



3RD ALL AFRICA POSTHARVEST CONGRESS AND EXHIBITION

Theme: Postharvest Loss Reduction for Sustainable Food Systems

BOOK OF ABSTRACTS

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Foreword

Dear Reader,

We have the pleasure of presenting to you the Book of Abstracts of the 3rd All Africa Postharvest Congress and Exhibition. The Call for Abstracts under the Congress theme “Postharvest Loss Reduction for Sustainable Food Systems” covered the following subthemes of the Congress theme:

1. Causes, Extent and Impact of food loss and waste – the metrics (data) and tools for FLW
2. Saving Africa’s harvest during and post COVID-19 Pandemic – lessons learnt, opportunities to strategize for future natural disasters and pandemics.
3. Innovative technologies, tools, practices and training/capacity building to reduce postharvest losses in food supply
4. Trade, business and economic transformation opportunities in postharvest
5. Financing postharvest loss reduction initiatives; Business Cases/Models in postharvest loss reduction; Innovative financing mechanisms for upscaling postharvest
6. Enabling policies, effective national/regional strategies, experience sharing, Collaborating, Learning and Adapting (CLA).

The Congress theme was specifically coined to align with the United Nations’ Food Systems Summit that is scheduled for September 2021. The summit will set the stage for global food systems transformation to achieve the Sustainable Development Goals by 2030.

The primary objective of the 3rd All Africa Postharvest Congress and Exhibition (and the others before it) is to create awareness about food loss and waste and showcase sustainable solutions in the African context. The Congress also provides a platform to network and establish partnerships for research, outreach and investment initiatives towards food loss and waste reduction.

In response to the call for abstracts, a total of 234 abstracts were received from authors around the world. The abstracts were subjected to a peer-review process where at least two subject matter experts from around the world reviewed each abstract. The reviewers provided the authors with comments and suggestions to improve their abstracts. In addition, the reviewers provided guidance on acceptance or rejection based on the abstract(s) alignment to the Congress theme and whether the paper should be accepted as an oral or poster presentation. A total of 175 abstracts were returned in their revised form and were accepted for oral (122) and poster (53) presentations during the Congress. The revised abstracts from authors were subjected to an editorial review by a select panel of editors before they were published in this book of abstracts.

The abstracts are an assortment of basic and applied research, development and capacity building, among other works of food sector actors (academia/researchers, private sector, development agencies, state and non-state actors etc.) that are aimed at addressing the problem of high postharvest losses and inefficiency in the food supply chain. Therefore, the book of abstracts provides a rich mix of valuable and actionable information to address the problem of food loss and waste in the collective efforts geared towards efficient and sustainable food systems.

We would like to thank and congratulate all the authors for preparing and submitting high quality abstracts for the 3rd All Africa Postharvest Congress. The contacts of corresponding authors of all abstracts have been provided to facilitate further interaction beyond this Congress. We would like to sincerely thank the members of the technical committee (TC) for taking their time to diligently and thoroughly review and subsequently edit the abstracts to ensure a quality publication. The TC members are also credited with organizing the abstracts in various workstreams for presentation during the Congress. Our gratitude also goes to the co-opted special matter experts who supported the technical committee members in the review process.

We hope that the readers of this informative publication will find it useful in their efforts to address the challenge of high postharvest losses in food supply chains, particularly in Africa.



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ABSTRACTS



SUBTHEME 1

CAUSES, EXTENT AND IMPACT OF FOOD LOSS AND WASTE - THE METRICS (DATA) AND TOOLS FOR FLW MEASUREMENT

2021

3RD ALL AFRICA POSTHARVEST CONGRESS & EXHIBITION, BOOK OF ABSTRACTS

Theme: Postharvest Loss Reduction for Sustainable Food Systems



Indigenous Knowledge, Postharvest Handling Practices, Losses and Determinants: The Case of Coffee in BenchMaji and Sheka Zones of Ethiopia

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Coffee production has a long history in Ethiopia and a rich indigenous knowledge base is embedded in the culture of the coffee producing communities. BenchMaji and Sheka Zones (BMSZs) are among the best known zones for coffee production and marketing in the country. However, despite the long history and tradition of coffee production in these zones, the quality of the coffee is hampered by poor harvesting and postharvest practices. This study was conducted to document the indigenous knowledge and postharvest handling practices of coffee in BMSZs, alongside an assessment of the extent, types and determinants of postharvest losses (PHL). Using a multi-stage sampling procedure, 180 coffee producers and 75 traders were randomly selected from five purposively selected districts of BenchMaji and Sheka zones of Southwestern Ethiopia. The required data were collected using a semi-structured questionnaire and secondary sources, and analyzed using descriptive statistics and ordinary linear regression model. Results showed that only 32.2% of the respondents harvest their coffee at full maturity stage and 20.6% of coffee producers used a selective harvesting method. Storing of freshly harvested coffee cherry prior to drying was done by 46.7% of the respondents. Forty seven percent of coffee producers mix their coffee while drying even though the harvested coffee was not similar type. At time of selling their coffee, 40% of interviewees reported that they sell a mix of differently harvested coffee types. This is due to the absence of differential pricing for quality variation. Thus, coffee producers give little attention to quality from harvesting through the postharvest processing and handling stages. This has contributed to the low and reportedly deteriorating coffee quality in the study areas. Improper harvesting and handling were considered by most coffee producers (69.4%) as the main cause of coffee PHL. The producers estimated that at producer level, a 4% postharvest loss of coffee occurred. At trader level, about 2% PHL of coffee was estimated. The majority of the traders (56.0%) as well as 27.2% of the producers did not believe there had been any improvement in coffee quality instead; they reported deterioration in coffee quality during the last 5 years. Regression analysis showed that responsibility of postharvest handling, lack of experience, storage facilities, coffee farm size, harvesting materials and drying methods significantly determined coffee PHL at producer's level. Family size, education status, experience, storage condition and cash limitation were also the major determinants influencing coffee PHLs at the traders' level. Reductions of PHL and quality deterioration are essential to increase income of producers as well as traders for the economic growth of the country as a whole. Therefore, in order to reduce coffee PHL, focus should be given to improve harvesting and postharvest handling practices.

Keywords: Harvesting, postharvest loss, processing, producers, traders

Postharvest Losses in Quantity and Quality of Table Grape (cv. Crimson Seedless) along the Supply Chain and associated Economic, Environmental and Resource Impacts

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High incidence of postharvest losses is a major challenge to global food security. Addressing postharvest losses is a better strategy for increasing business efficiency and improving food security as opposed to simply investing more resources to increase production. Global estimates show that among the crop groups, fruit and vegetables suffer the highest levels of postharvest losses and food waste, with 45% of production being lost. This represents 38% of total global food losses and waste (Statista, 2019). However, the lack of primary data on postharvest losses at critical steps in the fruit value chain and the unknown economic, environmental and resource impacts of these losses make it difficult to formulate mitigation strategies. This paper quantifies postharvest losses and quality attributes of 'Crimson Seedless' table grapes at farm and simulated retail levels. Table grapes were sampled from four farms in the Western Cape Province of South Africa, the largest deciduous fruit production and export region in Southern Africa. Mean on-farm losses immediately after harvest were 13.9% in 2017 and 5.97% in 2018, ranging from 5.51% to 23.3% for individual farms. The main reason for on-farm losses was mechanical damage (7.1%) during harvesting and handling. After 14 days in cold storage (-0.3 ± 0.7 °C, $81.3 \pm 4.1\%$ RH), mean grape losses were 3.05% in 2017 and 2.41% in 2018, which after 28 days increased to 7.41% in 2017 and 2.99% in 2018. After 10 days of further storage under simulated market conditions (5.4 ± 0.6 °C, $83.7 \pm 2.9\%$ RH), fruit losses were 3.65% during retail marketing and 4.36% during export. Storing grapes under ambient conditions (25.1 ± 1.3 °C and $46.6 \pm 6.0\%$ RH) resulted in a higher incidence of losses, increasing from 7.03 to 9.59 and 14.29% after 3, 7 and 10 days, respectively. The socioeconomic impacts of these postharvest losses amounted to financial losses of over ZAR 279 million (USD 17 million according to the conversion rate of 20 October 2020) annually in South Africa, and this was associated with the loss of 177.43 million MJ of fossil energy, 4.8 million m³ of fresh water and contributed to the emission of approximately 52,263 tons of CO₂ equivalent. The highest loss in the supply chain was measured at farm level, it is therefore important to include this stage when studies are conducted on quantification of postharvest losses. As mechanical damage due to the rough handling of bunches and crates was the main reason for these losses, this could be improved by making workers more aware of the necessity to handle crates with care. The timing of the harvest is also important as delayed harvesting reduces shelf life and results in an increased postharvest loss. The main quality problem were rachis and stem browning at temperatures higher than -0.5°C. During peak season 4.5kg - 10kg cartons are often stacked on the floor under ambient conditions. It would be advisable to keep cartons at -5°C, and high RH and only place bunches in punnets in 5°C display fridges as the stock sells.

Keywords: postharvest losses, table grape, shelf-life, decay, socio-economic impacts

Postharvest Losses of Vegetables in Senegal: from On-farm Data to National Scale Impact

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Postharvest losses (PHL) are a substantial concern for food systems. According to the literature, empirical information on how PHL connect to broader issues like economic value of total supply and international trade remains a challenge. Our paper contributes to the literature in focusing on farmers of perishable crops, and highlights the value of simple technology to deliver gains and how this connects to national scale issues. In Senegal, vegetable production has developed considerably over the past 20 years with total vegetable production increasing from 281,464 tons in 2005 to 886,130 tons in 2015 with onion, tomato and pimento accounting for 52.46% of total national horticultural production. We used a household survey data collected from 1305 farmers in 2017 to examine the extent of PHL for Senegal's main vegetable products, and then use an International Model for Policy Analysis of Agricultural Commodities and Trade-Standard IFPRI Multimarket Model (IMPACT-SIMM) to simulate the effect of a reduction in PHL on the economic value of total supply (defined as production available for sales or consumption by farmers) and international trade. Results suggest that on average, 31.2% of vegetable production is lost on farm and is therefore unavailable for sales or consumption. These losses are estimated at 32.1% for onion, 28.6% for tomato, and 29.8% for pimento and occurred essentially between harvest, drying, storage and transport. Simulation results suggest that eliminating all PHLs for vegetables in Senegal would increase the total value of supply by \$72 million and reduce imports by 127,000 tons. Specifically, for onion, survey data gave an average PHL of 18.03% for farmers who stored onions in a bag, as opposed to farmers who stored onions under 'bulk storage' conditions. Simulations show that reducing onion PHLs by storing onions in bags generated an increase in the total value of supply by US \$23 million per year. Our data suggest an extra cost of \$16.8 per ton to store onions in a bag, but the full costs, both for farmers and government, to achieve these reductions in PHL would need further consideration when planning investments in the agricultural sector and beyond. First, farmers experience substantial PHL, with vegetable growers reporting losing 31.2% of the production between harvesting and marketing and we found almost no farmers used cold or ventilated storage on-farm, which is a concern for perishable crops and places pressure on farmers to quickly consume their vegetables or send them to market. Two, if properly implemented, appropriate storage and conservation technologies can lead to a substantial reduction in vegetable PHL. To this end, government could take measures to increase access to finance for smallholder farmers, raise awareness and popularize knowledge to maintain the cold chain of perishable vegetable products, invest in adequate infrastructure and improve the vertical integration between producers and distributors of vegetable products.

Keywords: Postharvest losses, vegetables, multimarket model, Senegal

Perceptions and Practices on Postharvest Management Investment for Resilient Livelihoods in the Uporoto Highlands of Tanzania

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Low investment in postharvest infrastructure has resulted in a seasonal loss of millions of tons of food and produce in the sub-Saharan Africa. Postharvest loss reduction is stipulated as an important component in achieving the Sustainable Development Goal (SDG) 2 of Zero Hunger which targets ending hunger, achieving food security and improved nutrition and promoting sustainable agriculture by 2030. However, investments for postharvest management are still limited, especially in the low-income countries. The study used a survey method to assess postharvest management for reducing food loss and waste among the smallholder farmers. The techniques used included a questionnaire survey (QS), Key informant interview (KII) and Field Observation (FO) data collection techniques. Thematic and trend analysis were used for analysis of the qualitative data, and SPSS and Microsoft Excel for the quantitative data. The results indicate that lack of investment in postharvest management was highlighted as a cause of about 90% of crop loss, food shortage and loss of income among smallholder farmers. Persisting and pressing postharvest management challenges highlighted during the study included poor storage, production system, lack of processing knowledge, cultural aspects, poor storage infrastructure, seasonal market (during the harvesting season) and lack of a supportive environment (institutional support). Packing in bags (71%) and roof of the house (97%) were indicated as common postharvest preservation and storage methods which have repercussions on postharvest management. The study revealed a change in food consumption habits and the need for promoting of greater investment in postharvest management through improving knowledge, infrastructure, production process, processing, storage and distribution systems.

Keywords: Postharvest loss, food security, smallholder farmers, production process

Fungi associated with Bulb Onion (*Allium cepa* L.) Postharvest Rots in Major Markets Located in Growing Regions of Kenya

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Postharvest rot is one of the main causes of bulb onion losses in Kenya causing about 14% postharvest loss. Common bulb onion postharvest diseases include black mould, basal rot, neck rot and bacterial rot which are caused by various fungal and bacterial species. Globally, the fungal species reported causing bulb onion rots include, *Aspergillus* spp, *Penicillium* spp, *Alternaria* spp, *Fusarium* spp, *Rhizopus* spp, *Colletotrichum* spp, and *Botrytis* spp. However, in Kenya it is not known which fungi are associated with postharvest rots in bulb onion, therefore this study aimed to identify the fungal pathogens causing postharvest bulb onion rots in Kenyan markets. Identification of the fungi causing bulb onion postharvest rots will assist in developing a postharvest loss management strategy. Bulb onions showing symptoms of rotting were collected from major markets located in the high bulb onion producing counties of Kajiado, Meru and Bungoma. Isolates were obtained by cutting three mm segments of tissues from the margins of rotten lesions and culturing them in Potato Dextrose Agar (PDA) followed by seven days of incubation at room temperature. To ensure successful isolation and identification of the pathogenic fungi, a single spore isolation procedure was carried out. The isolates were identified morphologically. Also amplification of the TEF-1 α gene and ITS regions of the DNA was done using primer pair of ef1 and ef2 and ITS4 and ITS5 respectively. Out of 50 isolates cultured 18 of them were pathogenic on healthy bulb onion. Morphologically, the fungal pathogens were identified as *Fusarium* spp. The isolates indicated white dense to sparse aerial mycelia growth on the upper side of the colony. The pigmentation on Potato Dextrose Agar (PDA) media varied from white, violet, brown and yellow on the reverse side of the colony. In terms of conidia features, on Carnation Leafy Agar (CLA) media the isolates differed in terms of shape, number of septa and length of micro and macroconidia. Further, molecular technique confirmed the presence of *Fusarium oxysporum*, *Fusarium solani*, *Fusarium acutatum* and *Geotrichum candidum* as causative agent for bulb onion postharvest rots in Kenya. Of the isolates 55% were *F. oxysporum*, 17% were *F. solani*, 17% were *F. acutatum*, while 11% were *Geotrichum candidum*. *Fusarium solani* was isolated from Kajiado County markets, *F. acutatum* from Meru and *F. oxysporum* and *Geotrichum candidum* from Bungoma markets. According to pathogenicity test, *F. solani* was more virulent than *F. acutatum* and *F. oxysporum*. In conclusion, *F. oxysporum*, *F. solani*, *F. acutatum* and *G. candidum* pathogens cause bulb onion postharvest rots in Kenyan markets. To reduce bulb onion postharvest losses, management strategies of these pathogens such as harvesting at the right maturity, proper curing and storage conditions should be employed. Reducing these bulb onion rot losses will help enhance food and nutrition security and household income of smallholder farmers in Kenya.

Keywords: Bulb onion, *F. oxysporum*, *F. solani*, *F. acutatum*, *Geotrichum candidum*, Kenya

Examining Maize Agronomy and Pre and Postharvest Losses and Loss Reduction in Farmers' Fields in the Eastern Region of Ghana

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Maize (*Zea mays* L.) was cultivated in farmers' fields and the pre and postharvest losses were studied alongside innovative practices and tools for reducing them to enhance the sustainability of the food system. In Ghana and much of sub-Saharan Africa, maize is an important food security crop, but suffers losses during various activity stages. This study occurred in the major season (April to July) of 2017 on plot E20 of the Future Christ Builders (FCB) of Oyoko a suburb of Koforidua, the capital of Eastern Region of Ghana. Two different varieties were cultivated contiguously: the yellow coloured *Zea mays* var. *Abontem*, and the white coloured *Zea mays* var. *Obaatanpa*. The objective of the work was to collect agronomic data on maize while tracking both pre- and post-harvest losses and recommending measures to reduce them. Data were collected on both the freshly harvested sweetcorn and on the fully matured and dried cobs. Mean fresh ear/cob weight of *Abontem* with husks was 260.5g and without husks, 186.0g. Ear length was 26.4cm; and without husks, 17.1cm. Mean circumference was 15.9cm and 12.8cm with and without husks respectively. There were 14 rows of kernels per cob, and 30 kernels per row. Similarly, the fresh ears of *Obaatanpa* with husks had a mean weight of 300.3g, and without husks 200.5g. Ear length with husks was 29.0cm and circumference 16.5cm, and without husks, 18.3cm and 13.4cm, respectively. Mean number of rows of kernels and number of kernels per row of *Obaatanpa* were 14 and 33, respectively. For the dry produce, the grain weight per cob was 165.0g and 178.8g for *Abontem* and *Obaatanpa*, respectively and the 100-kernel weight 41.3g and 36.2g, respectively. Data from these farmer-fields did not differ from regular experimental station data. In the pre-harvest period, losses were higher in *Abontem* (being early maturing), as it was the only source of food for rodents and birds prior to the dry season. The incidence of insect pests and diseases, and thus losses, was high for both varieties as a result of high rainfall at the time from maturity through drying which encouraged growth of fungi and insects compared to during seasons when it was dry from maturity throughout drying. Opportunities for reducing these losses include good agronomic practices, such as, pest and disease control, careful handling to reduce unit and other losses, minor season production, investment in solar dryers and massive agricultural extension work to sensitize farmers, aggregators and transporters on reduction of spillage. In conclusion, to sustain maize production, efforts must be made to reduce losses at key stages in the value chain.

Keywords: Farmers' fields, maize, corn ear weight, 100-kernel weight, postharvest loss

Specificities of Rice (*Oryza spp*) Postharvest Practices and Losses in Ndop Hub, Cameroon

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The increase of rice productivity should take into consideration an increase of yield and the reduction of postharvest losses. This work aimed to assess pre and postharvest practices and measure quantitative and qualitative losses of rice. Pre and postharvest practices were assessed by structured questionnaire, with 236, 136 and 108 rice actors in Lagdo, Ndop and Mbam hubs, Cameroon, respectively. Quantitative (spilled or abandoned rice grains) and qualitative (broken grains, impurities, chalky grains, heat damaged grains, homogeneity, poorly filled grains) losses during each unit operation were evaluated under farmer's (routine farmer practices) and improved (technologies developed through research) methods. All possible points of losses were identified and evaluated at each of the unit operations: harvesting, threshing, cleaning, drying, parboiling, and milling, linked to routine harvest and postharvest practices of 10 rice actors randomly selected from five villages of Ndop hub. Spilled and abandoned rice grains collected at each unit operation were weighed and expressed as a percentage of the total weight of grains. An assessment of the pre and postharvest practices revealed that 59% farmers, got their seeds from agricultural services. Rice planting runs through May, June, July and August. Farmers used three key indicators to determine harvesting time namely days after planting, leaf/panicle colour and biting through rice grains. All farmers used rudimentary methods and equipment throughout the rice value chain. Rice actors' average total physical grain loss of 29.99 ± 14.70 % resulted from harvesting (14.12 ± 7.24 %), threshing (6.35 ± 2.76 %), drying (0.54 ± 0.52 %), parboiling (3.46 ± 1.58 %), milling (3.52 ± 2.60 %) and storage (2.00 %). Samples harvested at farmer's harvesting date had a higher percent broken fraction (47.24 ± 14.89 %) than those harvested at optimum harvesting date, 35 days after heading with moisture content between 20-24 %, (31.97 ± 15.25 %). The level of impurity in samples threshed by farmers (1.04 ± 0.34 %) was higher than those of the improved method (0.35 ± 0.33 %). Rice, dried with farmer's method had higher broken fractions (52.90 ± 24.72 %) and impurities (1.88 ± 0.82 %) compared to that dried with improved method (26.43 ± 23.94 and 0.41 ± 0.83 % respectively). Rice parboiled with farmer's method had higher broken fractions (25.86 ± 19.42 %) and impurities (0.65 ± 0.33 %) compared to that parboiled with improved method (3.77 ± 0.91 % and 0.03 ± 0.16 % respectively). The development and adoption of good production and post-harvest management practices could increase rice productivity and reduce rice losses in Cameroon.

