ldots, p \qquad (3)$$

being:

μ = total wholesalers' surplus observed between the total demand and total supply values;

SP_{ik} = price paid for the product *k* to the producer at region *i*;

DP_{jk} = demand price for the product *k* at region *j*;

X_{ijklm} = amount of the product *k* to be transported from *i* to *j*, with the vehicle type *l* and using the packaging pattern *m*;

Y_{ijklm} = effective amount of the product *k*, with the packaging pattern *m*, that arrives at the demand region *j*, from the supply region *i*, using the vehicle type *l*;

c_{ijklm} = unit transport cost to move product *k*, packaged under the pattern *m*, with the vehicle type *l*, from *i* to *j*;

e_{ijklm} = other expenses (unloading, wholesaler's commission, etc.) related to the supplied product *k*, packaged under the pattern *m*, with the vehicle type *l*, from *i* to *j*;

S_{ik} = supply of the product *k* by the region *i*;

D_{jk} = demand for the product *k* in the region;

W_{ijl} = weighed distance between *i* and *j*, using vehicle type *l*.

Fig. 1. The proposed model

Caixeta-Filho (1999) also states that those variables could be transformed following some approximations and assumptions.

The mathematical model proposed was processed using GAMS (General Algebraic Modeling System). As a mean of illustration, Caixeta-Filho (1999) applied his model to the trade of two of these commodities - pineapple and tomato - in the São Paulo State, using data taken from a cross-section of the trade occurred during 1993 in the Ceagesp (Companhia de Entrepostos e Armazéns Gerais de São Paulo), the main wholesale market in São Paulo city, in Brazil.

Results: The results obtained by the model were quite elucidative and consistent. The model proposed by Caixeta-Filho (1999), tried to contribute proposing a normative transportation model that incorporates the possibility of assessing losses due to the specific characteristics of the transportation system utilized, namely the road conditions, specialized equipment and packaging patterns. At that time, he faces several limitations, especially related to the unavailability of data. Anyway, the model has adequate grounding in economic theory and robust mathematical structure. The results obtained at the time demonstrated the potential of the model.

However, the concern of the author was also related to the distance from Transport Economics field to the Development Economics field, which are still both far away from the experiments conducted by the Agricultural Engineering and Science fields. This may explain, at least in part, to the lack of availability of technical parameters available to feed the model.

Conclusions: We conclude that the model has plenty of conditions to be adapted to other situations, segments and agricultural products. Research and development projects that focus on the building of optimization models to minimize losses, and that focus on the systematic collection of information from the field is also needed.

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Abstract # ADMI105

Towards a Strategy on Post-Harvest Loss in West Africa: Aligning a regional Strategy to a Continental Framework

Hamady Diop and Dr. Yvette Diei-Ouadi.

Fisheries Programme Officer, NEPAD Agency, Block B, International Business Gateway, Midrand, Johannesburg, South Africa.

Corresponding Author: Hamadyd@nepad.org

The fisheries sector (capture and farm raised) in Africa generates a variety of benefits including food and nutrition security, employment, livelihoods, exports and foreign currencies, conservation and biodiversity values. About 200 million people or about 30% of the continent's population consume fish as their main source of animal protein and micro-nutrition. Fisheries also provide livelihoods for over 12.3 million Africans , of whom 6.1 million are direct fishers, 5.2 million are processors and 0.9 million are fish farmers. Among 12.3 million people employed in the fish sector, 27.3% are women; of whom 91.5% are employed in processing, 7.2% are fishers and 1.3% is fish farmers. In Africa, estimates made in 2014 indicate that fish produces a total first sale value of about $19.72 billion, the majority of which is earned by small-scale operators supplying food to local and sub-regional markets.

Despite these benefits, fisheries resources in Africa face numerous challenges from local and global pressures, including high levels of post-harvest loss and trade impediments, that pose serious threats to food and nutrition security, livelihoods, optimization of income earning and overall, to the sustainability of natural resources. Recent studies conducted by FAO and NEPAD Agency, with support of the Swedish International Development Agency (SIDA), in the riparian countries of the Volta Basin (Benin, Burkina Faso, Cote d'Ivoire, Mali, Ghana and Togo) indicated a level of Post-harvest Loss in that region of at least 30%.

The Heads of African States and Governments that met in June 2014 in Malabo, equatorial Guinea have committed to ending hunger in Africa by 2025, and to this end they have resolved, among other goals, to i) halve the current levels of Post-Harvest Losses, by the year 2025; ii) to integrate measures for increased agricultural productivity with social protection initiatives focusing on vulnerable social groups through committing targeted budget lines within their national budgets to encouraging and facilitating increased consumption of locally produced food items, including the promotion of innovative school feeding programs that use food items sourced from the local farming community. These goals are captured in the Pan-African Fisheries policy framework and Reform Strategy that was adopted during the same meeting.

This presentation will address the issues of fast tracking the implementation of the strategy at the continental level. It will present the key outcomes of the analysis of critical supply chains bottlenecks in this sub-region/shared water body and specific interventions aiming at curbing post-harvest fisheries losses.

Abstract # ADMI106

Assessing performance of mechanical aeration to prevent stored grain loss and preserve grain quality

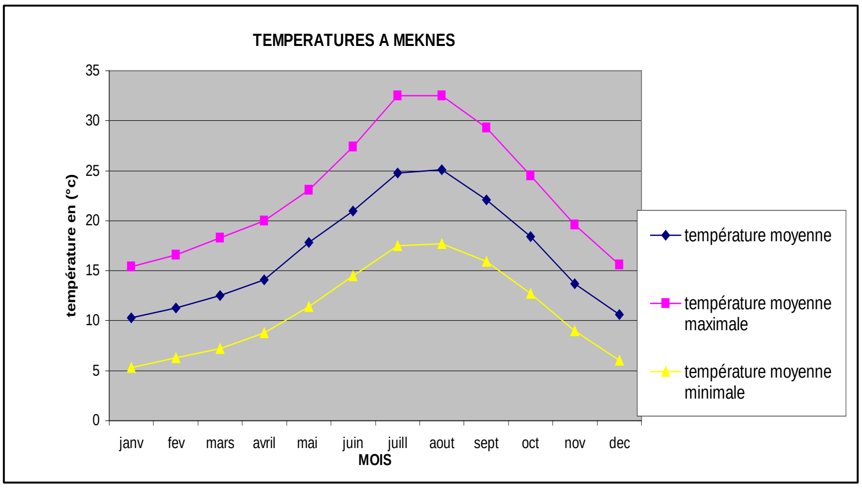
El Houssine BARTALI

Institute of Agronomy and Veterinary Medicine, Rabat, Morocco

Corresponding Author: bartali.h@gmail.com

Context: Grain represents a staple food in Morocco, it supplies three quarters of proteins and two thirds of calories needed. Annual consumption of grain per inhabitant is estimated at 210 kg. However annual production of grain is highly variable due in particular to climatic condition change and does not cover the country needs. Substantial efforts are made towards reducing the gap between production and consumption through increasing productivity (Green Morocco Plan). In parallel, Morocco is also investing efforts in order to reduce post-harvest losses and food waste in quantity and quality.

Situation and problem: Grain storage is two folds: modern and traditional. The latter is found on the majority of small and medium farms where grain is stored in bulk, in bags or in reed silos inside rooms. Underground grain storage is also used in different regions of the country. Evaluation of these traditional systems was carried out in previous studies and proposals for its improvements were identified and evaluated. (Bartali et al. 1990.)