Keywords. Pre- and postharvest practices, grain quality, quantitative and qualitative loss

Production, Postharvest Handling and Utilization of three Neglected Plants in Traditional Farming Systems of Benishangul-Gumuz Region of Ethiopia

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In Ethiopia, particularly in the Benishangul-Gumuz region, there are numerous underutilized plants, such as figl (*Raphanus sativus*), girgir (*Eruca sativa*) and karkade (*Hibiscus sabdariffa*) which are cultivated and consumed only by the local communities. However, information on production practices, postharvest handling, and utilization trends of these plants is limited. The current study aimed to assess the production, handling, and utilization pattern of figl, girgir, and karkade in the Benshangul-Gumuz region of Ethiopia. A cross-sectional household survey used a semi-structured questionnaire to collect primary data from 274 producers and 30 consumers. The data were analyzed using SPSS (Version 20.0) software package. The study found that about 46% of farmers produce figl and girgir for food, medicine, and income generation. More than half of the farmers produce karkade for use as a beverage and medicine. About 93% of the respondents showed that, edible parts of figl and girgir could attain commercial maturity within 15-35 days. However, calyces of karkade takes 121-150 days to mature. Most of the farmers consume leaves and roots of figl and leaves of girgir as local salads while 84.31% use dried calyces of karkade for making a beverage. About 94% of the farmers allocated less than 0.25 hectares of land for the production of figl and girgir, and 81% of the farmers allocated this amount of land for the production of karkade. The majority (80%) of farmers said they did not get extension services to support the production of figl, girgir and karkade, and 53% lamented that there is no market linkage for these crops. Figl and girgir play significant roles in mitigating food insecurity because the edible parts reach commercial maturity within a short period making it possible to have more than five cropping cycles throughout the year, particularly in marginal lands with appreciable agronomic practices. Future research should develop packages of farming technologies including propagation of the crops at research centers, adaptation trials across various agro-ecological zones, defined agronomic practices, variety registration and promotion.

Keyword: Figl; Girgir; Karkade; production, utilization

Needs Assessment for Postharvest Management Practices of Major Food Crops in Nigeria

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Postharvest losses in agricultural commodities have constituted a serious setback to the attainment of food and nutrition security and poverty reduction especially with respect to small holder agricultural producers and marketers in Nigeria. A rapid assessment of the postharvest management practices of major staple food commodities sorghum, millet, maize, cassava, yam and rice, was conducted in the four states of Kebbi, Kano, Benue and Edo in Nigeria. Data were collected through two focus group discussions at the level of producers, marketers and transporters per commodity. Each State focused on a commodity of comparative advantage. The results revealed that stakeholders were aware that postharvest losses occur and reported that the losses are high at every stage in the postharvest handling systems along the value chain (5-20% of produce). Most postharvest activities were done manually and mostly with indigenous storage and preservation methods and some unwholesome practices such as inappropriate use of chemicals, unhygienic drying on road sides. Processors and other stakeholders explained that the unhygienic disposal of effluent from cassava mills led to environmental pollution in the surrounding areas. Stakeholders were mainly concerned of health effect of smoke on the processors while frying wet cassava granules into 'garri'. It was also reported that the cassava mills suffer from poor quality spare parts leading to incessant breakdowns thus interrupting the processing activities. The study also found low levels of record keeping about postharvest activities among all stakeholders and a lack of awareness of potential opportunities for exporting cassava products. Phone calls were the main communication method used by all stakeholders. The study also found farmers and other stakeholders do not have access to improved postharvest technologies such as hermetic storage technologies and efficient processing equipment. Transporters found it difficult and costly to move goods due to poor road conditions in rural and urban areas, high cost of vehicle maintenance, fuel and frequent breakdown of vehicles. Most of the farmers reported unwholesome practices among marketers/ traders for all the commodities who mix less preferred long grain rice varieties with commonly preferred varieties to increase volume of sales. There were also allegations that some stakeholders process rotten or mouldy cereals and tubers into products for human food and livestock feeds. The articulated needs of the stakeholders based on the problems/situation analysis include trainings on: record keeping, export opportunities, group mobilization for action, agribusiness opportunities, optimal use of phone application and ICTs for agri-business and farming for all the actors along the value chains. In addition, an enlightenment campaign should be mounted to improve the stakeholders' knowledge of the dangers of unwholesome practices. Furthermore, fabricators could be trained to locally produce machine spare parts and cassava processors to adopt improve 'garri' frying model with chimney and fire set from outside through demonstrations of the model by Extension Agents. The Postharvest Working group of Nigerian Forum for Agricultural Advisory services (NIFAAS) is currently producing Fact Sheets in local languages on recommended postharvest handling techniques which could form part of a training manual on postharvest handling techniques.

Keywords: Needs assessment, postharvest management practices, major food crops

Postharvest Losses and Management Practices of Millet in Yobe State, Nigeria

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Millet is a staple food with an important role in the nutritional diet of many people in the world. Despite the fact that millets are nutritionally better than other cereals such as rice, their involvement in diet is still generally limited to the less privileged. Understanding the handling practices and other postharvest challenges encountered by millet farmers and proffering workable technologies across the value chain makes this study relevant. This study was conducted to assess the postharvest losses and management practices employed by millet farmers in Yobe State, Nigeria. A structured questionnaire was used to interview 350 millet farmers from 17 Local Government areas of Yobe State to learn more about the management practices and postharvest issues encountered at farm level. Data were analysed using descriptive statistics such as pie chart, frequency, percentage, mean and logistic regression. The majority (79.2%) of the farmers interviewed were male, the mean age of respondents was 36 years and 89.2% had formal education. Eighty per cent (80%) of the farmers were married with an average household size of 11 people, and 10 years farming experience. The post-harvest management practices as reported by farmers include sun drying (100%), winnowing (98.6%), threshing (100%), and cleaning (91.4%). The majority of the farmers (68.3%) are aware of moisture content and utilized biting of millet as a subjective measure in assessing the dryness of their grains before storage. In addition, 66% of farmers mentioned the usage of chemicals such as cypermethrin, dusting powder etc. as pest management measures during storage. The majority (57.5%) of farmers use local bags/sacks, while 32.5% use PICS hermetic bags for storage. The ordinal logistic regression analysis showed that among the socioeconomic factors, age ($p=0.000$) and farming experience ($p=0.051$) significantly influenced the level of postharvest loss. A strong positive correlation was found between the storage duration and the level of postharvest loss ($R=0.862$, $p=0.001$). The level of postharvest losses reported differed significantly between male and female respondents ($t=22.776$, $DF=348$). Extension agents were cited as the main source of postharvest information by 31.9% of respondents. The majority of the millet farmers (70.8%) stated that insect/pests and disease followed by high cost of farm labour (35%) and inadequate marketing pricing (24.2%) were the main constraints affecting their crop's performance. Most of the responding farmers (70%) indicated various levels of postharvest loss with majority and incomes losses of NGN 15,001-20,000 per harvest season. These findings provided an avenue for research institutes, such as the Nigerian Stored Products Research Institute, to put more effort into postharvest loss reduction training for farmers in the state and to disseminate their new storage technologies among farmers to improve food security and sustainability, as the current storage methods are not very efficient in reducing losses.

Keywords: Millet, farmers, postharvest, management, Yobe

Mycotoxins Occurrences among four Staple Foods in Northern Uganda

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Mycotoxins are food safety hazards that often contaminate grains. The toxins are derived from free-living fungi that occur almost everywhere and often result in severe contamination of food/ grains depending on the prevailing weather condition, pre-harvest, and post-harvest management. To highlight the threats to which people from Uganda are exposed to mycotoxins, we evaluate the occurrences of four mycotoxins (aflatoxins, fumonisins, ochratoxins, and deoxynivalenol) in maize (n=126), millet (n=78), groundnuts (n=66), and sorghum (n=130) from northern Uganda using ELISA method to estimate the risk of human exposure and to determine the food types highly vulnerable to mycotoxin contamination. The study revealed that only 7.07% of the food samples collected had no mycotoxin contamination. Sorghum (80.0%) and groundnut (78.79%) had higher aflatoxin contamination levels than maize (35.34%) or millet (20.51%). Similarly, fumonisins were more frequently detected in sorghum (92.91%) and groundnut (74.24%) than in millet (44.87%) or maize (67.20%). Contamination with deoxynivalenol was mostly detected in maize (77%) and sorghum (56.67%). Meanwhile ochratoxins contamination was lowest in maize (12%) and highest in sorghum (67.19%) and groundnut (65.15%). Sorghum 39 (31.2%) had the highest proportion of grains with aflatoxin concentration exceeding Uganda regulatory limit of 10 µg/kg followed by groundnut 13 (19.70%) and maize 11 (9.48%). Millet 1 had the least (1.28%) occurrence of aflatoxin concentrations exceeding Uganda regulatory limits 10 µg/kg. Co-contamination with all four mycotoxins was detected in 36 (12.72%) samples. Sorghum grains (n=35, 40.70%) had the highest proportion of grains contaminated with a combination of all the four mycotoxins compared to the other food types. In general, the four mycotoxins were common in all the staples food (maize, millet, sorghum, and groundnut) in northern Uganda, though with an unequal proportion of occurrence. Aflatoxins, ochratoxins, and fumonisins were frequently detected in groundnut and sorghum, in contrast to millet grains. The finding suggests that most people who used sorghum and groundnut as a priority diet are likely exposed to multiple mycotoxins in their diets that elevate the associated health risk. This highlights the need to strengthen mitigation measures among local farmers who are the primary source of these food items to minimize exposure to high concentrations of mycotoxins in homemade food items.

Keywords: Aflatoxin, ochratoxin, fumonisins, sorghum, maize

Life Cycle Assessment (LCA) of Mango Cold Storage Technologies in Kenya

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Cold store technologies have been essential in preserving the quality of perishable crops. In sub-Saharan Africa, where approximately 80% of farmers are smallholders, several low-cost cold storage technologies have been researched and recommended as economically viable for smallholder farmers. However, very few studies have assessed the environmental impact of the different cold storage technologies. Hence, this study attempted to quantify the environmental impact of three types of cold storage technologies in the Kenyan mango value chain. The technologies compared consisted of 1) an insulated air-conditioned container made of plastic (EPS) walls and equipped with the Coolbot temperature controlling device, 2) a wiremesh wall structure filled with charcoal used to create an evaporative cooling effect inside the structure, and 3) a brick double-wall structure with the gap filled with sand used to create an evaporative cooling effect inside the structure. A life cycle assessment (LCA) was carried out to quantify greenhouse gas emissions per cold store technologies. Preliminary results show that the brick and sand wall structure had the lowest greenhouse gas emissions of 282 kg CO₂ eq. Due to a limited cooling capacity the brick and sand wall structure was most suitable for pre-cooling mango fruit rather than storing them for an extended period. The air-conditioned container equipped with the Coolbot temperature controller had the highest greenhouse gas emissions of 3.2 Tonnes CO₂ eq during usage from the electrical energy used to run the air conditioner. However, the technology had relatively lower emissions (2.6 Tonnes CO₂ eq) resulting from the manufacturing process. Given that the air-conditioned container could be used for long-term storage of mango and its emissions during usage could be mitigated by replacing the electricity source from the grid to an independent solar panel source, this technology is potentially the most environmentally friendly alternative.

Keywords: Life cycle assessment, Mango cold storage, Postharvest technology

An Economic Analysis of Food Losses in the Maize Value Chain in the South-West and Northern-Eastern parts of Tanzania

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An economic analysis of postharvest losses in the maize value chain of smallholder farmers in the South-West and Northern-Eastern parts of Tanzania was carried out in 2016/17. The '4 S' (Screening, Sampling, Survey, and Synthesis) methodology recommended by the FAO under the Save Food Initiative was used. The Screening method was based on a review of secondary information, documentation and reports, and expert consultations. The Sampling involved taking actual measurements of food losses by sampling a few harvested farms and re-harvesting to collect all the remaining grains. Sampling was also applied to measure specific losses during postharvest handling, transportation, shelling, storage, milling and marketing. The Survey method implied observing the maize supply chain in the field and conducting interviews with the respective actors. The Synthesis method was applied to analyze, and aggregate the information obtained from Screening, Sampling and Survey methods. In this regard, the methodology helped to assess the losses at each node of the maize supply chain. Ten farms were sampled for load-tracking from harvesting, storage and milling. The study revealed that most of the losses occur during the storage (9.74 – 22.13%), harvesting (0.12 – 0.67%) and shelling (0.03 – 0.06%) stages of the postharvest supply chain. Transportation to homestead and milling nodes had the most negligible loss proportions. The accumulated loss ranged between 10 – 23 % of the total maize harvest. Poor postharvest handling practices resulting from the inadequate technologies used by most farmers led to these high losses. All the activities, from production to marketing, are mainly done manually, and there is limited use of improved technologies. The study also found an unprecedented application of pesticides where most farmers reported treating their maize grain directly with liquid Actellic 25 EC and 50 EC insecticides, strictly recommended for structural uses. Applying this chemical liquid may also lead to some re-wetting of the grain where farmers could not dry the maize grain adequately before storage. The moisture content for maize grains stored using liquid Actellic insecticides was relatively higher than those using powered insecticides. Were the grain to become and remain wet due to the pesticide application, this could encourage fungi and the formation of mycotoxins. The economic value of maize postharvest losses was calculated at TZS 100,000 – 230,000 (USD 43.48 – 100) per hectare. The study led to the recommendation for interventions such as developing a postharvest strategy for Tanzania, promoting good postharvest practices (GPHPs), initiating a postharvest loss monitoring and evaluation program, and improved bulk storage facilities to reduce the amount of maize being stored in domestic houses. Additionally, the study recommended that an assessment of the qualitative postharvest losses of maize be conducted to examine the quality of maize grain being consumed in the country and the associated health implications. Increasing farmers' technical know-how on GPHPs and the use of recommended interventions could reduce maize losses and improve household food and income security and consumer health.

Keywords: Food losses, maize, Tanzania, postharvest, 4S methodology

No Grain Left Behind: American Midwest Corn and Soy Harvest Efficiency Study

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Estimates indicate that 16% (19 million tons) of US food waste occurs at the farm level as loss, though this figure is based on a limited number of field studies. This study focused on harvest-related losses for corn and soybeans. Corn and soybean agricultural research in the US mostly focuses on increasing yield while research on losses in the supply chain has been lacking. Unavoidable food loss on farms may be preferable from an environmental and socio-economic perspective than loss and waste at later stages in the supply chain, where additional labor, transport, energy, and other inputs have been embedded into the product. The field study was conducted in October 2020, during the global COVID-19 pandemic. The majority of farmers had not experienced any practical implication of COVID-19 on their harvesting. Delayed impacts from the global pandemic have influenced soybean prices, and the markets are still watching in anticipation of what may happen to corn prices. This study drew on the Food Loss & Waste Quantification Methods of direct weighing, counting, and surveys. The study collected baseline primary data (measured actual loss that was left behind in the field during combine harvesting) that showed that the average field-level loss on corn farms was 4.7%, whereas farmers expected losses during harvesting to be only 0.65%. Extension agents encourage farms to aim for less than 1% loss during harvesting. The data indicates a mean excess loss of 3.7% is occurring, which when scaled to the national level, represents a loss of 503 million bushels (12.8 million tons) of corn worth \$2.07 billion, based on 2019 production figures. For soybean, farmers expected harvesting loss of 1.5 bushels per acre, while the study's measurement found they experience an average harvesting loss of 2.18 bushels/acre. This study recorded an average loss at the harvesting of soybean of 4.5%, whereas 3% is the accepted industry loss. This means a loss overage of 1.5%, which when scaled to the national level is an excess loss of \$0.53 billion. Notably, this study found that 31.3% of corn farmers contribute to 74.3% of the total loss, and for soybean, 27% of the highest soy harvesting loss farms accounted for 44.4% of total losses at harvesting. A strategic campaign to target these farmers, who are often smaller in size (100 – 200 ha) and use less sophisticated combine equipment, can improve future harvest efficiency rates and reduce losses. Encouraging farmers to check for losses when moving to new fields and sharing visual guides on how to do a quick check of field losses may address gaps in understanding of how to determine their harvesting-related losses.

Keywords: Food loss, corn, soybean, field harvesting, American Midwest

Drivers of Postharvest Losses in Traditional African Vegetables and Barriers for Improving Incomes and Nutrition of Actors in Cameroon

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Traditional African leafy vegetables (TALV) are high income earning and nutritious food crops. They contain important nutrients such as vitamins and minerals but postharvest losses are high and can reach 40 % of the total production due to a lack of or poor postharvest techniques and facilities. The objective of this paper is to identify drivers of postharvest losses of TALV at the level of the vegetables' value chain-based Innovation Platform (IP) and barriers to improve income and nutrition of the actors. A Commodity System Assessment for the most important TALVs in Cameroon [Amaranth (*Amaranthus cruentus*), Jute mallow (*Corchorus olitorius*) and African nightshade (*Solanum Scabrum*)] was conducted during a training session for 30 actors including farmers, transporters, agricultural technicians, transformers, retailers and consumers from the vegetables' value chain IP of Mbamayo, in the Central region of Cameroon. Results show that drivers of postharvest losses are systemic and include technological, sectoral and institutional challenges. Regarding technological challenges, the packaging pattern is adapted to the mode of transport but not to the protection of the produce which increases damage and postharvest losses; and an excess use of urea for fertilization reduces the shelf life of the vegetable products. In relation to sectoral challenges, there is no cleaning and sorting before transport, produce moves directly from farm to market as there is no packhouse. Cooling of produce is done by soaking the leafy vegetables in fresh water which limits storage of the vegetables to just 2 days. Concerning institutional challenges, TALV are not receiving enough attention from policy makers and researchers. Only a few institutions are involved in projects promoting TALV. There are limited financing opportunities for TALV producers as few lenders understand their potential. Moreover, marketing is a challenge as the price fluctuates depending on the volume of the produce which cannot be anticipated. The above-mentioned drivers of postharvest losses constitute barriers to improving the income of the TALV value chain actors. Additionally, the excessive use of pesticides to combat pests and diseases with the associated environmental and consumer health issues lead to some people avoiding the consumption of TALV; thus constituting a barrier to improve nutrition. Development/adaptation and dissemination of suitable options to reduce postharvest losses of TALV is needed to increase income of the TALV value chain actors via the supply of quality products to improve consumers' nutrition.

Keywords: Amaranth, Jute mallow, African nightshade, postharvest, value chain

Research on the Measurement of Harvest and Postharvest losses: Insights from the Literature on Minimum Losses by Commodity and Region

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The reduction of agricultural losses, especially among smallholder farmers, should be an essential component of food security strategies in developing countries. The recognition of the importance of reducing food losses to achieve food security was the basis for the decision to include a dedicated target in the 2015 United Nations Sustainable Development Goals (SDG) agenda, with target 12.3 stating: "By 2030, to halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including postharvest losses". Loss reduction strategies should be informed by evidence on optimal loss levels, or the point below which loss reduction efforts become economically unviable, characterized by loss reduction costs greater than benefits. Information on minimum losses can help provide a benchmark for farm management, formulation of policies and investment decisions. When this information is connected to farming practices or production technologies, as done by the present study, it can also help in assessing the effectiveness of loss reduction practices and of the underlying policies and incentives that promote them. While most empirical research and data collection activities on losses tend to focus on average losses, this paper aims to provide evidence on minimum harvest and postharvest loss levels for several commodities and regions of the world through a thorough meta-analysis, and compilation of an original dataset on minimum losses for a wide variety of activities, products and regions. This dataset reflects the performance of the most efficient production systems. Following an adapted and replicable statistical methodology, minimum loss percentages have been calculated by commodity, commodity group and region to establish a benchmark to which average country results can be compared. One of the main findings of this meta-analysis - in line with other recent studies - is the clear split between commodity groups with oil crops, pulses and cereals on one end (with minimum losses of 2.0%, 4.0% and 4.2%, respectively) and fruits, roots and tubers, sugar crops and vegetables on the other end (17.1%, 18.4%, 18.5% and 20.7%, respectively). In terms of regions, Central America, Western Africa and Eastern Africa had minimum losses of 5% while South America and South-Eastern Asia were found to have minimum losses of 2.5% for cereals. There are instances where the losses for some commodities in some databases fall below the documented minimum losses, the results are therefore not conclusive. There is limited information on minimum losses and therefore only 48 studies were used in this meta-analysis, this is work in progress and quality of data is envisioned to improve as more research is conducted in this area. This new and - to our knowledge - unique source of information constitutes a starting point in the establishment of optimal or minimum loss levels for a wider set of products, countries and regions, connecting losses to production practices or technologies.

Keywords: Food loss, harvest losses, minimum losses, on-farm losses, postharvest losses.

Examining Legume Postharvest Loss Data to Expand the Crop Coverage of the African Postharvest Losses Information System (APHLIS)

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Across sub-Saharan Africa (SSA) and beyond, legume crops such as cowpeas, common beans and groundnuts provide crucial dietary sources of protein and other important nutrients. These crops are produced, stored, traded, and consumed in large quantities. Their postharvest systems are complex involving multiple actors, activities, locations, and durations. Postharvest losses (PHLs) occur for a wide variety of reasons within these systems. Minimising these PHLs is an important dimension of building more sustainable, nutritious, and affordable food systems. Targets for reduced PHL are emphasised in the African Union's Malabo Declaration and Sustainable Development Goal 12.3. However, to better direct and prioritise loss reduction investments and policies we need to understand how much food is being lost, where, and why. The African Postharvest Losses Information System (APHLIS) www.aphlis.net was developed in 2009, in response to demands by development agencies for more accurate estimates of staple cereal crop PHLs. APHLIS brought a rigorous knowledge management approach to cereal PHLs. Knowledge of the proportions and quantities being lost postharvest, at different stages of the value chain, and differences within and between countries and crops is important for informed decision-making on PHL reduction investments. APHLIS also converts these PHLs into their financial and nutritional values and impacts, such lenses help decision-makers in deciding where to focus their interventions. Given the dietary importance of legumes, the need to increase the supply and ensure access to and quality of plant-based protein sources to meet the demands of growing populations, and support and encourage dietary shifts to more sustainable protein sources, greater understanding of where and why legume PHLs are occurring is needed. This work aimed to provide an evidence-based analysis of the scale, location within the value chain, and knowledge gaps of PHLs of staple legumes across SSA to expand the crop range covered by APHLIS. The legume scientific literature-base was systematically screened, extracting the loss figures and related information required to build profiles of the PHLs occurring along cowpea, common bean, and groundnut value chains. Loss levels can be influenced by contextual factors such as technology use, proportion marketed, storage duration, and climate, among others. Data on these contextual factors were collected from the literature and experts, and combined with the loss profiles, to provide science-based estimates of legume PHLs. For the focal legumes, 67 SSA studies containing PHL data collected using a medium to high quality loss assessment method have been identified, 60% include cowpea, 25% groundnut, 19% common beans. West African studies dominate (64% of studies), particularly Ghana, Nigeria, Niger and Benin. East and Southern Africa account for 24% and 13% of studies, respectively. Four studies were multi-country. Between them these studies contain 759 PHL data points, mainly for household-level storage losses (70%), in cowpea (59%). Meta-analysis of the data provides loss ranges for the different crops, activities, geographies, climates, and intervention groups. However, more measurement of legume PHLs is needed, particularly during non-storage stages. To help in reducing these knowledge gaps, four legume loss assessment studies are being conducted.

Keywords: Legume crops, postharvest losses, PHL metrics, loss estimates, African Postharvest Loss Information System (APHLIS)

Addressing Participants' Subjectivity during Physical Measurement of Field Postharvest Losses: Proposed Approaches

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A reliable methodology is critical for the generation of accurate postharvest loss (PHL) data to inform the development of appropriate policies, prioritise investment and recommend remedial action. Conventionally, PHL data are often collected using 'subjective' methodologies which depend on respondent (farmer, trader, processor etc.) recall and estimation abilities and therefore may be unreliable. In view of this limitation, the Global Strategy to Improve Agricultural and Rural Statistics initiative hosted by the Statistics Division of the Food and Agriculture Organisation (FAO) adopted the use of a physical 'objective' measurement methodology which involved the physical quantification of the PHL at some operational stages. For example, this novel methodology entails that a farmer harvests a demarcated plot of say 5m*5m, after which the researcher measures the harvest and meticulously collects the leftover grain and express it as a percentage loss at harvest. While the objective measurement methodology is a good attempt in addressing errors associated with subjective measurements, the 'objective' measurement methodology can also be prone to biases. For instance, the harvesting of a demarcated plot may not be perceived by farmers as a 'normal' exercise resulting perhaps in the farmers exercising greater care during the harvesting process; thus leading to underestimation of actual PHL that would normally occur at that stage in the absence of researchers. This limitation equally applies to other postharvest farm operations and is potentially a challenge associated with the 'objective' measurements. This paper articulates the possible biases of 'objective' measurement methodologies and proposes measures to minimise the subjectivity and improve the quality of PHL data obtained through these 'objective' measurements. Principally, the paper proposes and discusses the practical integration of the 'ambush technique' into the FAO's approach to eliminate respondent bias and move closer towards a 'true' 'objective' measurement methodology. However, tests will need to be conducted to determine the validity of the proposal and bring value to the PHL measurement discourse.

Keywords: Ambush technique, objective measurements, physical measurements, postharvest loss, subjectivity

An Analysis of Postharvest Grain Losses in Brazil under different Sustainability Metrics

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Society is increasingly concerned with food security and the efficient use of resources to guarantee a sustainable economic system long-term and to guide the production of sufficient food. The analysis of postharvest losses should move beyond a focus on purely the physical loss to include a broader range of sustainability metrics, the resource-saving effect and the availability increase effect. The resource-saving effect is associated with the amount that is saved when the loss is avoided. A range of physical, financial, environmental, and social resources are consumed to produce and move the product along the supply chain, such as fertilizers, water, diesel oil, greenhouse gas emissions, among others. When a loss is avoided, there is also the effect of increased availability of the product for consumers and food processors, as the loss avoidance increases the nutritional and energy availability from the product; consequently, it tends to reduce the price of the product. This research aimed to quantify the physical postharvest losses of corn and soybean occurring in Brazil. The research involved monitoring the flows of these crops from farms to consumer centers and ports, through different modes of transport (highway, railroad, and waterway) and warehouses (off-farm and on-farm), as well as quantifying the externalities of losses from the perspective of sustainability metrics, such as waste of water, fertilizers, land, nutritional, economic, environmental and energy. The method used consisted of a primary survey of information about losses in logistical activities and quantification of the chain through a mathematical optimization model (network flow). Physical losses of grain (corn and soybean) in logistics (transportation and storage) totaled 2.9 million tons in 2020 in Brazil. From the perspective of the availability effect, sustainability metrics demonstrated that these losses had prevented, 194 Giga calories, 12 thousand tons of proteins, 24 thousand tons of carbohydrates, and 6 thousand tons of fats from being available to society. Similarly, the grain losses in 2020 are equivalent to the wastage of grain from a cultivated area of 696,000 hectares. While the logistic operations for this lost grain used diesel fuel which emitted more than 95 thousand tons of CO₂ into the atmosphere. Almost 4 billion cubic meters of water, plus 274 thousand tons of fertilizers were used in producing the quantity of grain that was lost in 2020. The economic losses resulting from the physical grain losses totaled \$ 1.1 billion. It is essential that such losses are understood by different agents in the economy. This example demonstrates that although the relative proportion of losses of grains may be low, the total physical losses are significant with a monetary value of over 1 billion dollars. The impact on a series of sustainability indicators, multiplies the loss of physical, economic, environmental, and social resources used throughout the chain production of the products, as well as, reducing the availability of the product in the market.

Keywords: Brazil, grain, losses, logistics, sustainability

Identification and Characterization of *Rhizopus* species causing Postharvest Rot Disease of Sweetpotato isolated in Nigeria

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Soft rot caused by *Rhizopus* species is an important postharvest disease of sweetpotato tubers and accounts for about 40% of yield losses in producing countries. However, there is a paucity of information on which *Rhizopus* spp. infect sweetpotato in Nigeria. In this study, molecular characterization of *Rhizopus* isolates was investigated as the basis for management of postharvest rot. Using a random sampling technique, diseased tubers were selected from farmers' fields across five major sweetpotato producing Local Government Areas in Oyo state. Morphological identification of *Rhizopus* isolates was carried out using sporangia fruiting bodies and hyphal structures. Genomic DNA was extracted using Cetyl Trimethyl Ammonium Bromide (CTAB). Molecular identification and characterisation of *Rhizopus* isolates were done through amplification of the internal transcribed spacer (ITS) region of ribosomal DNA. Relatedness among the isolates was evaluated using random amplified polymorphic DNA. ITS sequences of rDNA 18S, ITS, and 28S D1/D2 of all *Rhizopus* species were analyzed. Basic local alignment search tool (BLAST) searches of the ITS region sequences were conducted and compared with standard database for identification to species level. All the 20 isolates were morphologically similar and identified as *Rhizopus oryzae* and *R. stolonifer*. Molecular analysis, however, confirmed 16 of the 20 isolates as *R. oryzae*, two as *Aspergillus brasiliensis* and the remaining two as *Lasiodipodia pseudotheobromae*. Phylogenetic analysis distinguished between the 20 isolates and grouped them into three major clades. Intraspecies variation among isolates and reference strains was minimal. This study not only provides, through the use of modern molecular tools, a baseline understanding of the identification and characterisation of *Rhizopus* isolates, but also confirms that ITS sequencing is a useful approach for precise identification of plant pathogens. This information would be invaluable in breeding for resistance to reduce the enormous postharvest losses associated with sweetpotato soft rot disease.

Keywords: Clades, polymorphic, postharvest, *Rhizopus*, sweetpotato

Food Loss and Waste in Egypt and Morocco: Implications for Food and Energy Security, Resources, and Greenhouse Gas Emissions

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Several research and development efforts have focused on ensuring food security in developing countries. Dissemination of improved agricultural technologies have been the main avenue through which increases in food supply have been achieved. However, food insecurity remains a major challenge because sustainably increasing productivity to feed the world's growing population in the face of major resource constraints and climate change is proving to be difficult. This paper argues and provides empirical evidence that reducing food loss and waste can be an effective food and energy security, and natural resource, and environmental conservation strategy. Estimates of global food loss and wastage range between 30-40% of total annual production. If true, these are much higher than yield gains possible through available technologies. Therefore, quantifying the extent, identifying the causes across all nodes of value chains, setting priorities based on the extent and ease of mitigation, and developing strategies for reducing food loss should be given high importance. In this study, the "life cycle of food" approach along with standard protocols developed in line with international initiatives led by the World Resources Institute were used for physical measurements of losses during pre-harvest, harvest, storage, transportation, and consumption at restaurants. However, due to cultural and intellectual property barriers for physical measurement, survey data and company records were used for estimation of losses during processing, marketing, and consumption at households. Micro-level estimates were aggregated to national levels using area and population weights. The estimates at each node were then used to make estimates of cumulative farm to fork food loss and waste. Our results showed total food loss and wastage of 20.62% of the total national wheat supply from domestic production and imports in Egypt, and 42% in Morocco. These losses are associated with wastages of 1.8 billion and 3.1 billion m³ of water, and 59.9 million and 74.7 million GJ of energy, respectively. Food losses or wastage at each node of the value chain ranged from 0.37% for pre-harvest loss in Egypt to 11.43% for loss during consumption in Morocco. If food losses were completely prevented, 34 million and 21 million more people could have been fed and emission from landfills of at least 19.3 million and 8.5 million kg of methane prevented in Morocco and Egypt, respectively. The low estimates of consumption loss in Egypt relative to the levels that prevailed before 2014 (23%) show that the bold measure the country took in 2014 to replace flour/bread subsidy with food vouchers given only to the needy was successful in reducing food waste with possible positive effects on nutrition. A major implication of our results is that besides the ongoing efforts to disseminate agricultural technologies, governments in Africa in general and particularly in North African countries, need to develop short- and medium-term national strategies to reduce food losses and wastage particularly targeting the storage and consumption nodes. Creation of awareness about the magnitudes and consequences of food loss and wastage and removal of the bread subsidy alone can be important actions for reducing them.

Keywords: Food waste and loss; value chain; farm-to-fork; measurement and estimation; water and energy use

Peri-urban pest rodents and storage losses in Northern Ethiopia

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In peri-urban areas of Ethiopia, storage losses due to rodents are poorly reported on compared to in rural areas. We conducted focus group discussions in two communities around Mekelle, namely Hdassie and Dungure, to gain an insight into the extent of the rodent pest problem and management in peri-urban settings in northern Ethiopia. We also conducted small mammal trapping in these settings to draw a picture of the local pest species. The main sources of livelihood of the communities were animal husbandry, small-scale cereal farming, and small businesses. Rodents were ranked as the top pest animals. Trap captures included one species of shrew (*Crocidura olivieri*) and two rodent species (roof rat *Rattus rattus* and grass rat *Arvicanthis niloticus*). While the roof rat is predominantly nocturnal, the grass rat is a diurnal species. This temporal difference in the living habit of the two species may have contributed to their co-occurrence in these human-dominated settings by reducing interspecific competition. The shrew was not perceived as a pest species. The rodents were perceived to thrive around the homestead all year-round, although their overall number was thought to increase from time to time. The perceived risk for rodent infestation varied with the socio-economic status of households and was attributed by the inhabitants to poorly stored animal feed, vacant houses, poor household sanitation, waste from domestic animals, stone bunds around houses, poor housing conditions, type of soil, and presence/absence of predators. The three most commonly used grain storage materials were woven polypropylene bags, metal and plastic barrels. The metal barrel was ranked as the most effective storage means against rodents and woven polypropylene bags as the least effective. Yet most households stored animal feed in woven polypropylene bags, mainly because the barrels were too expensive for them. Cumulative storage rodent economic losses of ET Birr 4,340 (US\$ 108) and ET Birr 2,900 (US\$ 72) were estimated in Hdassie and Dungure per year per household, respectively. The most practiced rodent management methods were trapping, homestead and storage area sanitation, domestic cat deployment and, more rarely, poisoning. Trapping was perceived as rarely effective, domestic cats as occasionally effective and poisoning as not effective. No response on the effectiveness of sanitation was provided. Rodents were perceived as potential disease carriers and transmitters both to humans and livestock, even though the diseases were not named except rabies that was quoted as a disease that could be acquired from rodents, as in dogs. Furthermore, food, water and utensils contaminated with rodent excreta were avoided for the fear of disease and religious beliefs. Finally, a range of perceived measures for better future rodent management were proposed by the inhabitants, including, improved (i) housing conditions of communities (e.g., rodent-proof walls, roofs, and floors), (ii) access to rodent-proof storage materials (e.g., loans to buy metal barrels), (iii) homestead and village sanitary conditions (e.g., regular community cleaning and waste disposal systems), (iv) access to multiple capture traps, and (v) introducing better and innovative management methods.

Keywords: Peri-urban rodents; economic loss; rodent pest management; Ethiopia

Assessment of Red Pepper Postharvest Practices and Losses in Jimma Zone, Ethiopia

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Red pepper is an important cash crop for the Ethiopian economy. However, poor postharvest handling is a major problem that hinders trading and results in an insufficient volume and quality of the crop. This study aimed to identify the major causes of loss of the pepper product during harvesting at crop maturity through to storage. The assessment was conducted in Jimma zone of Oromia region in southwest Ethiopia. For the study, members of 368 randomly selected households (HHs) were interviewed as representatives of the districts. Some of the main problems reported by farmers during harvesting were pods detaching (reported by 9.0% of respondents), unseasonal rain (94.8%) and field drying. The storage problems identified included; storage insect pests (90.2%), rodents (89.1%), improper store room (93.5%) and bag (89.7%). These problems require practical technical interventions alongside training to tackle the poor postharvest handling practices and minimize the losses. Unseasonal rain, late harvesting, over drying or prolonged duration of field drying, poor storage practice and storage insects were found to be the major causes of high postharvest loss of hot pepper. In addition to these challenges, farmers in the study area would benefit from the introduction of the concept of pre-processing and value addition practices prior to sale of the products. Some of the value addition practices that are already undertaken by the actors along the value chain include sorting (88.9%), milling (87.8%) and packing (1.4%). These practices should be encouraged by both government and other organizations which are focused on this economically important crop within the study area.

Keywords: Harvesting, hot pepper, postharvest loss, milling

Determinants of postharvest losses of maize at producer level in different agroecology settings of Malawi and Tanzania

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In low-to-middle-income countries, such as, Malawi and Tanzania, reducing food loss and waste is a major priority to promote more sustainable development. For strategic implementation of policy, it is critical to have accurate data on the extent and the drivers of losses. This study aimed to estimate postharvest loss (PHL) in maize-based systems in Malawi and Tanzania, and identify the factors determining the losses at producer level, using both a direct measurement approach and a self-reported/perceived method. Data were collected using a standardized survey protocol in 404 households in Nkhosha and Balaka districts of Malawi in June 2019, and in 428 households in Tanga region of Tanzania in August 2019. Estimates of total PHL of maize averaged 17.6% in Malawi and 28.3% in Tanzania. The main causes of PHL were mechanical damage of grains during harvest and postharvest handling, followed by insects and fungal spoilage during storage. Among the socio-economy of the household, agroecology, farming practice, postharvest practice and maize storage conditions, the main factors affecting maize loss after harvest at farmers level included the age of the farmer, the duration between harvest and sale or depletion of own-maize stocks, and market access. This study identifies key points for intervention and policy actions for efficiently reducing maize PHL.

Keywords: Food loss; maize; sub-Saharan Africa; producer; agroecology.

Postharvest Loss Assessment along the Rice Value Chain in Bunkure LGA, Nigeria

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High postharvest losses (PHLs) caused by poor postharvest management of rice is a serious food and nutrition security problem in Nigeria. The challenge is that there is no simple and accurate method of measuring losses which can convince small-scale farmers and traders who are dominant in the Nigerian food supply chain. This paper proposes a practical PHL assessment method aimed at creating awareness among farmers on the level and causes of PHLs. Assessment of PHLs of the irrigated SIPI rice variety was conducted in Bunkure Local Government Area in Kano State of Nigeria in August 2016. Extension staff and participating farmers were involved in conducting the field measurements. Six (6) sampling plots of 3sq.m each were randomly selected from six (6) farmers' rice fields measuring 2,000 sq.m each. Harvesting, threshing and cleaning of rice were conducted using traditional practices. In each process, the lost grain was collected and weighed (weight and moisture content). The average cumulative PHL was 6.34%, with component losses from harvesting, threshing and winnowing/cleaning recorded at 4.45%, 1.40% and 0.49%, respectively. Harvesting loss was incurred during the cutting of the straw, and laying, collecting and transporting it to the storage stack prior to further processing. The harvesting loss consisted mostly of shattered grain and grains missed during cutting. The traditional harvesting, threshing and winnowing methods are mainly manual and the quantity of grains lost due to poor handling cannot be ignored when addressing food security. Based on the results, Sasakawa Africa Association has introduced and scaled up improved methods of harvesting and threshing/cleaning of rice and other grains to help minimize postharvest losses and to reduce labor drudgery which will positively impact on food and nutrition security in the country. The results will provide evidence for policy-makers to use in designing intervention programs to help reduce rice PHLs.

Keywords: Postharvest loss, irrigated rice, harvesting, threshing, winnowing

The Economics of Postharvest Loss and Loss-Preventing Technologies in Developing Countries

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The objective of this article is to identify what is currently known and what remains unknown about postharvest loss (PHL) and technologies and practices aimed at mitigating loss that are appropriate for small-scale producers, traders and consumers in the developing world. We review this multi-disciplinary literature from an economic framework that considers decisions by actors along the value-chain who make postharvest related decisions based on their profit and/or utility maximizing decisions. As such, we contribute to this literature in two main ways. First, we develop a framework to think about how to measure PHL, in terms of both quantity and quality losses, the latter type of loss may be observable or unobservable to actors in the value-chain. Therefore, it is important to understand what that means for the incentives of different actors who play a role in connecting consumers to their food. Much of the existing literature focuses on quantifying the actual magnitude of physical losses from PHL (Kaminski and Christiaensen 2014; Abdoulaye et al. 2016; Ambler et al. 2017; others). However, in this article, we make the argument that the exact magnitude of losses misses the point and that losses of quality likely constitute a bigger concern from a public health and food safety perspective rather than the waste of resources and lost income from greater quantity losses. Second, we synthesize what is known about effective technologies and practices that reduce PHL quantity and quality losses. We update previous studies that reviewed both economic and multi-disciplinary issues surrounding food loss (Affognon et al. 2015; Sheahan and Barrett 2017; Stathers et al. 2020). The Affognon et al., Sheahan and Barrett and Stathers et al. articles all highlighted the dearth of evidence on PHL and socio-economic impacts and cited the need for more rigorous research linking PHL interventions to social and economic impacts. We aim to close this gap by reviewing the growing number of studies on this topic that have been published over the past five years. We consider the availability, cost-effectiveness and potential for wide-spread scale-up and adoption of these technologies and practices. The level of PHL is the result of some optimization behavior of economic actors given their risk aversions, and their constraints including technology and credit constraints. Just as we believe that people adapt to climate change, we should believe that people adapt to mitigate PHL to the point it is profitable to do so. If reducing PHL is costly to the agent, then it is likely that the optimal level of PHL is not zero. Adaptation strategies to mitigate PHL might include, i) selling food at a harvest (at a possibly lower price) to avoid losses; ii) applying insecticides to kill insects, iii) planting traditional varieties that are lower yielding but less susceptible to PHL. All of these strategies are optimal for farmers given their constraints, but better information and or new and improved technologies can potentially relieve these constraints and improve their welfare.

Keywords: Postharvest loss; postharvest technologies; economics; incentives; sub-Saharan Africa.