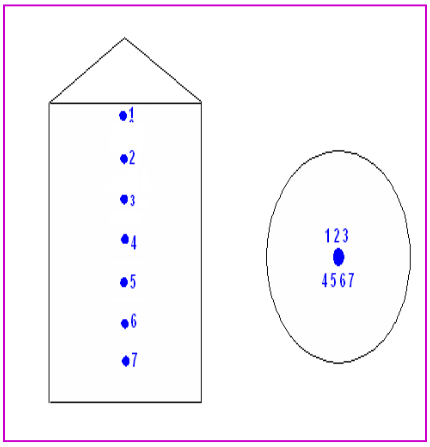


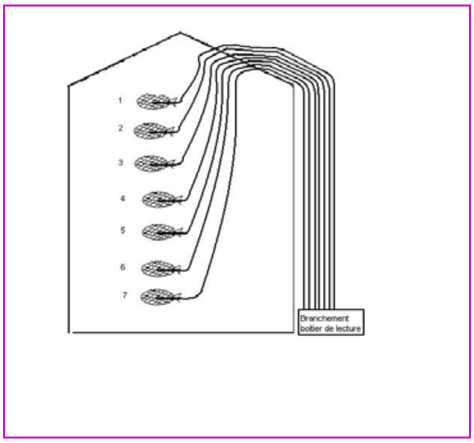
Modern systems of grains storage is undertaken by grain cooperatives, licensed dealers, flour mills and in harbor silos. In hot climate conditions (such as in Meknes area) grain losses on quantitative and qualitative levels are mostly caused by insects. One most common practice used to protect stored grain against insects is fumigation. On average 24 grams per ton of grain treated is used. This fumigant is able to kill insects at all stages of their growth. However, the lack of knowledge about the conditions required for its proper application (quantities, sealed conditions…) lead to the development of insect resistance and to the accumulation of phosphine residues in grain and flour which represents a hazard for human health and environment.

This study aims at investigation the performance of alternatives to the use of fumigation through mechanical aeration of grain. The objective is to reduce grain temperature to levels low enough to kill insects or to inhibit their growth. The methodology to carry out adequate ventilation of grain is demonstrated to cooperatives and farmers in an experimental silo.

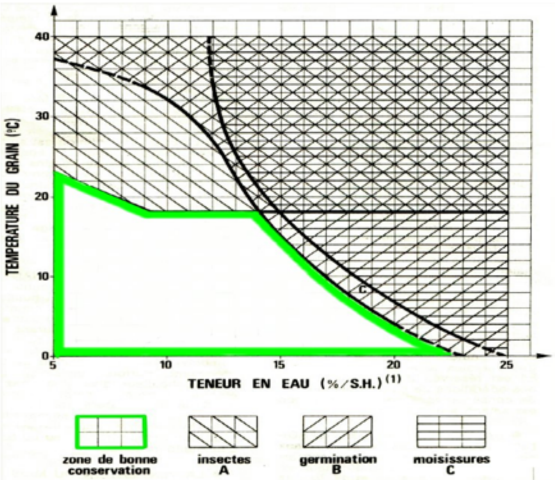
Methodology: The grain used is soft wheat borrowed to a grain cooperative in Meknes. It is stored in a 44 metric tons capacity steel silo equipped with; (i) 10 temperature sensors, (ii) a sensor of humidity; (iii) an electrical powered fan. It is cylindrical silo made galvanized corrugated steel sheet. It has a useful height of 3.76 m and an inner diameter of 4.32 m. The conical roof height is 0.9 m.

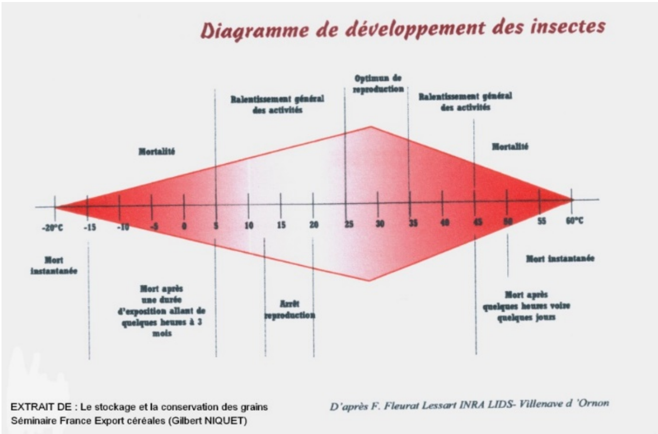
The silo if filled mechanically with a grain flow conveyed by an auger of 6 to 7 tons per hour, characterized by its simplicity, robustness and mobility, it serves for both filling and emptying and is located in the IAV experimental station on grain storage locates near Meknes. Initial characteristics of grain were determined prior to its introduction into the silo. Grain temperature was then monitored and grain aeration was implemented at intervals at given periods (at night) in order to progressively lower its temperature.



Analysis: Most insects have an optimum development between 25 C to 35 C. When ambient temperature decreases, there is a general decease in their activity. Between 20 C and 12 C, insect reproduction is stopped. When exposed to a 5 C temperature for 3 months, insect (all forms of grain weevils) die.The use of phosphine is not recommended. The system which comprises mixing the tablets stock is very dangerous because it can leave significant residues in wheat.The product's implementation is exceedingly dangerous both in storage cooperatives where the silos are not airtight or even on farms where its use is normally prohibited. The treatment performed in defective conditions causes the development of resistant insects which encourage an increase in treatment dose (up to 2 times the normal dose). Not to mention the danger of excessive residual dust of phosphine which can be harmful if swallowed or inhaled by people or consumers.





It is possible to cool the grain which is initially at of temperature 30 to 40C when introducing in the silos in June to 22 to 24C in July august and then through progressive cooling sequences between September and March to 8 to 10C. Cooling is performed at favorable times (at night in general) when temperature of ambient air is 7 C to 8C lower than grain temperature. This allows has made possible to store grain a steel silo over 6 months in Meknes area known for its hot continental climate.

In order to conduct a successful grain cooling, it important to make adequate design for grain silos devoted to long storage period: shallow silos. - In the cases where ventilation is used, it was found that there is a problem in design due to the large height of the cells and the small pipes which must convey a large flow of air.

Conclusion: This study showed that grain aeration is justifiable and beneficial for grain protection under Mediterranean hot climate (as is the case for colder climate). Grain aeration with ambient air temperature is efficient for insect control and represents an alternative to grain fumigation. In the absence of grain cooling, insects may cause important damage through physical and qualitative losses. On the other and best practice in grain storage include a thorough cleaning of the silos (aspiration of dust, brushing, and eliminating remains of vegetable wastes) before introducing harvested grain into them. As complementary actions it is recommended to apply a remnant insect treatment of silos walls (using spray or nebulization) as well as to perform cleaning of grain from impurities. Investment of private sector and incentives for the public sector should encourage the building of adequate storage silos and promote the use of grain cooling equipment in order to reduce grain losses and waste.

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Abstract # ADMI107

The most feasible, least cost and pragmatic approach to grapple with post harvest losses

Liaqat Ali

Liaqat Corp., Gujranwala, Pakistan

Corresponding Author: liaqatcorp@yahoo.com

Introduction: In this particular juncture when the whole world is suffering from menace of post harvest losses and humanity is facing potential threat of food shortage, a practical, least cost and the most feasible approach is needed to be adopted to avoid these losses. In lost decade's in spite of the fact that large literature is written to control these losses but we have fail to develop any practical approach that can match with on ground realities and prove a practical step to grapple with these losses. These losses are not proving harmful to developed world but giving fatal blow to population of developing countries which are already in scare resources and lacking any technological achievement to meet the demands of food for their increasing population. There is high time now to resolve all these prevailing issues by providing practical solutions to these poor masses of developing countries. A lest cost, practically suitable technology must be provided these growers that can prove beneficial not only to increase productivity but also mitigate post harvest losses of agricultural crops in general and horticultural crops in particular. Through our practical experience of 30 years, constant field working in farm sites and continues research and development we have evolved a practical least cost and the feasible approach to control these post harvest losses throughout the globe in general and in developing countries in particular. We are the pioneer processor of all horticultural, live stock, dairy and ready to eat halal meals since 1975. Our dried processing value added technology not only adding food values but proving a gigantic step to eradicate food losses.