Why Ethiopian Meat Considered as Dark Cutting and Unsuitable for the Export Market: Lessons Learned from Production Scenarios

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Dark-cutting meat (DCM), also known as dark, firm, and dry (DFD) meat, is one of the major challenges confronting the Ethiopian meat industry. It is faced due to stress in animals before slaughter which results in muscle glycogen depletion and increase of ultimate pH and decrease in shelf-life. These dark cuts occur due to pre-slaughter stress during on-farm and off-farm handling which affects the physical, physiological, emotional state of the animals, and ultimately changes the product quality and affects profitability of the meat industry. This study reviewed the available literature on the factors predisposing animals to dark meat cutting and provides directions for future research in the Ethiopia meat industry. The major on-farm factors causing dark cutting are disease nutrition, production systems beating, animal management, climate, genetics, age, and individual animals. Off-farm activities include transport, exhaustion on route to market, fear, fighting in lairage, beating, harsh climate, prolonged withholding of feed before slaughter, and mixing of unfamiliar animals, involving utilizing an enzyme to initiate modification of muscle to meat which may then change the meat colour from normal to dark. Dark-cut meat is most often known as dark, firm, and dry (DFD). DFD meat can also be called "high ultimate pH" meat as a result of depleted muscle glycogen prior to slaughter. Due to this problem, a high rate of carcasses were limited from exportation by Ethiopia and redirected for domestic consumption. Normally the most preferred meat colour is bright red or cherry red or pinkish to bright red. Consumers or importers may reject meat where the colour is skewed from normal. This review revealed that no single production factor causes dark cutting, but that a combination of factors lead to its occurrence. Dark cutting is a dynamic condition that can be handled by rigorous improved animal management, create awareness and formulate regulation relate.

Keywords: Carcass, dark cutting, meat, livestock, pre-slaughter

Fast Screening Method for Food Loss Assessment to Stimulate Adoption of Loss-Reducing Interventions

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Notwithstanding the high awareness of food loss and waste (FLW) and the significant number of methodologies for monitoring FLW, the number of practical databases is still very limited. Furthermore, the benefits of loss-reducing solutions are not always recognized. Such solutions may, in addition to increasing food availability, result in many other co-benefits such as, increasing incomes and reducing climate impact on food supply. Quantifying FLW is essential for identifying and assessing the potential effectiveness of FLW reducing interventions and system changes. Loss measurement is one of the means used to identify the hotspots to select the most appropriate FLW reducing interventions. However, measuring is time, data and resource intensive, which inhibits the broad implementation of FLW monitoring. Moreover, FLW measuring is often affected by lack of data and systemic faults. Consequently, the extent and impacts of FLW are often poorly understood and potential benefits of interventions are not recognized. To remove the hurdles associated with assessing FLW and simultaneously stimulate practical adoption of FLW-reducing interventions, a fast-screening method has been developed. The overall goal is to have faster implementation of interventions than the traditional approaches which often require substantial resources and time to collect FLW data via direct measurements at multiple stages of the supply chain. A key asset of this protocol is minimizing direct measurements and data collection to the most essential and using secondary information or expert-estimates for missing data. It is intended to boost FLW monitoring by pointing out causes and potential interventions for FLW. The tool is formulated with a supporting protocol that includes questionnaires and data registration tables for each stage. The tool is further complemented with a questionnaire that supports the identification of causes of FLW and suggests potential interventions or system changes and a pragmatic protocol that estimates the climate benefits of the interventions. To test the performance of the tool, a number of case studies on postharvest food losses in Nigeria and Kenya involving the assessment of mid-tech solutions for rice and potato have been conducted. For instance, for rice, manual harvesting (crop left on the field) and threshing (low efficiency compared to systems with mechanisation) were identified as FLW hotspots; practical research showed that in these settings mechanization results in major reductions in FLW. Notwithstanding the machinery energy use-induced GHG emissions, these interventions also result in reduction of GHG emissions per unit food product. In other studies, on potatoes in Kenya and tomato in India, FLW in the postharvest chain are strongly affected by seed variety/ quality and mechanisation in agriculture. Again mechanization, notwithstanding GHG emissions through energy use, results in net GHG emission reductions per unit food at the point of sale. All these interventions have a positive business case. In two cases however, other actors along the value chain profit from reduced losses more than the party who applies the intervention (the farmer or a service provider). New business models and financial arrangements are necessary to ensure parties who incur expenses also benefit.

Keywords: Food loss and waste, quantifying, greenhouse gas emissions, value chain interventions

Vegetable Losses Experienced by Smallholder Farmers in Gauteng Province of South Africa: Preliminary Study Findings

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Postharvest losses are the quantifiable depletion of a given produce during harvest or along the value chain of a postharvest system. The success of smallholder farmer support initiatives relies on the quantities sold to the market; these quantities are heavily influenced by postharvest losses. Overall, postharvest loss reduction has been overlooked as a strategy to improve food security. Therefore, the purpose of the study was to investigate the postharvest losses of vegetables in the Gauteng Province of South Africa. This was done through focus group sessions and a survey questionnaire with open-ended questions, covering five municipalities of the Gauteng Province. It was found that the main vegetables grown were spinach, tomatoes, beetroot, carrots, onion and cabbage. Pre- and postharvest losses were found as contributors affecting the productivity of the farmers. The loss points were at the field (27%), during and after harvest (29%). Up to 55% of losses were incurred during the summer months for cabbage, on average about 40% of onion was lost, followed by spinach (39%), carrots (35%), tomatoes (39%) and the lowest losses were for beetroot (11%). Planting at the wrong season was a contributing factor. Furthermore, in recent years, the farmers had experienced product losses of up to 100% in the field due to extreme heat (Tshwane area), a lack of water, and extreme cold (Midvaal area). Postharvest losses resulted from a lack of storage facilities, limited access to the formal market, and customers not collecting ordered produce. The farmers' suggestions to resolve these challenges included infrastructure support such as borehole drilling, cooling facilities and net houses. Field losses and postharvest losses are still a major challenge and there is a need for strategies that can bring resilience to climatic variations and preserve product quality during and after harvest as these are major limitations for farmers' acquisition of relatively high returns.

Keywords: Gauteng Province, postharvest losses, smallholder farmers, vegetables

Physical Quality of Coffee (*Coffea arabica* L.) as Affected by Harvesting Methods and Drying Materials

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Coffee is a stimulant crop with high socio-cultural value and economic significance in Ethiopia. But coffee quality is affected by inappropriate harvesting methods and drying materials. Physical quality problems in coffee are mainly associated with improper postharvest processing and handling practices. Therefore, this study was conducted in 2019-2020 to investigate the effect of harvesting methods and drying materials on the physical quality of coffee beans. The experiment was done considering two factors, harvesting methods and drying materials. These were laid out in a factorial arrangement in a randomized complete block design with three replications using a landrace coffee variety. The results showed that the interaction of harvesting methods and drying materials were highly significant ($P < 0.01$) for coffee bean size and dried coffee berry weight. The highest number of beans retained above screen were recorded from the interaction of mesh wire (90%) and cemented drying (89%) materials with selective harvesting methods. The highest dried coffee berry weight (69.33 gm) were attained from the interaction of selective harvesting with mesh wire drying materials. The lowest dried coffee berry weight (63.79 gm) was attained from strip harvesting with tin drying materials. Significant ($P < 0.05$) variation for primary defects and length of drying period were recorded. Longer drying periods (41.67 days) were recorded from the interaction of mesh wire drying material with selective harvesting method, and the lowest (20.33 days) was recorded from the interaction of tin drying material with strip harvesting method. The highest percentage of primary defective beans were recorded from the interaction of selective harvesting methods with mesh wire drying materials (15%), and the lowest number were recorded from strip harvesting method with drying on plastic (5%). Therefore, it can be concluded that using the interaction of selective harvesting and drying on mesh wire is better for the optimum physical quality of coffee in the studied area.

Keywords: Coffee, harvesting methods, drying materials, Ethiopia

Postharvest Loss Assessment of Sesame (*Sesamum indicum* L.) Seeds in Ethiopia

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Sesame is an economically important foreign currency-generating crop for Ethiopia. Despite its economic importance, the crop is prone to significant postharvest losses (PHL) and efforts to add value are minimal in Ethiopia. This research aimed to investigate PHLs of sesame seeds in the field and during storage. A survey and load tracking assessment following FAO's '4S' (screening, surveying, sampling, and synthesis) approach were used to estimate the on-farm losses in the East and Horro Guduru Wollega Zones of the Oromia region. For the survey, 382 sesame producers were interviewed. For the load tracking assessment, three categories of farms namely small (<5 ha), medium (5-10 ha) and larger (>10 ha) size were selected at the major postharvest supply chain activities (harvesting, field drying, bundle carrying, threshing/winnowing) to investigate the cause and extent of losses. The survey found that more than 90% of the farmers confirmed that shattering is the major cause of loss. About 95% of the producers conducted field drying without using plastic/canvas sheeting, 90% of them did not use packaging materials during transport of the sesame bundles to threshing sites. Threshing and winnowing were also identified as contributing activity stages for on-farm losses. In comparison to the subjective results of the survey, load tracking results in a more objective result by identifying the cause and measuring the extent of losses. The load tracking indicated that pre-harvest shattering (4.7% loss), field drying (7.1%), bundle carrying/transport (1.6%), and threshing/winnowing (3.5%) are critical on-farm loss points of sesame seeds. An aggregate loss of 17% was recorded. In addition to the on-farm PHL load-tracking assessments, storage losses of five sesame seed varieties stored under ambient conditions in conventional (polypropylene bags) and hermetic storage containers (GrainPro bags, metal silos and Purdue Improved Crop Storage (PICS) bags) for 12 months were measured. A two-factor factorial design (5x4) with three replications was employed with use of repeated measurement analysis. Quantitative losses, the physicochemical properties of the seeds, and the impact of different storage containers on seed damage by the Indian meal moth (*Plodia interpunctella*) were investigated. A significant reduction in thousand seed weight, moisture content, oil content, and germination capacity for all varieties stored in woven polypropylene bags (WPB) was observed. On average, about 9.4% weight loss occurred due to *P. interpunctella* and moisture loss, and additionally 5.7% loss due to webbing by *P. interpunctella* was measured for seeds stored in WPB, a total of 15% loss for seeds in WPB. While only minimum weight loss and webbing occurred for the same parameters in sesame seeds stored in hermetic containers (PICS bags>metal silos>GrainPro bags). This study showed that PHL of sesame can be as high as 32% [17% on-farm + 15% storage] in the Ethiopian supply chains. Such high losses have a significant negative impact on the country's economy. Improved postharvest management practices at the field level and the use of hermetic bags during storage could contribute to a significant reduction in losses of sesame seeds.

Keywords: Load tracking, postharvest loss, *Plodia interpunctella*, sesame, hermetic storage containers

Identification and Assessment of the Causes of Onion (*Allium cepa* L.) Postharvest Losses in Khémisset Region of Morocco

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Onion (*Allium cepa* L.) is one of the most consumed vegetable crops in the world and has significant nutritional proprieties. The semi-perishable characteristic of onion and inappropriate postharvest practices lead to significant losses from the point of harvesting to consumption. The present study aimed to assess and identify the main causes of postharvest losses at every step of the onion distribution chain in Khémisset region of Morocco. A total of 2 wholesalers, 10 retailers and 10 households were surveyed to estimate the quantitative losses of onion bulbs during the selling and consumption period. Symptomatic onion bulbs were transported to the laboratory under controlled conditions to identify each of the causes responsible for such losses. Direct observations were also conducted on the markets to gather existing information about the factors and problems that can contribute to the onion postharvest deterioration. Findings indicated that the percentage of postharvest losses at wholesalers, retailers and households was 17%, 15% and 27 %, respectively. The observed damage was caused mainly by physical injury and disease infection. Averages of 5%, 6% and 7% of losses were recorded because of the *Fusarium* bulb rot disease, while losses of 4%, 2% and 8% were recorded because of neck rot disease, in wholesalers, retailers and households, respectively. Physical damage affected 8% of the onion bulbs observed in households. In fact, *Aspergillus niger* was also identified in this study as a postharvest fungus causing losses in onion crops. Moreover, the market infrastructure was deemed to be inappropriate for sales and distribution of onion and no strategy exists to conserve the bulbs until the time of sales. Therefore, improvements in the onion distribution system and creation of a good storage facility in the wholesale stages remain important topics for minimizing the postharvest losses of onion.

Keywords: Onion, postharvest losses, fungus, Morocco

Stakeholders' Perceptions of Postharvest Losses of Maize in Rwanda: the Main Causes and Potential Solutions

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Maize is a staple crop is grown in all districts of Rwanda. Improvements in postharvest handling techniques could improve grain quality, reduce the scale of postharvest losses that occur and reduce hunger, not only in Rwanda, but also in neighbouring countries. To achieve this, a maize postharvest loss survey was recently replicated in different altitude zones of Rwanda, low altitude (Nyagatare), high altitude (Musanze), mid altitude (Huye) and Kigali Province (Gasabo and Kicukiro). The objectives, developed through consultation between the research team and other stakeholders, were to: 1. identify where losses occur along the maize supply chain; 2. assess causes of the loss; and 3. identify potential solutions for reducing maize postharvest losses in the country. Structured questionnaires with closed and open-ended questions were administered to maize stakeholders in the five purposively selected districts. For qualitative evaluation, maize samples were taken from stores of growers, wholesalers and cooperative aggregations. Growers, wholesalers and processors reported losing significant quantities of maize. About 70% of growers reported losses at harvesting and shelling due to moulds, and insufficient drying causing breakage of grains. About 60% of wholesalers reported losses during storage due to molds, sprouting and insects. This suggests an additional winnowing, sorting and drying at at wholesaler level before selling could support a considerable reduction in quantitative and qualitative maize postharvest losses. About 85% of processors reported losses at storage level due to weight decrease, moulds, sprouting and insects. Total defective, including discoloured, germinated, immature, mouldy, pest damaged, rotten and diseased grains comprised 13.5-30.9% of the grain sample, moisture content was 15-18% and impurities 1-1.7%. Inadequately dried grains favour mould growth and sprouting especially during storage. According to the maize stakeholders interviewed, the main causes of maize losses in Rwanda are mould, breakage and insects which they link to insufficient drying, winnowing and sorting as well as inappropriate infrastructure and materials. Reliance on sun-drying of maize is risky given Rwandan weather patterns, and an improved drying system was viewed as promising potential solution for reducing maize postharvest losses in the country. Research into urgently required interventions such as improved drying systems is of high importance.

Keywords: Maize, postharvest losses, causes, solutions, Rwanda

Assessing Drivers of Postharvest Losses in the Raw Cashew Nut Supply Chain: a Tangible and Intangible Resources Perspective

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Increasing global raw cashew nut (RCN) production began in the 1990's. Stakeholders are concerned about the sustainability of the supply, and the need to address postharvest losses (PHL) occurring in the RCN supply chain. However, the resources available to various supply chain stakeholders to address PHL remain a challenge. The current literature-base on cashew PHLs provides limited detailed insight into the drivers of these PHLs. This study aimed to address this knowledge-gap by systematically identifying and analyzing the critical drivers influencing PHL in the RCN supply chain by studying the contribution of tangible and intangible resources, based on experts' opinions. The nine experts are comprised of academics and managers in the supply chain, non-governmental organizations (NGOs), government agencies and supplier enterprises who are directly involved in the production and processing of RCN. Each expert had no less than 10 years of experience. Through the initial review of the extant literature, the study identified five drivers related to tangible resources. They include, lack of appropriate storage facilities, lack/insufficient use of proper packaging materials, lack/insufficient drying technologies and materials, lack of availability/proximity to the marketplace, and drivers related to financial and economic constraints of supply chain members. Similarly, seven drivers were identified related to intangible resources that include, premature harvesting of RCN, inadequate knowledge about postharvest technologies, improper handling of RCN and detaching fruit, lack of information dissemination on PHL within RCN suppliers, insufficient/lack of management support and commitment, lack/inadequate partnership among industry players, intermediaries, and NGOs, and lack/insufficient commitment and trust among cashew suppliers/enterprise and industry actors'. The Fuzzy-Decision Making Trial and Evaluation Laboratory (Fuzzy-DEMATEL) methodology was employed to analyze and convert experts' judgment into quantifiable data to establish the causal relationship among the drivers. The method has the ability to distinguish the contextual relationship among the drivers into cause and effect groups to explicitly construct a causal-effect diagram for a clear understanding of the drivers. The findings reveal that for addressing PHL in the RCN supply chain in Ghana, urgent and short-term attention should be given to the primary tangible driver of lack/insufficient proper packaging materials. While medium-term strategies suggest RCN suppliers, government agencies in-charge of agriculture and industry bodies, need to surmount three key cause drivers, consisting of i) premature/green harvesting of cashew nuts, ii) financial and economic constraints of the various actors in the supply chain, and iii) lack of appropriate storage facilities. Additionally, drivers such as the insufficient/lack of management support and commitment, and lack of information dissemination on PHL within RCN suppliers should be addressed in the long term. The study provides a framework for supply chain managers and policymakers to understand the interrelationship among PHL drivers from a resource perspective to enable the implementation of strategies that address PHL. However, it is limited to the data input of experts from Ghana, which may not reflect what pertains in other cashew growing countries or regions. Further studies can be conducted in other countries or geographical regions and compared.

Keywords: Postharvest loss, supply chain, decision-making trial and evaluation laboratory (DEMATEL), resource

Knowledge and Perceptions on the Importance of Postharvest Handling and Value Addition of African Leafy Vegetables in Western Kenya

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Increasing awareness of the role of African Leafy Vegetables (ALVs) in human health, their climate smart attributes and economic value has led to efforts to understand communities' knowledge levels and perceptions on the importance of postharvest quality and value addition of ALVs. ALVs have high nutritional value, forming a potent weapon against the pressing hidden hunger problem in Kenya, but they are not yet sufficiently adopted as cash crops by Kenyan small-scale farmers to meet the rising demand for ALVs in the urban areas. This study sought to establish the knowledge levels and perceptions of actors on the importance of retaining quality postharvest and value addition for three ALVs (spider plant, cowpea & African nightshade). A community-based cross-sectional survey together with purposive sampling technique was adopted for this study. The study sites were Kisumu, Siaya, Homa Bay and Busia Counties of Western Kenya. Eight (8) focus group discussions and eight (8) key informant interviews were conducted with ALV farmer groups and those in charge of agricultural extension. Data was audio recorded, transcribed, coded and thematically analyzed using NVIVO 12 PRO software. The value chain actors used poor harvesting techniques, hygiene was poor, and the vegetables were typically contaminated either at the market or during transportation. Gunny bags/sacks were commonly used to pack and store the ALVs, but they also often contained dirt such as soil or dust from previous harvests. Both the gunny bags and the ALVs are washed with water, the source and quality of which is often questionable. The ALVs are aired to remove the field heat and to control the temperature. Despite the community members in the study area receiving training and information from media platforms and extension officers they did not adopt the technologies they were being trained on. Although all respondents involved in ALV production and consumption viewed the crop as an important household food security crop, the majority of them had poor knowledge and incorrect perceptions regarding the importance of retaining quality postharvest and value addition opportunities. This study has highlighted weaknesses and gaps in knowledge related to ALVs particularly the poor harvesting techniques, hygiene and storage and the very limited and poor processing currently occurring of ALVs. It appears that knowledge gaps exist at both the community and extension staff level. These findings demonstrate the need to fill this knowledge gap to ensure that producers and their agricultural extension service providers are well equipped with the scientific and practical knowledge for retaining quality postharvest and investing in value addition opportunities for ALVs, as well as the consequences associated with the lack of this knowledge.

Keywords: ALVs, postharvest, value addition, knowledge, perceptions

Causes of Postharvest Losses in Avocado Fruits, and Identification of Associated Fungal Pathogens in Hossana Town Market of Ethiopia

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The poor postharvest handling of avocado contributes in part to postharvest decay of the avocado fruits and loss in quality along the value chain. Postharvest diseases derived from biotic sources such as microbial pathogens, or abiotic sources such as those derived from physiological disorders contribute to the short postharvest life of the avocados. The aim of this study was to assess causes of postharvest losses and identify postharvest pathogens associated with decay of avocado fruits in Hossana town market, in the Southern Nations, Nationalities and People's Regional State of Ethiopia. A survey on the causes of postharvest loss of avocado in 14 shops as well as the market in Hossana town was done. Identification of the disease-causing pathogens was conducted in the pathology laboratory of Wachemo University College of Agricultural Science. Avocado fruit with different damage and disease symptoms were collected from 14 shops and the market. Sample fruits were transported to the laboratory and identification of pathogens was done through incubation of samples taken from different parts of the fruit on potato dextrose agar (PDA) for seven days. After isolation of a pure colony, morphological identification of the disease-causing pathogen was carried out. Data was analysed using SPSS statistical software. Results from the survey revealed that postharvest loss of avocado varies across different postharvest handling stages and the highest loss was recorded during storage (40%) followed by harvesting (26.7%). The most mechanical damage was observed in avocado from the Mesalemia shop (100%) followed by the Hossana market (83.3%). This may be due to poor harvesting practices and unsuitable field or marketing containers and crates, which may have fractured wood, sharp edges, poor nailing or stapling. Disease incidence assessment showed that in three shops (Adebabay 2, Meneharia 2 and Mesalemia) 100% of fruits were infected. The highest disease severity index rated as 5 (>75%) was observed from the samples taken from three shops (Adebabay 2, Meneharia 2 and Mesalemia) and Hossana market followed by fruits with a disease severity index rated as 4 (51-75%) from three other shops (Adebabay 3, Gombora 3 and Naramo). The laboratory findings indicated that a total of 82 fungal colony growths were observed from fourteen (14) shops and the market in Hossana city. *Colletotrichum gloeosporioides* was the most frequently isolated species (60 percent) followed by *Fusarium* spp. (26.67 percent). Anthracnose caused by *Colletotrichum gloeosporioides* is the most devastating disease which affects the avocado fruits while in the field as well as after harvest. These results highlight the need for training of stakeholder on and implementation of appropriate postharvest handling practices and technologies from farm through to fork stages to reduce the high postharvest loss of avocado fruits.

Keywords: Avocado, postharvest loss, postharvest fungal pathogens, identification, isolation

Extent of and Causes of Cowpea Grain Postharvest Losses under Smallholder Farmers' Management in Benin

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Cowpea is an important source of dietary protein for millions of people across Sub-Saharan Africa. However, postharvest losses of cowpea are perceived to be high, reducing the quantity and quality of food available. This study explored the extent and causes of smallholder farmers' cowpea losses in Benin during the different postharvest stages. A structured questionnaire was used to collect qualitative information on 120 farming households' cowpea postharvest systems, measured loss assessment was conducted with 60 of these households who farmed at least 1 ha of land, and storage losses measured bi-monthly during an 8-month period with 48 of these households. Six main varieties of cowpea were cultivated, due primarily to their yield, coat colour, early maturity and resistance to disease characteristics. In all four of the focal agro-ecological zones, cowpea postharvest activities were undertaken using traditional practices and rudimentary equipment. Most cowpea postharvest activities are conducted mainly by women and children, while storage of cowpea grain is under the control of men (52%) and women (48%). The measured loss assessment with 60 households found the mean cumulative postharvest quantity losses from harvesting through to store loading was $11.29 \pm 0.88\%$. Within these postharvest activity stages, farmers experienced the most losses during: harvesting ($3.89 \pm 0.36\%$), drying of the pods ($2.05 \pm 0.11\%$) and threshing ($3.71 \pm 0.76\%$). The farmers reported that the main causes of cowpea losses during the different postharvest stages are: rainfall during harvesting and late harvest due to lack of labour; rainfall and cowpea consumption by animals during drying; inadequate threshing method; lack of labour and drudgery during sorting; infestation by insects and rotting during storage. The main cowpea storage practices used were cowpea grains stored in polypropylene (PP) bags and left untreated (25% of respondents), followed by grain storage in plastic or metal drums, or PP bags plus treatment with a synthetic chemical pesticide dust, a fumigant, dried chilli, or leaving the grain untreated. All 48 households where samples were taken during storage, stored their cowpea for at least 6 months and some for up to 8 months. Mean number of insect damaged grains increased from 3.6% at beginning of storage to 9.4% and 13.3% by 6 and 8 months of storage, respectively. Mean percentage grain weight loss due to insect-damage increased from 1.0% at beginning of storage to 1.5% and 2.3% by 6 and 8 months of storage, respectively. Grain protection differed between households, use of chemical protectants or fumigants, such as Sofagrain, Actellic Super dust or Phostoxin, resulted in lower storage losses than chilli pepper or grain left untreated. Prior to consumption households sorted the grains, removing and either discarding or feeding to livestock the insect damaged or shriveled black immature grains. This led to a mean weight of grain requiring removal of $6.63 \pm 5.72\%$; $12.01 \pm 7.17\%$ and $14.92 \pm 8.42\%$ at 0, 6 and 8 months' storage, respectively. The study highlighted the urgent need for participatory on-farm research to support farmers in reducing the significant cowpea losses occurring during harvesting, drying, threshing and storage.

Keywords: Cowpea, grain storage loss assessment, farmers practices, losses, grain quality

SUBTHEME 2

SAVING AFRICA'S HARVEST DURING AND POST COVID-19 PANDEMIC: LESSONS LEARNT, OPPORTUNITIES TO STRATEGIZE FOR FUTURE NATURAL DISASTERS AND PANDEMICS

2021

3RD ALL AFRICA POSTHARVEST CONGRESS & EXHIBITION, BOOK OF ABSTRACTS

Theme: Postharvest Loss Reduction for Sustainable Food Systems



The impact of COVID-19 pandemic lockdown on loss of tomato (*Lycopersicon lycopersicum*) fruit in Southwestern Nigeria

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The outbreak of Covid-19 pandemic hampered food security due to the movement restrictions across most countries of the world. In Nigeria, full lockdown was in session between late March and early July 2020 which is the onset of raining season in the south, and increased the demand of tomato fruit from the northern part of the country. Tomato among other vegetable fruits is indispensable as it is consumed on a daily basis due to its full nutrition potential and numerous use as sauce, salad, puree and so on. The study examined the effects of the pandemic lockdown on postharvest loss of tomato fruit along the value chain in southwestern Nigeria and propose likely ways to avert similar occurrence in the future. To achieve this, highlights on the estimated loss was evaluated at each chain between April and June 2020. The assessment was conducted using questionnaires administered via google form and phone interviews to minimize close contacts with the respondents. In this evaluation, 168 respondents were interviewed across the six states in southwest Nigeria. The results showed that tomato value chain was grossly affected during the pandemic lockdown. Average of 46.7% loss were estimated from farmers, while 23.6% and 25% were estimated from retailers and wholesalers, respectively. Consumers estimated 3% less of tomato fruits purchased which was due to high price and high demand limiting their purchasing power despite the urge to embark on panic buying prior and during the pandemic lockdown. Farmers with irrigated farms reported that the primary/major cause of loss emanated from bumper harvest during the lockdown (48.1%); followed by their inability to get a movement pass (25.8%) while estimation of 26.1% loss was due to harvest of immature fruits to meet market periods, while farmers who plant only on-season lost tomato seedlings/plants on nursery beds/fields due to restrictions and inability to get movement pass and fear of disease transmission. Retailers estimated highest (34%) postharvest loss to conveying method of produce. Wholesalers estimated highest (47.4%) loss due to lack of storage facilities followed by 23.4% loss due to irregular market days. In summary, actors along the tomato value chain recommend capacity building on managing postharvest losses through smart agriculture, effective packaging material, efficient handling, storage and processing; and achievable government policy on road network, price regulation, effective linkage between producers and institutions among others. Therefore, this study would assist the government and other agricultural related bodies to rise to the call.

Keywords: Covid-19, food security, tomato, value chain, Nigeria

Post-harvest handling of Smoked dried fish against insect pest and strategies during and post COVID-19 Pandemic in Africa: A Review

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Post-harvest losses (PHL) in smoked dried fish lead to reduction in quantity, quality, or monetary value in the supply chain. Losses typically represents a major food security concern in Africa. No phenomenon has quickly and radically altered household production parameters and daily food patterns in the in the World as the onset of the COVID-19 pandemic. Post-harvest smoked fish loss for the global fisheries sector amounted to 35%, between 9 and 15% of these losses occurred along the value chain. In sub-Saharan African countries, 15% of total losses occurred during post-harvest operations (storage), 24% during processing operations, 40% during distribution and 5% during consumption at household level. Soon after the national emergency declaration, key inputs into household production shifted extraordinarily, consumer spending decline by more than 30%, and employment rates and earnings among low-income class declined by more than 35%. Smoked dried fish is an important source of food and income to many people in the developing world. In Africa the populace depends wholly or partially on the fisheries sector. Each stage of the chain is susceptible to being disrupted or stopped by impacts arising from COVID-19 and related measures. Reduction in domestic demand and widespread containment measures affects both a nation's imports and reduces foreign income, with significant consequences on a sector highly dependent on international trade, financial distress in businesses leads to a reduction in wages, working hours and labour layoffs. As the financial sector is in difficulty, it has fewer resources to sustain the economic losses incurred. In addition, many insurers do not cover business interruptions due to events such as the COVID-19 disease. The sustainable availability of this is hampered by insects and arthropod pests, major pests on smoked dried fish include *Dermestes maculates*, *Necrobia rufipes*, *Calliphora vicina*, *Lucillia* and *Musca ssp.*, *Lasioderma serricorne*, *Lardoglyphus konoi*, *Suidasia medamensis* and *Tyrophagus spp.*, and flesh flies (*Sarcophagidae*) that affects production, marketing and its availability. Food security involves food availability, accessibility, sustainability, and utilization to ensure people have access to the basic food. Careful methods that will minimize post-harvest spoilage, reduce losses and improve the quality of the smoked dried fish through better processing, storage, packaging and transportation, which would be achieved through adequate hygienic practices are among the suggestions proffered.

Keywords: Post-harvest, COVID-19 Pandemic, smoked dried fish, insect pest, Food security

Impact of covid-19 on input/output markets and implication for postharvest management in Niger

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In Niger, agricultural activities constitute the main source of income for more than 90% of the population. Agricultural production is low and is affected by many biotic and abiotic constraints. The advent of the Coronavirus disease (COVID-19) pandemic and its restrictions disrupted agricultural value chains and input supply chains which affected crop production and postharvest handling and storage. In order to assess the impact of COVID-19 on agriculture, we interviewed 636 farmers in October 2020 in Maradi and Zinder regions of Niger. All respondents were aware of the COVID-19 pandemic. Almost three quarters (72.9%) of farmers were sensitized on COVID-19 restrictions. Despite a national lockdown mandate, only 4.4% of respondents had their field activities affected and 2.4% had difficulties recruiting labour for crop production. About 22.5% of farmers reported having difficulties accessing input such as seeds, fertilizers, and hermetic grain storage bags. The COVID-19 pandemic significantly disrupted postharvest activities with about two thirds (66.9%) of respondents reporting limited access to threshing services and grain storage technologies. In terms of output markets, COVID-19 restrictions affected about half of the respondents (49.9%) regarding their ability to go to markets and to selling their agricultural products (49.9%). Prolonged lockdowns combined with limited access to threshing services, storage technologies and markets had the potential to lead to more postharvest grain losses. These findings suggest that restrictions on mobility due to a health crisis such COVID-19 can exacerbate postharvest losses. Efforts should be made to put measures in place that would improve the availability of inputs and services and access to markets during a health crisis to increase the resilience of smallholder farmers and improve their food security. These efforts could include making agricultural activities essential services and using digital technologies to link and facilitate trade among the key players in the value chains.

Keywords: Covid-19 restrictions, agricultural productivity, postharvest, lockdown

Postharvest Markets and Access to Information under COVID-19 in Zimbabwe

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African agricultural policy makers were caught off-guard by COVID-19 because they have not been used to responding to shocks that come from non-agricultural avenues like health. They have been used to responding to droughts, floods, fall army worm and several types of diseases. Like many African countries, Zimbabwe is an agro-based economy and any shocks to the agriculture sector affect economic performance, livelihoods, employment creation and income of more than 70% of the population. The main actors in the agricultural food sector are farmers, traders, and vendors. The majority of these earn their income and livelihoods from trading in mass markets where more than 80% of the commodities are traded. Following the outbreak of the COVID-19 pandemic, the author conducted a study around Zimbabwe's markets and food production zones to try and answer the following questions, among others: (i) To what extent have mass markets, as post-harvest hubs, been affected and trying to cope with COVID-19 from an economic, food supply and nutrition perspective? and (ii) To what extent has COVID-19 provided an opportunity to introduce better data and information collection systems towards informing decision-making from farmers to policy level in order to prepare for future disasters? Qualitative and quantitative methods were used to collect data including use of digital tools like mobile phones and radio from eight food markets and 12 production regions across the country. Among other results, the study showed how COVID-19 emergencies have introduced social distancing measures, that are often not applicable in ecosystems of mass food markets because they are often congested. More than 80% of post-harvest activities are in the hands of the mass market comprising traders, vendors, transporters, and other actors. The closure of these markets has not been a viable option because it risked denying food to the majority of urban population and hinder the livelihood of farmers and vendors with no other opportunities for income diversification. While there has been an increase in post-harvest losses, mainly of perishables, communities have resorted to indigenous knowledge of processing and preserving food. The study also revealed how mobile communication has become a big investment for most organizations which have been forbidden from organizing face to face workshops.

Keywords: Mass market; traders; vendors; post-harvest hubs; social distancing measures; food and nutrition security nexus

Safeguarding food and seed assets in Sierra Leone during the Ebola crisis- Lessons for COVID-19

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In 2014, Ebola escalated throughout Sierra Leone during the main crop growing season. Internal local markets, which routinely provide farmers with both food and seed, were officially banned. National lockdowns and travel restrictions meant that access to markets (local and international) was cut off completely. Field assessments at multiple sites, showed that harvests for key crops such as rice, maize, and groundnut were relatively good (with a few exceptions). While much of the humanitarian community was focused on bringing emergency aid into the country, a novel development effort spearheaded ways to help farmers safeguard their own harvested grain and seed assets. Catholic Relief Services; Purdue University; the Ministry of Agriculture, Forestry and Food Security; Caritas Kenema; the Sierra Leone Agricultural Research Institute (SLARI); CORDAID; and SEND partnered in introducing and disseminating the Purdue Improved Crop Storage bags (PICS) technology to farmers. Hermetic bags (PICS) empowered farmers to preserve seed and grain quality (against pests – insects, rodents, etc.) during the lockdown. Farmers had the flexibility to wait until markets were opened and prices were attractive to sell their commodities. Several strategies were used to build awareness and disseminate the PICS technology while minimizing the spread of the disease. The training of trainers was organized remotely via skype. Trained extension agents then conducted demonstrations in small groups (20 farmers or less) in many repeated decentralized district meetings. Radio talk shows/adverts/jingles, training posters, and short message services (sms) were used to build awareness among farmers and other value chain actors (seed producers, grain traders, consumers, etc.). Two cellphone videos, produced in English and Krio and disseminated via Bluetooth, served to reinforce training on the use of PICS bags among farmers and other users. The PICS bags were distributed to farmers in different regions with the support of the health teams who were allowed to travel to different parts of the country. Ultimately, 105 extension agents were trained, and 4,600 farmers attended demonstrations (each receiving two PICS bags). Among the farmers who received PICS bags, 2,100 stored rice grain, 1,350 stored rice seed, 125 stored gari, 76 stored maize, 52 stored dried cassava, and 35 stored beans of different varieties. Using media, digital technology, and small meetings helped achieve these results. This effort showed that even during a nation-wide health crisis and lockdown such as with Coronavirus disease (COVID-19), agricultural programs (e.g., postharvest innovation) can be implemented to empower farmers to become more resilient and lay the foundation to launch a technology commercialization. Partnering with unusual collaborators (e.g., health team) and using technology (phone, radio, skype) can help improve agricultural interventions during a health crisis such as COVID-19.

Keywords: nation-wide health crisis, agricultural intervention, postharvest management, storage technology, information and communication technology

COVID-19 pandemic and food losses in Mali

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Postharvest loss (PHL) reduction offers an opportunity to increase food availability while saving valuable inputs required to produce that food. In effect, food loss reduction is a crucial strategy in the fight against food and nutrition insecurity and low income of farmers in Africa. Unfortunately, the current COVID-19 pandemic has exacerbated high food losses. The spread of the virus and the measures implemented to limit infections have posed varying challenges to farmers and the food system. Almost every country in Africa has implemented some type of restrictions on the movement of people and goods. This has resulted in widespread disruptions to agri-food networks at all levels of the food system. These disruptions have affected postharvest management leading to increased losses, increased food prices as well as shortages of some food products. This study focused on four food commodity categories supply chains - cereals, fruits, vegetables, and animal protein to provide a general picture of PHLs in Mali. Within the food commodity categories, key food supply chains were selected for case studies based on their economic importance, contribution to household nutrition and income, and sensitivity to storage. We applied the before and during the COVID-19 pandemic approach using a rapid appraisal methodology to quickly learn from local people about their realities and challenges faced and the estimation of postharvest losses. Results reveal that, the producers in the potato supply chain suffer losses in storage of 15 - 24% during the pandemic crisis in comparison to 10 - 15% during the period before the pandemic. Potato losses in storage were twofold higher in the pandemic crisis (12- 16%) compared to period before the pandemic (4 - 8%) at the wholesaler's level. At the retailer's level, losses were higher during the pandemic crisis (12 - 17%) compared to the period before the pandemic (5 - 7.5%). PHLs in storage for onion/shallot were estimated at more than 21% during the pandemic crisis in contrast to less than 20% losses during the period before the pandemic. At the wholesaler's level, onion losses in storage was two to threefold higher during the pandemic (10 -17%) than in the period before the pandemic crisis (3 - 7%). At the retailer's level, losses of onion were less than 6.5% during the period before the pandemic compared to 11 - 17% during the COVID-19 pandemic crisis. Shallot losses in storage were three to four times higher during the pandemic crisis (10 - 19%) compared to the period before the pandemic (2 - 7%). In the mango supply chain, the delay of transportation caused postharvest losses estimated at 30 - 40% during the pandemic crisis in contrast to 1 - 5% losses usually observed in the period before the pandemic crisis during transport. During the COVID-19 crisis, milk producers estimated PHLs between 0 to 20% compared to zero loss due to spoilage before COVID-19 crisis. Poor postharvest handling and storage practices and poor sale and low market demand resulting from the pandemic containment measures are the principal causes of the postharvest losses.

Keywords: COVID-19, postharvest, food losses, restriction measures, Mali.

The Impact of COVID-19 Pandemic on Crop Postharvest Management and Sustainable Food Systems in Nigeria

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Before the outbreak of Coronavirus disease (COVID-19) in Nigeria, there had been pressing issues on food security and inadequate nutrition recording a stunting rate of about 37% and a wasting rate of 7%. This had resulted in over 32.1 million people being malnourished. National Bureau statistics did a household survey on the impact of Covid-19 and found out that 51% households reduced their food consumption to cope with the pandemic. With the restrictions on movement during this period, food security was greatly affected which brought about a great need to look for measures to manage postharvest losses (PHL) and also to sustain the food systems. This paper reviewed the impact of the COVID-19 pandemic on crop postharvest management in relation to sustainable food systems in Nigeria. White papers written by organizations like the United Nations (UN) and other studies on COVID-19, postharvest losses, and food systems were reviewed. Postharvest losses could have been reduced greatly if, there had been improved postharvest food handling and management practices in areas such as drying, processing, extension, and modification of existing storage structures as well as the introduction of new storage types and food distribution systems. Inclusively, financial reward benefits may be given to farmers who have improved crop quality and practice improved technologies. All this will significantly improve the quality and quantities of food produced by 50% and reduce postharvest losses. To sustain the food systems in Nigeria, support is needed from the federal government, civil society, UN agencies as well as the private sector toward helping the food sector deal with the effects of the pandemic. As a response to that, the federal government launched the mass agricultural programme in May 2020 under the Economic Sustainability Plan. Thus, the implementation of these measures will reduce postharvest losses thereby reducing the negative impact of COVID-19 on food systems in Nigeria.

Keywords: COVID-19 pandemic, crop postharvest management, postharvest losses (PHL), food security, food systems.

Identification and understanding challenges and impacts of COVID-19 pandemic on food loss in Mali and Sierra Leone

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The impacts of food loss and waste (FLW) on the sustainable use of natural resources and the current and future food and nutrition security call for concrete actions to address it at the local, national, and global level, involving all relevant food systems stakeholders from the public and private sectors and civil society. Unfortunately, the COVID-19 pandemic has exacerbated high food losses along the value chain. The spread of the virus and the measures implemented to limit infections have impacted the agricultural sector, adding challenges to farmers. Almost every country in Africa has implemented some type of restrictions on the movement of people and goods. This has resulted in widespread disruptions to agri-food networks at all levels of the value chain, including at the production levels, downstream processing, and logistics, and at the levels of markets for food products and inputs for goods and services. These disruptions have affected the post-harvest management that has led to increased food loss, increased food prices and shortages of some food products. In particular, this has been a big challenge for perishable crops such as fruits, vegetables, dairy, and fish products. Movement restrictions resulted in workers not being able to get to farms for work, leading to a workforce disruption. Direct implications of this workforce shortage include an overall reduced production due to lack of care for crops, fish, livestock; an inability to harvest, process or prepare food products; increased food loss and waste; and in some severe instances, complete closure of farms or production systems. Therefore, there is a need to support farmers and other stakeholders along the value chain to achieve sustainable post-harvest management and reduction of food loss and waste. However, to do so we need to understand the scale of the challenges and suggest evidence-based recommendations. Understanding this situation, FAO and CORAF undertook a stock-taking study in Mali and Sierra Leone to identify and understand the challenges and impacts of the COVID-19 pandemic on food loss especially for smallholder farmers in these two countries in West Africa. The study led to the identification of the key challenges including low demand due to trade disruption as consequences of limited operation or closure of businesses and reduced purchase power of consumers and the logistical challenges leading to high production and postharvest losses and as border closures prevented traders to sell their products to neighbouring countries. Others are an increase in the losses of dairy products due to long curfews combined with poor storage conditions. Recommended solutions on how to address the identified challenges and impacts on food loss were suggested including the provision of evidence-based policy.

Keywords: Food loss, COVID-19 pandemic, challenges, disruptions, policy.