Objectives: In this alarming situation when the issue of food losses is very important to combat hunger general masses in developing countries there was a time to develop least cost technology to control food losses in general and post harvest losses in particular. Our sole aim was to conserve natural resources maximally and control post harvest losses of horticultural crops so in pursuit of our objective we adopted a practical approach to save food for humanity. We are also based on the principle to add food value for man on this very soil so with increasing food productivity food security is our prime issue we are dealing with. Our objective is to provide on ground solutions to farmers and all stake holders while remaining practically in touch with them. Therefore to achieve sustainable life is our prime goal on this very soil which is hardly possible without saving food for life on this planet.

Methodology and approach:

1. **Crop monitoring at both pre-harvest and post harvest stage**

A) Enhancement of food productivity through better adoption of seeds. After harvesting we carefully monitor the crop and on qualitative basis select the seed for next crop. Crop which is of better quality and fit for production of seeds is converted into seeds, crop which is better to sent in the market we put it into the market and in third category we choose crops for processing purposes and in the last stage wasted crop is use to enhance organic fertility of the soil and for animal feed too. In this way after carefully monitoring at each stage we give 100 percent consumption of our harvested crops and avoid food losses.

B) After harvesting of any crop time span is very crucial element which must be considered. Soon a saturated stage appears in the market and further supply may create loss of food. This is very alarming stage for small farmers in the developing countries. The crop on which they have spent millions now going to be in wastage and gap of technology appear. At this stage to avoid food losses of horticultural crops we provide solution and 100 percent guarantee to save food. Our dried processing value added technology developed by our own R&D ground realities and practical experience of 30 years give guarantee/warrantee to save foods. Our post harvest field searcher extensively visits field area to analyze extent of these food losses and on the basis of their feedback we quickly move into the relevant farming sites to rescue these farmers. After careful monitoring of their crops we provide them solutions to avoid these losses. The crops which are about to perish we quickly bring them to our processing stations installed in different farm areas of Pakistan.

2. **Save food methodology for the crops which are in harvesting to consumption stage**

From harvesting to consumption stages there appear many stages when lot of food goes into wastage. At every stage we have to treat crops differently on the basis of his condition and extent of food losses. On following ways we treat crops differently at different stages.

A-On farm treatment

On farm treatment of crop is first step of our post harvest loss control method. After converting the best crops into seeds we produce the vigor seed for enhancing production. After meeting market demands and crop which is not fit for seed we apply our processing technology at farm sites. In this way washing, peeling slicing and drying is done at farm sites. Normally during this first stage the most feasible, economical and chronicle process of sun drying is done during which peeled, sliced crop is spreader in the field on polypropylene sheets to maintain qualitative vigorness of the crop and moistures contents are reduced according to types of crops. Then we bring that crop into our small processing stations developed into farm areas for further processing. Here again moisture contents are reduced up to desirable limits. In this way through on farm treatment of crops we have contributed well for that portion of food which is about to go into wastage. Our feasible, and least cost dried processing lines really rescue these farmers at their own farm sites.

B-Saving at fruit vegetable market

It is point to be noted that a huge quantity of food losses occur in locally made fruit vegetable mandis. Our post harvest field staff is also present in these markets and rapidly report us to situation of these markets. After 12 o clock a large amount of non sale able fruits vegetables goes into wastage and to avoid food losses a readily available technology is required which can be suitable and easily access able to these market sites. In fruit market there is permanent skilled labor in the fruit market for washing, slicing and grading etc. the fruits and vegetables which are about to perish initially after peeling, slicing we expose it to sun drying and then finally we take it into our small processing units for further reduction of moisture level. In this methodology we not only saved for future consumption but also due to reduction in weight and volume millions of logistic charges are reduced. In this way mandi crops which are about to perish after 12 o'clock and become the part of dust bin is saved through our feasible, practical market-suited technology.

C-Saving at retail market

We don't even let the fruit to be wasted in retail market too. Our post harvest field searcher also present in fruit retail market and in the evening fruits and vegetables which remain unsold are brought to our small processing units where we process them into value added products and also save them for future consumption.

D-Consumption of final wastage at every stage

We do not even let the food wastage of every stage into dust bin. Our peeled material damaged horticultural produce, crop top-tails are also used positively used in fish farming. Therefore it is not exaggeration to say that through adoption of this method we ensure hundred percent saving of food losses.

3. **Seasnal processing stations with collaboration of cooperative department**

The third main point of our practical approach adopted on the basis of on ground realties and problems is that before one month of harvesting we install seasonal processing stations on the basis of on ground data collected by our post harvest field searcher team and data taken by provincial cooperative department. Normally for 15-25 villages one processing station is installed where all stake holders are engaged to get proper feedback. With collaboration of cooperative department we normally identify the most influential farmers of that area and also train them to our training centers developed at these processing stations. After sun drying crop is taken into these processing stations which are developed of different capacity.

Through our practical experience of last 30 years we came to now that farmers in developing countries are very much reluctant to bring their excessive production and non saleable crops to processing units owing to reasons that they don't have resources to afford as it is observed facts that logistic cost to bring their produce into processing units is out of their resources. Through on ground realities we realize the establishment of processing stations in adjacent vicinity of their farm areas is prerequisite to avoid these food losses. So we have developed these processing stations with collaboration of provincial cooperative department and our practical approach has not only mitigated food losses but also contributed greatly in establishment of agro-food industry in rural areas of Pakistan.

4. **Establishment of the most least cost mobile drying system in the whole world for small and medium scale farmers**

On the basis of our practical approach and past experience we realize that mobile drying system is very much necessary for small to medium scale farmers. These dryers can not only reduce emerengence of different on farm diseases of different crops but the most suitable technology to avoid post harvest losses of agricultural crops. It is point to be noted that drying technology is always considered costly and out of bound area for these farmers in developing countries but we are proud to mention here that we have developed mobile dryers of different capacity in most least cost in the whole world and we can challenge that these least cost dryers developed by our own R&D can prove can give maximum output as any other drying system in the world. Our post harvest field searcher gathers data and on the basis of this collected data we normally move our dryers to that vicinity. It is point to be noted that more than 80 percent emergence of plant diseases appear due to presence of moisture and owing to that lot of food losses appear every year. Considering this important point into our mind we developed the least cost mobile dryers that can really prove to be a gigantic effort in mitigating post harvest losses of agricultural crops. We give hundred percent guarantees for successful working of these dryers as practically we have used and achieved maximum results from these drying units.

5. Practical approach to avoid Aflatoxins a major agent of food losses

Aflatoxin is major agent of destruction and causing more than 70 percent food losses. These are mycotoxins which are produced by two important species of fungi. 14 different types of aflatoxin are produced in nature. They can colonize and contaminate grains before harvest and during storage. We are practically engaged in reducing aflatoxins. Our mobile drying system rapidly reaches the spot where outbreak of aflatoxins appear and our seasonally installed processing stations endeavoring hard to eradicate aflatoxins.

6. **Women participation in save food methodology**

It is pertinent to mention here that women contribute more than half of the population of the world and in developing countries particularly unemployment rate increases due to unemployment of women although they appear more trained and vigilant in food related issues. Therefore we use this capital in our favor excellently. Women participation in save food methodology is the most important aspect of our practical approach. We use these skilled women for peeling, slicing grading and many other related issues. In this way they contribute in economy of our country, well being of their own families but play a wonder full role in food saving process adopted by us.