Improved storage mitigates vulnerability to food-supply shocks in smallholder agriculture during the COVID-19 pandemic

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Millions of smallholder farmers in low-income countries are highly vulnerable to food-supply shocks, and reducing this vulnerability remains challenging in view of climatic changes. Restrictions to limit the spread of the Coronavirus disease (COVID-19) pandemic produced a severe supply-side shock in rural areas of Sub-Saharan Africa, including through frictions in agricultural markets. We used a large-scale field experiment to examine the effects of improved on-farm storage (hermetic storage bags) on household food security during COVID-19 restrictions. Based on mobile telephone text message survey data, we found that the prevalence of food insecurity (measured through the reduced Coping Strategies Index, rCSI) increased in control group households during COVID-19 restrictions (coinciding with the agricultural lean season). In the 30 days immediately before the implementation of COVID-19 restrictions, 40.8% of control group households were food insecure. However, within 30 days of COVID-19 restrictions, the prevalence of food insecurity increased significantly by 8 percentage points (or 19.6%) to 48.8%. In contrast, in treatment households, equipped with an improved on-farm storage technology and training in its use, the initial food security shock observed during the COVID-19 pandemic was strongly buffered. The prevalence of food insecurity among treatment households increased only slightly (by 3.7 percentage points) in the 30 days immediately following COVID-19 restrictions. This underscores the benefits of improved on-farm storage for mitigating vulnerability to food-supply shocks. These insights are relevant for the larger, long-term question of climate change adaptation, and also regarding trade-offs between public health protection and food security.

Keywords: Food insecurity, COVID-19, Smallholder farmers, Post-harvest losses, Hermetic storage, RCT

Impact of COVID-19 on postharvest handling and storage of crop and animal products: implications on food and nutrition security in the SADC region

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The study on Southern Africa Development Community (SADC) Coronavirus disease (COVID-19) Regional Food, Nutrition and Livelihood Analysis was commissioned by the World Food Programme (WFP) Regional Vulnerability Assessment and Analysis (RVAA) and SADC. The study was motivated by the need to mitigate the threat of a looming health, food, and nutrition crisis in the SADC region as member states implemented measures to arrest the spread of COVID-19. To reduce the spread of COVID-19 infections, SADC member states instituted lockdown measures of varying dimensions and rigidities that placed restrictions on the movement of people, goods, and services; opening hours for shops and supermarkets; closed informal markets and restricted international travel and trade with considerable negative consequences on postharvest handling, shelf life, nutritional quality and storage of crop and animal products. Intensive, high input, short-cycle production systems such as fruit, vegetable, poultry and pig production, distribution and marketing systems were more severely disrupted by COVID-19 containment measures implemented by SADC governments than less intensive and long-cycle animal and crop production systems. For fresh produce (fruits and vegetable) and intensive livestock systems, in-bound and out-bound supply chains were severely disrupted, including withdrawal of transit hence inaccessibility of inputs and markets. Further, these sectors intensely suffered from COVID-19 induced restricted movements and unavailability of labour, wholesale closure and unavailability of markets, which were worsened by limited availability of storage facilities. In many of the SADC member states, there was evidence of reduced availability and accessibility of all types of foods, including cereals, animal-source foods such as fresh meat, fish, milk and milk products, and perishable horticultural products such as fruits and vegetables to the general population. Significant and extensive fresh produce losses estimated to be worth USD5 million emanating from delayed harvesting and postharvest deterioration occurred in the first 2-3 weeks of hard lockdowns that were instituted in March-April 2020 in SADC member states, with significant negative effects on the livelihoods of large- and small-scale producers and millions of informal vendors and day traders. Reduced access to safe and nutritious foods was reported in South Africa, Mauritius, and Seychelles. As a result, people were relying more on long-shelf-life highly processed foods which are not nutritious. On a positive note, there were reports of a change in food consumption patterns in Namibia, Tanzania and Zambia driven by community perceptions that consumption of fresh fruits (lemons and other vitamin C rich fruits) and vegetables (garlic, ginger) and local indigenous grains, pulses and cucurbits boosted immunity against COVID-19 infection. It is recommended that SADC member states develop policies that ensure that production, harvesting, distribution, marketing and storage of perishable animal and plant products are not severely disrupted during disasters and emergencies such as the COVID-19 outbreak. Partnerships with regional and international development entities to develop and test the concept of Fresh Food Vouchers and cash-based transfers to empower poor and vulnerable rural and urban beneficiaries to continue to access fresh animal and plant products during emergencies in SADC are recommended.

Keywords: Perishable food commodities, plant and animal products, COVID-19 lockdown, postharvest losses, food and nutrition security.

SUBTHEME 3

**INNOVATIVE TECHNOLOGIES, TOOLS, PRACTICES AND
TRAINING/CAPACITY BUILDING TO REDUCE POSTHARVEST
LOSSES IN FOOD SUPPLY CHAINS**

2021

**3RD ALL AFRICA POSTHARVEST CONGRESS &
EXHIBITION, BOOK OF ABSTRACTS**

Theme: Postharvest Loss Reduction for Sustainable Food Systems



Small Scale Postharvest Practices: A Key to Sustainable Food System

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Postharvest loss (PHL) has been a major challenge for both farmers and food processing companies, mostly in developing countries in Africa. PHL not only reduce the quantity of food available but can lead to food insecurity because of the high price of food available and the increasing population. It is estimated that about 1.3 billion tons of food are wasted every year due to various underlying factors and challenges across the food supply chain like poor farm practices, poor storage facilities for this harvested produce and poor infrastructural facilities to aid the movement of this produce to the end-users. In developing countries, it has been estimated that about 40% of food losses occur on the farm during the harvesting and storage process. From the above estimation, it can be said that the cause of food loss and waste in developing countries are connected to financial, managerial, and technical limitations in harvesting techniques, storage, and packaging facilities. This paper review provides a comprehensive study of small scale postharvest techniques in the form of small-scale postharvest practices that can enhance the reduction of postharvest losses across the food supply chain. Small scale postharvest practices which include the use of maturity indices to identify proper harvesting time, improved container to protect crops from damage during transport and the use of best on-farm storage practices like the hermetically sealable bags, metal silo and modern store with regulated temperature are easy to try and succeed. This study shows that lower postharvest loss is obtainable with the right postharvest practices.

Keywords: Postharvest loss, Developing countries, Innovative technologies, Small-scale practices, Food supply.

Physicochemical Attributes, Phytochemical Properties and Antioxidant Capacity of Dried Pomegranate (*Punica granatum*) Arils as Affected by Cultivar

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A comparative study of the physicochemical attributes, phytochemical properties and antioxidant capacity of dried arils from three pomegranate cultivars (Acco, Herskawitz and Wonderful) was conducted. The hot-air drying experiment was carried out at 60 °C, 19.6 % relative humidity and at air velocity of 1.0 m s⁻¹. Dried pomegranate arils of each cultivar were assessed for colour, total soluble solids (TSS), titratable acidity (TA), pH, total phenolic content (TPC) and total anthocyanin content (TAC). The antioxidant capacity of dried arils was evaluated through radical scavenging activity (RSA) and ferric reducing ability power (FRAP) assays. The results showed that desirable quality attributes and functional properties of the investigated dried pomegranate arils were cultivar dependent. The TSS, TA and pH were in the range of 16.3 – 21.0 °Brix, 1.23 – 1.50 (% citric acid) and 3.36 – 3.85, respectively. 'Wonderful' had the highest TPC (113.0 mg GAE/ g), which was 7.4 % and 10.4 % higher than 'Acco' and 'Herskawitz', respectively. However, the TAC was not significantly ($p > 0.05$) different amongst the cultivars ('Wonderful' (23.9 mg C3gE/g), 'Herskawitz' (20.8 mg C3gE/g), and 'Acco' (20.1 mg C3gE/g)). All investigated cultivars had high antioxidant capacity with dried arils from 'Acco' having 28 % more RSA than the other cultivars and the highest FRAP in 'Wonderful' and 'Herskawitz' cultivars.

Keywords: Cultivar, dried arils, total soluble solids, colour, anthocyanin, antioxidant capacity

Enhancing the Shelf-Life of Fresh Cassava Roots: A Field Evaluation of Simple Storage Bags

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Postharvest physiological deterioration (PPD) of fresh cassava roots limits their shelf-life to about 48 hours. There is a demand for simple, cheap, and logistically feasible solutions for extending the shelf-life of fresh cassava roots at various processing scales. This study tested a novel and simple approach using fresh cassava placed in different storage bags after harvest. Issues considered during testing includes: bag material, in-bag wetting, harvest damage, peduncle retention, PPD and starch loss during storage. We report on the initial findings and their potential implications for adopting the bag storage approach to reduce postharvest losses. We also reported evidence on the relationship between carbon dioxide and shelf-life. Carbon dioxide concentration in the stores was significantly correlated with the starch loss in fresh cassava roots and is proposed as a possible method for continuously and remotely monitoring starch loss in large-scale commercial operations and reducing postharvest losses. Further research and development in configuring cassava bags to gari production practices are ongoing in Nigeria, including recording current gari-making practices, optimising bag size, pilot trials and demonstration, and measuring the benefits of cassava bags. This work will help support the further market entry and commercialisation of cassava storage bags in major cassava producing countries.

Keywords: cassava; storage; PPD; starch; shelf-life; postharvest losses

Drying Behavior of Anchote (*Coccinia Abyssinica* (Lam.) Cogn.) Tuber Slices as Affected by Pre-drying Treatments and Drying Temperature

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Anchote (*Coccinia Abyssinica* (Lam.) Cogn.) is a potentially productive and nutritious tuberous crop endemic in Ethiopia; and its utilization is yet traditional. Due to its productivity and nutritional advantage processing the crop could be important. This study was carried out to evaluate the effect of pre-drying treatment (blanching and boiling) and drying temperature (55, 60, 65 and 70 °C) on the drying behavior of anchote (*Coccinia Abyssinica* (Lam.) Cogn.) tuber slices. The drying characteristic of the samples was examined by scheming moisture loss during drying process as a function of time. Ten selected thin layer drying models used for agricultural products were fitted to assess the suitability of the models to describe the drying process of anchote tuber. The parameters: Correlation coefficient (R^2), chi-square, and root mean squared error values were used to evaluate the goodness of fit of each model for anchote slices. Effective moisture diffusivity ($Deff$) was determined by plotting $\ln MR$ (Moisture Ratio) against drying time; and Energy of activation (Ea) for the moisture diffusion was estimated from the plot of $\ln Deff$ against inverse absolute temperature (T^{-1}). All the samples showed similar trends in the rate of moisture losses at the respective drying temperatures; and the drying process exhibited nearly a single falling rate. Among the tested models, Page model was the most suitable model to fit the drying kinetics of the entire tuber samples. The MR predicted by the Page model showed high similarity with experimentally determined MR, with R^2 ranging between 0.9934 and 0.9999 for all the treatments. The values of $Deff$ for all the samples were ranged in 3.7×10^{-8} to $1.3 \times 10^{-7} \text{ m}^2/\text{s}$. The Ea for the raw, blanched and boiled anchote slices were found to be 56.3, 63.6 and 86.1 kJ/mol, respectively. The energy needed to initiate drying process increased by pre-treatments (blanching and boiling) anchote slices. Drying the raw slices is better for faster drying rate and more energy efficiency compared to the pre-treated slices.

Keywords: Activation energy; Anchote; Drying kinetics; Effective moisture diffusivity; Pre-drying treatment

Effect of Pre-treatment and Drying Temperature on Physicochemical and Functional Properties of Anchote (*Coccinia abyssinica* (Lam.) Cogn.) Tuber Flour

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The transformation of agricultural outputs into semi-processed and processed food materials is one of the current scientific demands. There might be changes in original property and composition of the product during processing. As part of this concern, physicochemical and functional properties of raw and pre-treated (blanched and boiled) anchote (*Coccinia abyssinica* (Lam.) Cogn.) tuber flours prepared by drying at different temperatures (60, 80, 100 °C) were evaluated. A factorial experiment in a completely randomized design was employed to run the experiment. Ranges of the results for pH, total soluble solids (TSS), water absorption capacity (WAC), oil absorption capacity (OAC), water absorption index (WAI), water solubility index (WSI), swelling power (SP), foaming capacity (FC), and foam stability (FS) were 5.70-6.47, 5.37-10.8 °Brix, 2.42-4.21 g/g, 0.94-1.44 g/g, 3.40-5.42 g/g, 11.40-20.37%, 4.56-7.20 g/g, 3.31-33.33%, 1.89-20.00%, respectively. The results showed that both pre-treatment and drying temperature significantly ($p < 0.05$) affected these parameters of the flours. The flour obtained from boiled anchote dried at lower temperature exhibited better functional property relative to the raw. This value-added product could be preferably used as an ingredient in different food formulations.

Keywords: Anchote flour; Drying temperature; Functional properties; Physicochemical properties; Pre-treatment

Farmer2Consumer ICT4ag integrated application

Andrew Egala

C.E.O Green Without Borders

ICT solutions are being used to communicate relevant knowledge to rural farmers and provide a cost-effective way to facilitate access to markets, (<https://www.engineeringforchange.org/research/trend-analysis-post-harvest-ict-solutions-east-africa/>). Farmer2Consumer (F2C) is a mobile and web-based application that integrated ICT4ag bundled services end-to-end solutions from producers, processing, trade till consumption. F2C meets the needs of farmers/producers and value chain actors by ensuring better access to information, better access to extension services, better market links, distribution networks and better access to finance creating efficiency in value chains thus reducing postharvest losses. F2C technology platform reaches out to both sector/value chain specific audiences and masses tailored according to localized information that meets farmers/ producers and other value chain actors needs for adoption and adapting, leading to optimum usage and acceptance for effective strategy to mitigate postharvest losses. F2C fills the gap of limited availability of the extension services by communicating, sharing reliable, effective and seamless information service through short messaging service (SMS), and different formats (text, audio, video) via email, social media and web-based banners and posters. F2C business support component in collaboration with stakeholders offers technical capacity building, training of knowledge and strategies in postharvest management along various value chains. F2C Data-driven ecosystem enables predictive supply and demand analytics interplay while technology eliminates abnormal price fluctuations. This enables logistics actors' channel to produce commodities at pre-determined rates, expected quality and quantity, ensuring ease of trade eliminating absolute pricing that would have rendered huge and quality deterioration leading to postharvest losses at farm and markets. F2C in-depth information system data analytics, interpretation of input data at beginning season acts as an early monitoring toolkit, reliable planning model for pre-order linkages to markets, mitigating and reducing postharvest losses to minimum. F2C technology is an informative communicative, educative platform, one-stop resource base to academia, researchers and policymakers for decision making using historical data, trends for monitoring, enhancing and allocating resources for postharvest management. Our single data-driven management system, minimizes duplication ensuring consistency, addresses a variety of requirements, customization to ensure seamless user experience, ensuring timely cost-effective management of postharvest by stakeholders. F2C platform is user friendly available on Google play, farmer can log in details, value chain actors and stakeholders can also input data on behalf of producer groups.

Keywords: Data, Model, Postharvest, Toolkit, Value chain

Innovative postharvest management practices in small grains value chains in the drylands

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Food security among smallholder farmers in dryland farming systems remains a challenge due to low productivity as a result of inadequate rainfall and as such the drylands in Zimbabwe are usually a net importer of cereals. This is compounded by postharvest losses experienced along the value chains, which can be as high as 50–60% in cereals particularly during the storage stage. Reducing and preventing losses is the most efficient and practicable approach to ensuring increased food availability to what will have been harvested by the farmers. Limited efforts have been done to understand losses for dryland communities and assess the current pre- and postharvest losses particularly for sorghum, which are environmentally compatible with semi-arid areas and a staple for some households. The objectives of the study were (i) to find out the different storage technologies of sorghum in Zimbabwe; (ii) to quantify postharvest losses; (iii) to identify the determinants of losses; and (iv) to make policy recommendations for reducing postharvest losses. This study uses literature review, data from key informant interviews, cross sectional interview of 140 households in Matobo and community focus group discussions of farmers residing in the drylands. The findings showed that losses range from 20 to 40% depending on control of birds, time of harvesting, drying and processing method and the storage used. The Tobit model revealed that the most significant determinants of levels of postharvest losses for sorghum were education, storage type and membership to groups. The study therefore recommends training in postharvest loss management including improved technologies, linkages to shelling machinery as well as breeding for bird resistance.

Keywords: Dryland Farming Systems, Sorghum, Postharvest Losses, Zimbabwe

Potential Socio-Economic Impact of Replacing Traditional Woven Baskets with Reusable Plastic Crates on Livelihoods of Basket Makers in Southeast Nigeria

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The study assessed the potential socio-economic impact of replacing traditional woven baskets with reusable plastic crates (RPCs), for fresh tomatoes transportation, on the livelihoods of basket makers in southeast Nigeria. Primary data were collected using structured questionnaires, key informant interviews and observation. Overall, 430 basket makers were drawn from 16 basket production villages in Anambra, Imo, Ebonyi and Enugu states of the southeast. Results indicated that 45.2%, 29.7%, 3.3% and 100% of the respondents were men in Anambra, Imo, Ebonyi and Enugu states respectively. The age of respondents ranged between 14 and 73 years with a mean between 31-40 years. The majority (87.5%) of the basket makers had one form of formal education or the other, primary (28%), secondary school (52%) and tertiary (6.4%) education. The primary source of income of the majority (90.6%) of the respondents was basket making, with other sources of income being mostly trading (21.3%) and farming (18.6%). The income of most (28.9%) of the respondents was between N11,000 and N20,000 followed closely by 24.1% earning between N6,000 - N10,000 and 36.4% earning above N20,000. As many as 76.7% were willing to diversify into other businesses, particularly, trading (37.3%), provision selling (16%) and skilled work (10.6%). The major challenges identified in diversifying were the shortage of capital (96.3%) and lack of prerequisite skills (3.7%). These challenges could be resolved by government intervention (47.8%), and provision of financial aid, (39.2%), new jobs (2.2%) and loans (3.2%). Alternative income-generating activities included opening a provision store, food selling, rearing of animal/animal husbandry, trading in automobile spare parts, fruit selling, meat selling, bakery and confectionaries. Perceived impacts of replacing traditional baskets with RPCs were joblessness, increased poverty level, crime and prostitution, rural-urban drift and dwindling national economy.

Keywords: Socio-economic impact, socio-economic characteristics, basket makers, livelihood activities, reusable plastic crates

Effects of Hermetic Storage on the α -Amylase Content and Antioxidant Activity of SRW Wheat

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Wheat is the third most consumed staple food in the world with a need for cost-effective and sustainable storage techniques having minimal energy requirements. Hermetic storage of wheat grains offers a suitable approach to meet these concerns especially for regions with an intermittent supply of electricity. On another note, hermetic storage has been observed to ensure the conservation of the compositional and functional profile of stored grains. In this study, Agmax 438, Agmax 485 and Truman varieties of soft red winter (SRW) wheat were stored hermetically and conventionally at 10 °C for three months and their α -amylase content and antioxidant potentials were measured thereafter. The study was conducted in a walk-in parameter control chamber (PGC, North Carolina, USA) set to 10 °C and maintained through the period of study, with the samples of 200 g in sealed 6 x 9 inches hermetic bags (GrainPro, Washington, USA) in triplicates, and the conventional samples of 30 g in 50 mL screw-capped centrifuge tubes fitted with a nylon filter membrane at the top for gaseous exchange. Samples were withdrawn at the beginning and end of the storage duration and the analyses were performed to evaluate the target characteristics. Results obtained showed higher significant changes in the conventional storage with a decrease in the α -amylase content and an increase in the antioxidant profile during storage. The investigation showed stronger conservation of wheat constituents for the hermetic storage relative to the conventional storage.

Keywords: Hermetic storage, soft red winter wheat, α -amylase, antioxidant

Reduction of postharvest losses of African indigenous vegetables using low cost storage technologies: Ethiopian mustard & Spider plant

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Postharvest losses of fresh fruits and vegetables are estimated to be around 40% in Africa, out of which there are some under-utilized crops often referred to as African indigenous vegetables (AIVs) such as Ethiopian mustard (*Brassica carinata* A. Braun) and spider plant (*Cleome gynandra*). These AIVs are produced by local households and sold at local markets. However, the current postharvest handling and storage conditions practiced by the producers lead to losses as these produce has a short shelf life. Thus, a study was carried to determine the shelf life of several cultivars of these two types of fresh African indigenous vegetables (AIVs) stored under different storage conditions. Low-cost storage technologies were used to store the AIVs for seven (7) days. These include: Zero Energy Cooler (ZEC), Shadebot (under the shade) and open sunlight as the control with the following corresponding mean storage temperatures over a five-day period $25.6 \pm 3.1^\circ\text{C}$, $29.5 \pm 0.6^\circ\text{C}$ and $31.4 \pm 1.1^\circ\text{C}$, respectively. The AIVs were observed for visual changes such as loss of turgidity, and colour changes as well as the amount of vitamin C content, as a measure of the rate of deterioration under these storage conditions. The AIV samples were analysed for vitamin C content on a daily basis for the whole period of storage by the indophenol titration method. Results revealed that the AIVs stored under Zero Energy Cooler had the lowest rate of vitamin C degradation at 28.5% after five days of storage compared to 95.7% and 98.4% for the Shadebot and open sunlight over same period, respectively. The visual observation showed that the AIVs stored under ZEC had the longest shelf life of five days while those stored under Shadebot had two days and half a day under open sunlight storage before the leaves of the respective AIVs were discoloured and wilted. The AIVs stored under ZEC retained their green colour and turgor for the entire 5-day period. This study demonstrates a low-cost practical solution to postharvest losses of vegetables which can easily be implemented to reduce food waste and increase incomes for small scale producers and traders who are mostly women and youth.