7. **Paternership with universities at turn-key basis**

Training to young agricultural graduates, land holders and growers is integral part of our practical approach towards mitigating post harvest losses. We actually do partnership with all stake holders on following parameters.

A-Inovolment of all stake holders on a single point

The central idea on which our philoshy is based that we integrate all stake holders on a single point. A joint venture of all stake holders is held to create awareness in each indivual component involved in agriculture and which can perform its role in reducing post harvest losses of horti crops. In this partnership university facilitate us by providing land, building, agro- farms and other infra structure required to train these stake holders. Normally local university students, local growers and middle man involved in fruit-vegetables market are trained in collaboration with local university of that area. Therefore it is not an exaggeration to say that we collect all stake holders on a single point. Through this approach students of that university practically get know how about the problems and this practical experience guide them in their future endeavors to control post harvest losses of horticultural crops. Not only students are trained but training of local growers are carried on through this partnership which are actually and practically engaged in dealing with post harvest losses. They not only get training but also get aware about all latest agricultural issues prevailing at that time.

B-Transfer of technology on turnkey basis:

The second most important feature of this partnership is that we transfer our technology developed by our own R&D to these local universities. And all these stake holders are trained to use this least cost effective technology.

8. **R&D for processing lines and fabrication**

development of on farm saving stations, mobile dryers for small land holders and a value added range list of approx 300 products is product of our continuous research and development process.

9. **Development of LEAST COST dried processing lines for dairy and live stock products**

Our main mission is to save valuable food for humanity. Therefore we concentrate on every kind of food. Though our prime focus is towards post harvest losses of horti- crops but we don't even let the dairy and live stock food ingredients to get waste owing to that we have developed dried processing lines for all horti-dairy crops. The important features of our dried processing lines are.

A-Value addition

we work on the principle that try to use every ingredient of food life on this very soil therefore keeping this idea on front we move ahead and convert all necessary food ingredients into value added products. Food losses cannot be mitigated until the raw material is converted into value added products. In this regard we have developed a value added range list of almost

B- Organic production methods

We are certified by Skal Holland in organic production methods. We work on the principle that pure food can really save the life of man an use of additive in processed food endanger the health of man therefore we try our best to use organic production methods in processing of food.

C-conversion of food wastes into valuable products

The third important feature of our dried processing lines is that we never let a single ingredient of food to go into wastages therefore we convert these horti, dairy and live stock wastes into value able products. For example a list of under mentioned wastes is used for fish-farming as a feed. These wastes can be enumerated as,

- Peeled potato skin
- Vegetables and fruit roots
- Fat tissues
- Wasted fruits and vegetable pieces
- Chicken/mutton/beef bones

In additions to our processing unit, our post harvest field searcher also present in retail market collect these wasted materials from butchers, and vegetable/fruit shops and then these wasted products are usefully used by us.

d- Using every ingredient of food to save life

We are organic processor of horticultural crops/dairy and live stock products and try to conserve natural resources maximally. We don't let a single ingredient of food get waste. After using the last remaining ingredients for live stock and fisheries feed we use the ruptured fruits, vegetables, peelings to add organic fertility of soils. Therefore we provide these end remains to local farmers of our vicinity which use them as an organic fertilizer.

10. **Development of post harvest loss assessment method**:

Our post harvest field searcher directly report to our main office from where instructions are passed rapidly to act accordingly. Therefore at each tehsil level we have developed a data base that favored us to develop a post harvest loss information system where every concerned stake holder also report about prevailing situation.

Results and findings: We have developed a proper data base for post harvest losses of our district Gujranwala of each year. Each year due to our practically persuaded approach we find a significant decrease in post harvest losses of horticultural crops. The only problems prevailing with us are that we have limited resources to precede our mission on large scale for whole humanity.

Conclusion: Due to our success we strongly recommend this practical approach must be adopted in the world generally but particularly in developing countries where all involved stake holders have less resource to control these losses. Owing to our practical experience we give 100percent guarantee/warrantee to eradicate post harvest losses of horticultural crops. We conclude this hoping that a chance will be provided for display of application of our various technologies. In this way we can only grapple with post harvest losses only engaging our self with all stake holders practically. Through theoretical efforts idea to control these losses seems to be a night mare.