Keywords: Shadebot, Zero Energy Cooler, vitamin C, postharvest, food losses, vegetables

Impact of Adoption of Hermetic Storage Systems on Rural Households' Welfare: Evidence from Mali

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Food insecurity and hunger are of great concern in the Sahelian region of West Africa. Thus, reducing food wastage postharvest, especially during storage is vital. Hermetic Storage systems (HSBs) are designed to reduce/eliminate pest attacks on stored grains. The adoption of HSBs is expected to improve households' welfare through a reduction in crop losses, increase in food availability, and households' income through sales of quality produce. Using a household survey collected on a sample of 2240 households from rural Mali, we estimated the impact of the adoption of HSBs on households' welfare. Using the Propensity Score Matching (PSM) and Heckman Selection Model (HSM) we controlled for the selection biases due to observable and unobservable characteristics of the households, respectively. We used the households' per capita expenditure as a proxy for the household's welfare measurement. Results show that the number of years the farmers have lived in their respective villages, level of literacy, access to credit, contact with extension agents, having agriculture as the main occupation, and being a member of any organization were the main factors that significantly influenced the adoption of HSBs. At the same time, a large household size significantly reduces the adoption of HSBs. Also, the per capita expenditure of adopters was higher than that of the non-adopters and the difference varies between 15294 and 17974 CFA franc (\$ 28.22 and \$33.16). Likewise, the non-adopters would have had a significant increase in their per capita expenditure if they had adopted HSB (between 21076- 22872 CFA franc (\$38.89-\$42.20). Furthermore, the adoption of HSBs can potentially increase welfare among the adopters by 28 to 31 percent. Similarly, the non-adopters would have had an increase of about 41-43 percent of welfare if they had adopted. Thus, this suggests that households' welfare depends on the adoption of HSBs, and the adoption of HSBs is related to higher household welfare. The highlighted factors that influence the adoption of HSBs should be enhanced, and HSBs should be made available to rural farmers at affordable prices.

Keywords: Stored Grain, Pests, Propensity Score Matching (PSM) and Heckman Selection Model (HSM)

Freefreeze, a solar off-grid cold storage technology to save postharvest losses of smallholder farmers

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Annually, one-third of food produced globally, worth more than \$1 trillion, is lost according to FAO. Those losses are even higher in Africa to reach 50% of their total production. One of the main leading factors to such losses is the lack of access to cold storage solutions adapted to the African context where half the population live with no electricity and suffer from limited financial means. Farmers are compelled to sell at mediocre prices before crops spoilage; reducing their income by at least 15%. The environmental impacts are also high; the total carbon footprint of food wastage is around 4.4 Gigaton CO₂eq per year and 1.4 billion hectares of land is used annually to produce "wasted food". Regarding those drastic economic and environmental repercussions, solutions to address post-harvest losses are therefore critical. Freefreeze is an off-grid cold storage unit invention powered by solar thermal energy. It provides a cooling capacity of 5 tons, 5 °C capable of extending fruits and vegetables' shelf life from 3 days to 20 days on average. The prototype validation is a major stage of the project's development. Free freeze is a modular solution that includes multiple and diverse technologies requiring high expertise in different scientific domains including thermodynamics, mechanics and fluid dynamics. To develop this technology, accurate theoretical models are built through simulation and laboratory experiments to design every part of the solution. As of today, a 1/2 tons prototype is at its fourth version, and after validation, the full-scale prototype of 5 tons will be manufactured and tested. Free freeze is a new patentable technology based on solar thermal energy which oversteps the economic and environmental limitations of the existing solutions using solar photovoltaics. It can achieve higher efficiencies up to 40% compared to 20% of photovoltaics. Moreover, Freefreeze technology represents an important cost advantage. It can provide more power, thus reach a wide range of storage temperatures and capacities, without a significant impact on the costs induced. This aspect allows it to be replicated to other locations without the need for a major adjustment. To make the solution affordable and accessible to smallholder farmers, a pay-per-use business model will be adopted where farmers pay an affordable fee for every crate stored. The service will be delivered through an intuitive USSD (Unstructured Supplementary Service Data) digital service to overcome digital illiteracy and poor connectivity. The potential market of this technology is very high as does its expected impact. The cofounders conducted a field market research study during 10 days in the two first markets they are targeting, Togo and Ivory Coast. They conducted interviews and focus groups with more than 200 farmers to collect information about the amount of crops' loss due to lack of cold storage. Through primary and secondary data collected (market value of the crops, production, seasonality, the study reveals that for one year use, one unit of 5 tons enables 50 smallholder farmers to save up to 314 tons of post-harvest losses and increase their income by 68% on average, being \$1896.

Keywords: postharvest losses, off-grid cold storage, solar thermal energy, food waste

Application Of Botanical Treatments and Packaging Technologies in the Preservation of Postharvest Quality of Tomatoes

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In Kenya, the tomato is one of the most valuable vegetables in terms of consumption, turnover, and margins. It is widely available and highly nutritious, as it contains vitamins A, C and antioxidants such as lycopene. It is also highly perishable, which has contributed to the fruit's high postharvest losses, ranking it high among the fresh produce which incurs the highest postharvest losses. The fruit experiences postharvest losses of up to 50% of its total yield, making it unavailable to consumers and negatively impacting Kenya's food security situation. These losses are also the primary cause of the country's lack of self-sufficiency in production, necessitating the import of fresh produce to compensate for the deficit. The primary level at which these losses occur is at the on-farm level. Although research has been directed towards developing postharvest management strategies, progress has been less significant due to the slow rate of adoption by smallholder farmers owing to the cost and technical expertise required. Botanical coatings are easily accessible to farmers because they are found in their communities, are inexpensive, and are easy to apply as they require minimal preparation before storage and have been used as preservation techniques. They also have antibacterial and antifungal properties, which can be transferred to fruits and vegetables. While edible coatings have been used as a postharvest management strategy in the fruit and vegetable chain, research on their application in Kenya is very limited. The purpose of this review is to highlight literature review findings on the effectiveness of three botanical coatings: Neem, Moringa, and Bitterleaf, when combined with simple MAP technology such as microperforated paper and cling film foil as a postharvest management strategy. Both technologies are easily and readily available in the Kenyan market. Results show that when used, they are effective in extending the shelf-life of fresh tomatoes up to 4 weeks compared to the predicted 2-3 week lifespan of the tomato. The coatings also help in retaining their physicochemical characteristics and reduce attack from micro-organisms hence preserving the quality. However, there is no known documentation of their application in Kenya, hence the need to investigate their ease of application. This is to mitigate postharvest losses caused by on-farm activities as on-farm losses account for a more significant proportion of postharvest losses in Kenya's tomato value chain. These botanical coatings and proper packaging technology on-farm can reduce the risk of postharvest losses in tomato supplies.

Keywords: Tomatoes, Postharvest loss, Botanical Coatings, Preservation, Postharvest management

Enriching Maize-Legume Flours with Orange - Fleshed Sweet Potato (OFSP) can Help Reduce Vitamin A Deficiency and Postharvest Loss in Malawi

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Consumption and utilisation of orange-fleshed sweet potato (OFSP) are affected by seasonal availability due to high moisture content which increases microbial contamination, perishability and contributes to the postharvest loss. This calls for approaches to process OFSP into more sustainable forms like flours to reduce wastage and ensure availability throughout the year. The Malawi government and its development partners are promoting the utilisation and consumption of OFSP to combat vitamin A deficiency and reduce postharvest loss. The present study was conducted to promote utilisation of OFSP by processing into flour and enrich maize-soy blend in the process of combating vitamin A deficiency especially among pre-school children in Malawi. OFSP (*Mathuthu* and *Kaphulira*) varieties were subjected to blanching, sodium metabisulphite and no treatment (control). Six blends of flours made of OFSP, maize and soybean flours were formulated based on the nutrient strength of the individual flours. The physicochemical properties and sensory characteristics of the flour blends and porridges were determined. Analysis of variance (ANOVA) was used to determine the differences ($p < 0.05$). XLSTAT (version 17.1.01) was used for the analysis of descriptive test results. There was a significant difference in the sensory characteristics of the six flour blends produced from the combination of two OFSP varieties, maize and soybeans. All the six porridges were acceptable by the mothers and children, but the most preferred porridge was from the blanching treatment. Information from this research can complement the existing programs in Malawi (e.g., commercial fortification of food products and micronutrient powders). Incorporating OFSP flour into maize-soy bean flours did not affect the acceptability of the porridges by both the mothers and children. OFSP can be utilised through flour that can be kept longer and used during the lean period to diversify diets thereby reducing post-harvest loss and help combat VAD at scale.

Keywords: Beta-carotene, Orange Fleshed Sweet Potato, blanching, preservation, sodium metabisulphite

Soy kits: An economically viable value addition technology for soymilk processing in Malawi

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Malawi suffers from high poverty rates and malnutrition. The Feed the Future Malawi Agriculture Diversification Activity (AgDiv) identified soy processing as having the potential to alleviate these problems by providing both an affordable protein source in rural communities and a source of income for soy processing entrepreneurs. AgDiv is promoting soy processing using soy kits- small machines and manually operated. Malawi is one of the countries that produce a lot of soybeans and most of it is sold to vendors and processing companies by the farmers resulting in very little income and low consumption. More soybeans are produced in rural communities where malnutrition rates are high compared to urban areas. However, most farmers sell all the soybeans without keeping some for-household consumption due to a lack of knowledge in preparation and diversification. Soybean is rich in protein and with proper utilization and consumption, malnutrition rates could be alleviated. Therefore, AgDiv piloted 30 soy kits targeting individuals in rural communities, especially women to process soybean into soy milk. Women are most vulnerable in the communities hence empowering them with simple technology as a source of income in their families means a lot. Women are responsible for taking good care of basic household needs, buying nutritious food which improves the livelihood of the entire family. Besides that, women are good at handling the farm produce after harvesting to reduce the loss. The soy kit is a technology that process soybeans into soymilk and the byproduct- okara. The okara is promoted as animal feed and an ingredient for bread, snacks, and other foods, hence there is no wastage as everything is being utilised in various products. With 600g of soybeans, an entrepreneur produces 4 litres of soy milk per batch for household consumption and selling at MWK300-MWK350/litre an equivalent of US\$0.34-US\$0.39/litre which will help reduce the prevalence of malnutrition and reduce poverty in the household, respectively. This activity reduces postharvest losses of the soybeans as farmers have discovered the hidden gold obtained from soybeans through soymilk processing. This means a kilogram of soybean would produce 6.6 litres of soymilk and if sold, one would make about MWK1,800/US\$2.01. The calculated cost of producing this milk is MWK760/US\$0.85, hence a profit margin of K1,040/US\$1.16. This is a huge profit considering that farmers sell their soybean to vendors at MWK150-MWK200/kg (US\$0.17-US\$0.22/kg) at harvest time. Data collected on production and financial results for soy kits show significant production of soy milk in the targeted communities. Most soy kits processors are generating enough income to make the kit economically viable. The soymilk entrepreneurs have opened the market to their fellow farmers hence every farmer takes good care of the soybeans during and after harvesting. As a result of the positive findings, AgDiv has scaled up the distribution of soy kits in Malawi from 30 soy kits in the year 2018 to 4000 kits in 2021, targeting 4000 individual beneficiaries (80% are women) and youth clubs who are supplying the nutritious soy milk to thousands of people in the rural areas.

Keywords: Soykit, soymilk, okara, entrepreneurs

Can warehouse receipt systems and community grain banks be potential climate adaptation strategies for postharvest loss reduction in Malawi?

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Losses during grain storage remain a challenge for smallholder farmers across sub-Saharan Africa (SSA). Climate change and increased climate variability (CC & CV) are expected to further increase these grain storage losses. The introduction of warehouse receipt systems (WRS) and community grain banks (CGB) in SSA could help reduce grain storage losses. However, comprehensive information on the feasibility of using WRS and CGB as adaptive strategies in reducing grain storage losses in CC & CV prone areas such as Shire Valley in Malawi is not available. This study was carried out to assess the feasibility of using WRS or CGB as adaptation strategies for reducing crop storage losses in Shire Valley. Two structured questionnaires were administered to management (responsible for the day-to-day running of the storage systems) and the beneficiary members at the start of the study. The questionnaires focused on individual respondent's characteristics, crop production, storage structure, membership and marketing information. Stored grain (maize and pigeon peas) samples of ~1kg per grain type were collected at 8-week intervals for 24 weeks from WRSs only because CGBs had no stored grains during the 2016/2017 storage season. The grain samples were assessed for weight loss using rapid visual loss assessment methods. Results revealed that maize and pigeon pea deposits being made at the WRS and CGB by individuals, farmer groups or cooperatives totalled up to 15 metric tonnes per crop per site. The majority of the WRS respondents (54%) and some of the CGB respondents (15%) only deposited crops such as legumes, and no maize, with the quantity of grain, deposited ranging from 1 to 3 mt per depositor. A moderate positive correlation ($r = 0.491$; $p = 0.002$) was observed between the reported quantities of maize produced and deposited during the 2015/16 growing season. According to 59%, WRS and 38% CGB interviewees, the collective storage systems have an impact on climate-related risks, for example, on the local supply of grain during the lean months, as reported by 12% WRS and 5% CGB interviewees. The initial pigeon pea grain weight loss reported was $2.2 \pm 0.7\%$ to a maximum of $7.3 \pm 1.7\%$ after 24 weeks of storage. The maximum baseline insect-damaged pigeon pea grain was $16 \pm 4\%$ which increased to a maximum of $24 \pm 4\%$ after 24 weeks of storage. An initial damaged maize grain of $4 \pm 1.3\%$ and a maximum of $20 \pm 3.2\%$ was reported after 24 weeks. At the start of the study, the total stored grains at Nsanama, Balaka and Mwandama WRSs were valued at US\$ 850,668-00. Therefore, these collective storage models can be a useful part of adaptive strategies compared to relying solely on smallholder grain storage in communities frequently affected by climate-related disasters which also contribute to increased crop storage damage. The introduction of collective storage systems can play an important role in maintaining grain quantity and quality within communities. The grain can then be used by affected HHs in times of emergency.

Keywords: Grain storage losses, visual loss assessment methods, grain storage systems, climate change, climate-related risks

Formulation, acceptability and nutritional value of cassava root - leaf flakes

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Cassava is an important food crop grown for its tuberous roots to supply daily needed calories to households in the cassava growing communities including coastal Kenya. This region contributes up to 27 % of the national cassava production though it remains food insecure with a high prevalence of malnutrition. Cassava roots are deficient in most nutrients except carbohydrates while the leaves are rich in a range of nutrients including protein but are less often consumed as vegetables. The study sought to establish the most acceptable cassava root-leaf blend/s with improved nutrient content. This involved formulation of blends of cassava flakes through mixing roots and leaves in varying levels ranging from 0 % to 50 %. Fermented and unfermented flakes were developed. A total of 18 formulations were developed before consumer acceptability and nutritional content were determined in the most preferred blends. The results showed cassava root-leaf flakes were best accepted when fermented root material is blended with 20% leaf component. Leaf content above 40% was unacceptable as such blends exuded unpleasant aroma. The nutritional value showed that cassava root-leaf flakes had vitamins A and C improved by 353% and 53% respectively, minerals-iron and zinc by 5.6% and 85% respectively and protein by 430% when compared with flakes processed from 100% cassava root. It is recommended that more studies be carried out to determine the bioavailability and nutritional effect of consumption of the flakes on children and pregnant women.

Keywords: Acceptability, Cassava Flakes, Fermentation, Nutritive Value.

Protecting perishable crops with packaging: Evidence for reducing postharvest losses from the Ceres2030 scoping review

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A scoping review of interventions to reduce postharvest losses was part of the Ceres2030 project on Sustainable Solutions to End Hunger. The objective of this project was to use evidence synthesis to identify the most promising investment solutions for building sustainable food systems and achieving Sustainable Development Goal 2 of zero hunger by 2030. Reducing postharvest losses (PHLs) of food crops is a critical component of sustainably increasing agricultural productivity, and while many PHL reduction interventions have been tested, synthesized information to support evidence-based investments is scarce. This scoping review, covering 22 crops across 57 countries in sub-Saharan Africa and South Asia, identified 12,907 peer-reviewed and grey literature documents. These papers were subjected to a two-stage double-blind screening process using strict exclusion and inclusion criteria to identify field-tested interventions that small-scale producers and their associated value chain actors can use to measurably reduce postharvest losses. Data were extracted from the 334 studies that met the selection criteria and the postharvest interventions were categorized into different intervention types. Of the 1565 specific interventions in these 334 studies 8.8% were classified as predominantly packaging interventions on perishable crops (specifically cassava, potato, sweetpotato, banana, mango, citrus, cabbage, onion, tomato and leafy vegetables) and a further 1.0% were predominantly storage structure interventions for these perishable crops with packaging as a secondary factor. Studies from South Asia accounted for 60.1% of packaging interventions compared to 39.9% from sub-Saharan Africa. The majority of the packaging interventions were conducted on citrus (29.0% of packaging interventions), followed by tomato (19.6%). In general, the use of plastic crates, bags, modified atmosphere packaging and fibreboard cartons reduced quantity (overall loss or weight/water loss) and quality (decay, damage, unmarketable) losses compared to unpackaged produce or produce packed in baskets, sacks and wooden boxes. For example, tomatoes packed in wooden boxes had 48.3% quantity loss and 17.0% quality loss compared to those packed in plastic crates (17.5% quantity loss and 6.9% quality loss). However, the number of studies contributing to these data was low, and for some of these perishable crops, there was a total lack of data. Given the ability of packaging interventions to reduce postharvest losses of these nutrient-dense roots, tubers, fruits, and vegetables, there is a need for focused research on packaging on a wider range of crops, and on the barriers and facilitators to commercial use of improved packaging materials to reduce postharvest losses in Africa.

Keywords: Cassava, Citrus, Mango, Potato, Tomato

Mechanizing the processing of pearl millet in Senegal: The role of research and technology adoption

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The arduous work of primary processing of local cereals such as pearl millet with which the women of the rural world in Senegal were confronted using manual tools (pestle and mortar) to transform millet brought the technological researchers of the Senegalese Institute for Agricultural Research (ISRA) to seek solutions allowing the reduction of the husking and the milling of cereal such as pearl millet. The main objective of this study is to show the contribution made by agricultural research in the development of a combined unit of huller-mill suitable for rural, semi-urban and urban areas in the primary processing of local cereals, especially pearl millet, in order to alleviate the arduousness, with which the rural processors are confronted with. The methodology of the study involved reviewing the literature on all the reports and articles available on primary processing in Senegal, for which the National Center for Agronomic Research of Bambey (CNRA), through its agricultural machinery and post technology service, has produced or published. The results of this study show that with the support of the International Development Research Center of Canada (CRDI) and in collaboration with the Sahelian Industrial Society for the Mechanization of Agricultural Materials and Representation in Senegal (SISMAR) (the only manufacturing industry of agricultural equipment from the country with the very sophisticated tools allowing to manufacture high quality machines respecting international machine construction standards) combined machine units (huller-mill) suitable for rural, semi-urban and rural areas urban have been tested and successfully popularized in rural communities in Senegal, thereby relieving the drudgery of women during the processing of crops around the world. Also, the research ensured the training of local artisans in the construction and manufacture of shellers and mills, allowing the supply and availability on the Senegalese market of these machines.

At present, in the country, local artisans have a perfect mastery of this technology, thus resolving the problem of the primary processing of millet in Senegal. Also, on the other hand, the research had to provide training sessions for women processors of local cereals such as millet in the use and maintenance of huller and mill.

At present, with the financing of the Agricultural Productivity Program in West Africa (WAAPP), attempts to alleviate the arduousness of the work on the secondary processing of pearl millet are carried out by the agricultural machinery and technology post harvester of the department of ISRA by the development of a multifunctional granulator allowing to make «couscous or durum wheat» thus contributing to the second reduction of pearl millet processing work in Senegal.

Keywords: Grain processing, ISRA, pearl millet, postharvest technology, Senegal

Effect of Using Plant Extract with Coating Material on Physicochemical Quality of Tomato Fruit (*Solanum lycopersicum* L.) Stored at Ambient Temperature

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Abstract: Tomato (*Solanum lycopersicum* L.) is one of the widely consumed fresh vegetables in the world. Tomato is a very nutritious and health-protective food but has a highly perishable nature. Its susceptibility to postharvest losses, postharvest diseases and physical injury limit its successful marketing during handling, transport and storage. Due to this problem, simple technology is required to reduce the postharvest loss of this commodity. The use of edible coatings with plant extracts appears to be a good alternative preservation technique to extend the mature tomato fruit. This study was, therefore, initiated to investigate the effect of using plant extracts (garlic bulb and capsicum) incorporated with coating materials (maize starch and beeswax) on physicochemical quality of tomato fruit stored at ambient conditions (temperature 15.5 to 20.2°C and relative humidity of 55.5 to 67.3%). The experiment was conducted using a complete randomized design of two varieties (Fetane and Melkashola) with six treatments. The tomato fruits were coated by dipping into the solution for 3 minutes. The treatments prepared were a coating solution of 9.5% coating materials mixed with 0.5% plant extracts, 10% coating materials without extracts, and control. The treatment means were tested at a significance level of $P \leq 0.05$. The effectiveness of plant extracts with coating materials on tomato fruits were evaluated at three (3) days intervals for 30 days. There was a significant difference ($P < 0.05$) between coated and uncoated fruits. All coatings delayed tomato ripening and improved the keeping quality parameters, but the best results were exhibited by 9.5% beeswax mixed with 0.5% capsicum extract followed by 9.5% maize starch mixed with 0.5% garlic bulb extract by maintaining the mature tomato fruit for 30 days. The study showed that the Fetane variety has maintained more quality attributes than the Melkashola variety during storage.