Table from Abstract # ADMI038

Harvesting: Effects of Crop Maturity and Moisture on Losses

Author: Marvin R. Paulsen

Table 1. Recommended harvest moistures and harvest maturity condition characteristics for cereals, oilseeds, and pulse crops from various references.

Crop	Typical harvest moisture range, % wb	Ideal harvest moisture range, % wb	Harvest maturity condition characteristics	References
Cereals				
Rice	20-28	22-28 20-24	Rice panicles are bent, hulls yellow, grains full highest head rice yield	deLucia and Assennato (1994) Khan and Salim (2005)
Rice		20-25 110-120 days after seeding 100-110 days after transplanting	28-35 days after heading (dry season harvesting); 32-38 days after heading (wet season) 80-85% of grains are straw colored; kernels should be firm, but not brittle when squeezed between teeth	IRRI (2015) Rice knowledge bank from: http://www.knowledgebank.irri.org/step-by-step-production/pre-planting/rice-varieties
Wheat	10-20	13-15	Wheat kernels transition to hard dough stage, peduncles turn from green to yellow	Wiersma (2006) McNeill et al. (2009)
Maize	16-32	 23-28 20-23	Formation of black hilar layer indicates physiological maturity usually 55 – 65 days after silking This moisture minimizes risk of stalk lodging, ear rot 20-23% moisture minimizes quality loss. If harvested wetter, kernel pericarps are soft subject to threshing damage. If dryer, kernels are more susceptible to breakage.	Nielsen (2013) Thomison (2010) deLucia and Assennato (1994) Paulsen and Nave (1980)
Sorghum		20-25 16-20	Stems and leaves dry, kernels resistant to thumbnail Panicle is cut from standing stalk	deLucia and Assennato (1994) Meija (1999)
Millet (Bajra)			Manual panicle harvest when upper half of panicle seeds are mature, lower panicle seeds	Oelke et al. (1990)

			can be in dough stage but should have lost green color	
Crop	Typical harvest moisture range, % wb	Ideal harvest moisture range, % wb	Harvest maturity condition characteristics	References
Oilseeds				
Mustard		12-13	Shatters easily if overripe, dry to 10% for safe storage	Oplinger et al., 1991
Soybean	8-18	13-15	Harvest above 12% to avoid splits and seedcoat cracks. Decrease cylinder/ rotor speed as soybeans dry. If seed is overdry (8-10%, seed damage increases) so harvest early morning or evenings when humidity is high. Harvest above 13% to reduce shatter losses	Staton and Harrigan (2011) Pederson (2006) Paulsen et al. (2014)
Safflower			Harvest when leaves turn brown with very little green left on bracts of new flowering heads; seeds are white and easy to thresh; store below 8% for safe storage	Oelke et al. (1992)
Sunflower		9-10	Upper leaves dry, flowers faded	deLucia and Assennato (1994)
Groundnut		30-35	Yellow leaves, shells dry, kernel skins are easy to detach	deLucia and Assennato (1994)
Pulses				
Cowpea (*Vigna sinensis L.)*		14-18 12-14	Once pods reach full maturity, shattering will occur, 8-9% moisture for long term storage	Ag Forestry & Fisheries (2011) Mullen et al. (2003)
Pigeon pea (*Cajanus cajan (L.) Millsp*.) (red gram)			Harvest after leaf drop, dry to 10-13% for safe storage	Sheahan (2012) USAID (2012) White (2005)
Chick pea *(Cicer arietinum L.)*	8-16	14-15 14-16	Harvesting below 14% increases risk of lodging for seed, harvest at 14-16% and dry to 10-12% leaves start to drop, pods turn yellow, seed feels hard and rattles in the pod	O'Mara (2015) Gaur et al. (2010)