Keywords: Tomato fruit, Ambient temperature, Edible coating, Plant extracts, Physicochemical Quality

Hermetic bags preserve the quality of dried fruits (*Ziziphus mauritiana* (L)) in Niger

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Ziziphus mauritiana Lam is a valuable commercial fruit crop that is delicious and used in herbal medicine. It's postharvest management poses challenges due to insect infestation. In the Sahelian zone, the *Z. mauritiana* fruits are eaten dry. The presence of storage insects causes fruits spoilage and degradation resulting in loss of quality and market value. We assessed the performance of the Purdue Improved Crop Storage (PICS) bags for preserving dried *Z. mauritiana* fruits. Dried fruits were purchased from three local markets in the Maradi region of Niger. The experiment was carried out using small PICS and woven (control) bags that each stored 400 grams. Each treatment was repeated four times. Data collected at the start and end (four months) of the experiment included: i) weight of the sample, number of live insects, and number of insect emergence holes per 100 fruits, ii) sugar content, and ii) sensory/organoleptic characteristics (colour, sweetness, flavour, texture and general acceptability). Only one insect species, *Aubeus himalayanus* Voss (Coleoptera; Curculionidae), was observed on dried *Z. mauritiana* fruits. Insect infestation increased in woven bags while it remained the same in PICS bags. After four months of storage in the control woven bag, there was an increase in insect population (up to 215.5%) and the number of emergence holes per 100 fruits (up to 24.96%). The weight loss of dried *Z. mauritiana* fruits ranged from four to nine per cent. In the PICS bag, however, the different parameters related to pest infestations and damage were comparable to those observed at the beginning of the experiment. Similarly, moisture content of dried *Z. mauritiana* fruits increased in control woven bags after four months of storage but stayed the same in PICS bags. Overall, the proportion of sugar content of dried *Z. mauritiana* fruits after four months of storage remained the same for all treatments when compared to the start of the experiment. Organoleptic properties of dried *Z. mauritiana* fruits stored in PICS bags were more appreciated (with a score of 16.02% higher) than those of fruits stored in control woven bags. PICS bags can be promoted to effectively preserve organoleptic properties and other qualities of dried *Z. mauritiana* fruit.

Keywords: dried fruits, insect management, postharvest storage, airtight PICS bags, Sahel

Effect of different pulping methods on the physicochemical properties of the Kenyan red and white-fleshed guava pulp

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Fruit pulps are among the most traded types of fruits on an industrial scale. Due to seasonality constraints, bulk pulp storage is a common practice among fruit processors worldwide, as it helps reduce postharvest losses and food waste, maintains the quality and safety of processed fruits and provides raw materials for continuous manufacturing during the fruits' offseason. The industrial processing of guava remains untapped in Kenya because the crop's value chain has not been commercialized due to negligence contributing to its high annual losses of more than 70%. The current study sought to evaluate the impact of pulping methods on the quality of pulp from white- and red-fleshed guavas. Both hot and cold extraction methods were tested, with the hot extraction method involving both steam and hot water blanching. The pulps were then subjected to yield extraction, physicochemical analysis, and post-processing changes to determine their suitability for processing other value-added products. Results indicate that the pulp yield was highest in the red guava regardless of the method of extraction used ($p < 0.05$). The pulp to by-product ratio was significantly ($p < 0.05$) high in the red guava pulp ranging from 2.58, 2.97, and 3.30 for the cold, hot water, and steam-blanching compared to the white guava's 1.66, 1.95, and 2.03 respectively. There were no significant ($p > 0.05$) differences in the moisture loss during the pasteurization of the resultant pulps, averaging 2.59 ± 5.41 - $5.1 \pm 2.6\%$. Although hot extraction methods resulted in significantly ($p < 0.05$) higher yields (67.02 ± 0.99 - $76.73 \pm 0.61\%$) compared to the cold (62.43 ± 0.69 - 72.02 ± 1.83) the heat-labile nutrients were affected with as much as 60% of the white guava's and 64% of the red guava's vitamin C were lost besides leaching of minerals and significant ($p < 0.05$) losses in the antioxidant and total phenolics of the resultant pulps. The steam blanched pulps exhibited the most significant ($p < 0.05$) changes in the color parameters leading to the highest overall color changes (ΔE) ranging from 21.97 ± 4.51 - 29.69 ± 7.71 in the pasteurized white guava pulp compared to the red's (-0.24 ± 4.50 - 5.7 ± 0.76). The cold extraction method led to significantly ($p < 0.05$) better retention of the vitamin C, β -carotene, zinc, iron, calcium, flavonoids, and the antioxidant activities in the red pulp compared to the white guava pulp. In comparison to the white cold-extracted pulp, the cold-extracted red guava pulp was more suitable for further processing due to its high nutrient retention, as well as high pulp to by-products ratio and textural properties.

Keywords: Guava, pulp, hot and cold extraction, nutrients, processing

Capacity Building in Post-Harvest Loss Management of Food Commodities to Increase Local Capacity for Sustainable Climate-Hazard Preparedness.

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Post-Harvest Losses among small-holder farmers in Zambia are very high, estimated at 30% for grains and 40% for horticultural products. The Government of the Republic of Zambia has identified this challenge being faced by the smallholder farmers, and with support from the World Bank it is implementing a project called Transforming Landscapes for Resilience and Development (TRALARD), to strengthen the resilience towards climate change risks and vulnerabilities of smallholder farmers in 16 target districts in three provinces of Northern Zambia (namely, Muchinga, Northern and Luapula provinces). At the same time, climate change has emerged as a major challenge to development efforts, as it has a dramatic impact on livelihoods, economy and environment, often undermining growth and disturbing ongoing developmental efforts. It limits the availability of foods in many communities and exposes them to high levels of food and nutrition insecurity for many months of the year. Therefore, a total of 326 Agricultural Extension Officers (AEOs) were trained in key aspects of good postharvest management practices of food commodities to increase local capacity for sustainable climate-hazard preparedness. AEOs will in turn train smallholder farmers (SHF) in these practices, who will then be able to reduce losses, thereby increasing resilience to natural hazards and their ability to rapidly recover after a shock. This will lead to significant improvements in the food and nutrition security of targeted rural communities and hence have a positive impact on their livelihoods. The training was based on the Post-Harvest Loss Management (PHLM) manual that was produced in October 2020. Objectives of the training were to conduct a postharvest loss management training based on the TRALARD Post-Harvest Loss Management (PHLM) manual, to empower AEOs in the TRALARD operation areas with knowledge and skills to minimize food commodity losses and improve the quality and quantity of food commodities and to formulate action plans for their respective districts. Target group: The selected staff to participate in each of the provincial training was Camp Extension Officers, Livestock officers, Veterinary, Forestry and Fisheries Officers. Contents of the training: Content of the training included mitigating post-harvest losses, postharvest loss management practices of cereals, legumes, root crops, horticultural crops, forestry products, and small livestock. The output of the training: A total of 381 Agricultural front-line staff were trained in the seven separate training courses that were conducted in PHLM on how to employ appropriate technologies at each stage of the Post-Harvest Value chain, to reduce post-harvest losses among smallholder farmers and the impact of losses on the environment and climate change effects!

Keywords: Sustainable Climate-hazard preparedness, Environment, Post-harvest Loss management, Smallholder farmers, Livelihoods, Agricultural Extension Officers.

Use of Polyurethane Insulated chambers to reduce postharvest losses for the Nigerian market

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The metabolic activity of perishable commodities rises with increase in temperature and leads to postharvest losses. The temperature management has been used successfully to control deterioration and maintain the viability of these farm produce. Rigid polyurethane (PU) commonly used for insulated chambers has a very low thermal conductivity coefficient of 0.023W/m.K at 10°C with an average K-value of 1.14m² k/W per inch, depending on the formulation density. They exhibit very good dimensional stability between -180 °C and +140 °C making it a suitable for storage technology to forestall and reduce postharvest losses for agricultural produce. Nigeria has experienced an unimaginable food loss, since the outbreak of the COVID-19 pandemic, threatening food security and precipitating massive importation. This has led to a surge in the country's postharvest losses, currently estimated at \$9billion (₦3.4 trillion based on the current official exchange rate of ₦380) by the Federal Ministry of Agriculture. Postharvest losses in Africa's most populous nation have been estimated to range between 5 % and 20 % for grains; 20 % for fish and as high as between 50 % and 60 % for tubers, fruits, and vegetables. Losses can be the result of a reduction in quality and safety. In the absence of refrigeration systems for controlled temperature and quality packaging, farm produce deteriorates faster while the farmer waits to sell. The longer it takes for farm produce to reach the consumer market, because of poor transportation infrastructure, the higher the deterioration and loss in value. The quality may preclude the attraction of premium prices with health and safety implications. The economic loss is a cost to the enterprise, which is often transferred to the consumer while the public health and safety concern of consuming the decay farm produce is another challenge the society contends with. Vitapur Nig. Ltd., a polyurethane insulation company developed a PU Insulated chamber with a tricycle as its carrier to help forestall postharvest losses. The designed regulated PU insulated chamber helps to preserve the quality of farm produce and the transportation problem is solved using the tricycle as the carrier. The study showed that the PU Insulated chamber, a composite that comprises majorly of rigid polyurethane systems (Polyol and Isocyanate) and chromadek sheets as the facer can help reduce postharvest losses by almost 27 %, depending on the specific design used. The PU insulated chamber, which has been used by other sectors as freezer rooms for storing food items at 0 °C in large stores, cooling rooms for storing consumable materials at a regulated temperature in manufacturing plants, clean rooms in pharmaceutical industries etc. have been serving as good storage technology and helping preserve the quality of farm produce through the supply chain.

Keywords: Postharvest, Food Safety, Farm Produce, Rigid Polyurethane, Quality

Controlled Fermentation of African nightshade (*Solanum scarbrum*)-a comparative study on nutrient composition and reduction of food-borne pathogens

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Africa is endowed with rich varieties of indigenous leafy vegetables which can help to alleviate malnutrition among poor populations. Due to the warm and moist weather of the tropics, vegetables are prone to faster spoilage. It is, therefore, necessary to develop a proper method of food preservation that is cheap, locally available that also ensures product safety and quality. Fermentation of vegetables with lactic acid bacteria (LAB) has been reported across the world, although it is not widely adopted in the fermentation of African indigenous leafy vegetables (AIV). Fermentation of AIVs may help improve safety and quality. In this study, 2 LAB starter cultures were used to ferment African nightshade (*Solanum scarbrum*) and their success in inhibiting food-borne pathogens was determined as well as assessing the effects of fermentation on nutrient composition. African nightshade was cultivated at Max-Rubner Institute (MRI), Germany, and Jomo Kenyatta University of Agriculture and Technology (JKUAT), Kenya for 7-8 weeks. The leaves were harvested, washed, and dried. Fermentation of 1kg leaves was performed in 5-litre pots with the starter cultures of *Lactobacillus plantarum* and *Lactobacillus fermentum* 106 CFU/ml in the presence of 3% salt and 3% sugar at 25°C for 144h. The lactate and sucrose concentrations were determined after fermentation. Vitamins B1, B2, C and E were determined by HPLC analysis while protein or raw nitrogen was evaluated by the Kjeldahl method, and the ash was analysed by the furnace method. The challenge test was done to determine the ability of the starters to inhibit *Listeria monocytogenes* and *Salmonella enteritidis*. Fermentation of nightshade leaves with LAB reduced pH below 4 within 24h. Spoilage microorganisms were inhibited after 72h. Sucrose was metabolized in both starter culture and control batches at 24h and after 48h. Lactate showed an increase after 24h and 72h in both starter culture and control batches, respectively due to a reduction in the pH and increase in LAB counts. While African nightshade had high amounts of vitamins, fermentation seems to reduce vitamins B₁, B₂, C, and protein while it increased ash and vitamin E contents. Therefore, the use of LAB starters contributes to a more predictable quality and safety of African nightshade leaves, thus preventing food poisoning and illness.

Keywords: Fermentation, lactic acid bacteria, safety, African nightshade, vegetables

Thermal and functional properties of chemically pre-treated cassava flour using response surface methodology

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Cassava flour (CF) is mostly constituted to “dough form” in various food applications which involves the incorporation of water in the presence of heat. This study using response surface methodology (RSM) comparatively investigated the effects of two pre-treatments (calcium chloride and citric acid) interacting with varying drying temperatures on the loose and packed bulk densities, water holding capacity and thermal properties of CF from two South African cassava landraces (red and white). The drying temperature ranged from 45 – 74°C while the concentration of pre-treatment was from 0.6 – 3.4% w/v. Differential scanning calorimetry was used in determining the gelatinisation temperatures and enthalpy of CF under varying conditions. Gelatinisation temperatures of onset (60.32 – 120.30°C), peak (71.85 – 126.84°C), conclusion (93.31 – 140.98°C), and enthalpy of gelatinisation (0.14 – 54.95 J/g) were recorded for all CF samples. Processing conditions had an increasing effect on the gelatinisation enthalpy of the flour. Citric acid treatment had a decreasing effect on the water holding capacity of the flours, compared to calcium chloride. Drying temperatures significantly influenced the bulk densities of CF, while the loose bulk density increased with drying temperature. An increase in enthalpy of gelatinisation for chemically pre-treated CF infers that more energy will be required for gelatinisation to occur. Processing conditions confer on CF more stability in the presence of heat and water. The use of RSM was efficient in generating data for different processing conditions for CF with varying thermal and functional properties. Depending on the desired end-use properties of the CF, the optimal processing condition may be extrapolated from the values obtained in this study.

Keywords: Cassava, flour, pre-treatment, thermal properties, water holding capacity

Evaluation of the Effectiveness of Low-Cost Cold Storage Options to Preserve Postharvest Quality of Mango

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Sub-optimal storage temperatures contribute to the fast deterioration of harvested mango fruit leading to high postharvest losses. Proper cold chain management including appropriate cold storage is critical for quality preservation in perishable produce such as mango fruit. An on-farm experiment was therefore conducted to compare the effectiveness of different low-cost storage technologies to preserve the quality and extend the shelf life of mango fruits. Homogenous mature-green 'Apple' and 'Kent' mango varieties were divided into 10 batches of 60 fruits each and were subjected to different storage options including CoolBot™ cold room ($10\pm 2^{\circ}\text{C}$, $75\pm 20\%\text{RH}$); Evaporative charcoal cooler (ECC) ($20\pm 5^{\circ}\text{C}$, $95\pm 5\%\text{RH}$); Zero energy brick cooler (ZEBC) ($20\pm 5^{\circ}\text{C}$, $90\pm 10\%\text{RH}$); Wakati™ tent ($25\pm 5^{\circ}\text{C}$, $95\pm 5\%\text{RH}$) and ambient room ($25\pm 5^{\circ}\text{C}$, $55\pm 15\%\text{RH}$). The fruits for each storage option were divided into two batches whereby one was packaged in Activebag™ modified atmosphere packaging (MAP) and the other one left unpackaged. The experiment was laid out as a completely randomized design with a factorial treatment arrangement. Three fruits per treatment were sampled at 3 days interval until the fruit reached predetermined end-stage (based on flesh firmness) to evaluate ripening-related changes and quality attributes including, physiological weight loss, firmness, colour, total soluble solids (TSS), titratable acidity (TA), β -carotene, sugars and vitamin C. Cold storage with or without MAP significantly increased shelf life of mango fruits compared to storage at ambient room conditions. In the 'Kent' variety, shelf life was extended by 21, 9, 9 and 9 days by CoolBot™ cold room, ECC, ZEBC and Wakati™ cold storage, respectively in comparison to storage at ambient room conditions. A combination of cold storage and MAP extended the shelf life further by 6, 9, 9 and 9 days, respectively. Cold storage also significantly preserved the quality attributes of the mango fruit in comparison to ambient room conditions. 'Apple' mango variety, fruits stored under CoolBot™ cold room, ECC, ZEBC and Wakati™ cold storage retained 50.0%, 48.5%, 47.3% and 46.1% of the initial vitamin C contents respectively compared to fruits stored at ambient room conditions. There was a synergistic effect when MAP was combined with cold storage, leading to better retention of vitamin C compared to unpackaged fruits. The findings showed cold storage to be effective to extend shelf life and preserve postharvest quality attributes of harvested mango fruits.

Keywords: Cold chain, MAP, Shelf life, Storage temperature

Assessment of PICS Bag for Maize Storage in Ghana

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Despite the recent introduction of improved grain storage methods and technologies, many smallholder maize farmers in Ghana still use traditional storage practices and structures for storing their maize grains after harvest. This practice contributes to the high postharvest losses in maize grain at the smallholder level, largely due to insect pest infestation. Hermetic bag storage is a proven technology effective in reducing grain damage and losses from insect pests. Biological respiration within the bags creates an environment that is unsuitable for insect development and growth. In this study, the efficacy of the Purdue Improved Crop Storage (PICS) bag was compared to polypropylene (PP) bag stored with maize treated with Betallic Super EC chemical and PP bag stored with maize without Betallic treatment (Control) during a 6-month storage period. Data on grain moisture content (MC), number of live insects, insect-damaged kernels (IDK) and maize weight loss were collected monthly for analysis. Grain viability and nutrient analysis were also conducted before and after storage. The results showed initial grain moisture content of 11.4% was not significantly affected in the PICS bags but increased by 1-2% in the PP bags. PICS bags and Betallic treatment significantly reduced insect damage grains with mean weight loss of < 5% and 6.35 % respectively compared to the control treatment with a mean weight loss of 21 % over the 6-month storage period. The germination rate of sampled seeds after storage in the PICS bags (75 %) was not significantly different to the initial germination rate (78 %) compared to the control treatment of 56 %. Overall, maize grains stored in the PICS bags showed no signs of deterioration as compared to grains in the PP bags. The PICS bags were superior to the PP bags in terms of other grain quality metrics assessed and the nutrient characterization such as protein and carbohydrate which was 9.02% and 77.55% for PICS bags and 8.77% and 75.38% for PP bags with Betallic respectively. The results show that PICS bags can be effective in protecting maize grains during storage. Smallholder farmers are therefore encouraged to consider this technology especially for controlling insect pests of stored maize.

Keywords: Insect pests, Polypropylene, Smallholder farmers, Purdue Improved Crop Storage bag, post-harvest losses

Challenges with Effective Packaging of Locally Processed Foods in Ghana

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Effective and affordable packaging of agricultural produce and processed food products are widely accepted as necessary complements to improving postharvest management and thus the overall agricultural productivity in any country. With the increasing urbanization, changing lifestyles, changing consumption patterns, and working mothers, pre-packaged foods are increasingly helping to achieve the goal of food and nutritional security in Ghana. In response to these trends, there are increasing numbers of micro-small to medium-scale (MSMS) companies in food manufacturing producing several pre-packaged and innovative convenience foods from local agriculture produce in Ghana. There were varied complaints with some of the locally packaged foods. This paper, therefore, examined the challenges with the packaging of locally processed foods in Ghana. Primary data were collected through an online Qualtrics survey administered to 250 key stakeholders in the food manufacturing industries, including retailers and consumers, covering several aspects of food packaging in Ghana such as cost, appropriateness of packaging materials, reliability of supplies, the capacities and capabilities of local packaging producing companies. The survey also considered consumers' reactions and perceptions about locally packaged processed foods. Additionally, secondary data on volumes and cost of imported packaging materials as well as case studies on the issue of minimum ordering requirements of the foreign packaging-producing companies over the last 15 to 20 years were analyzed. 30% of the 50 food manufacturers contacted complained that packaging could be as much as 30% of the cost of production, making their products not competitive with that imported one. Another challenge manufacturers complained about was the absence of specific packaging materials with adequate moisture-proof flexible laminated plastic for dried foods. 69% of the 70 retailers complained about the quality of locally packaged when compared to foreign ones. 48% of the 150 consumers surveyed were of the view that some of the packaging used for locally processed were not fit for the purpose and affect the nutritional content and storage of the packed foods could have been compromised given the problems that these packaging materials offer. It may be worthwhile for the government to reduce taxes on the packaging as an initial incentive to help the local food packaged products to be competitive with foreign ones and also find ways to attract more packaging producing companies in Ghana.

Key Words: Pre-packaged food; Locally processed foods; food manufacturing companies; local packaged products; quality of packaged foods

Effects of Fortifying Wheat- Sorghum Composite Flour with Omena (*Rastrineobola Argentea*) on Nutrient Composition of Biscuits

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Undernutrition, which is result of insufficient protein and micronutrient intake, is a serious problem in developing countries where poverty makes people subsist on a starchy staple such as maize, sorghum, millet, wheat, and cassava for all their nutrient needs. The young ones/ children are most at risk of nutrient inadequacy due to their high requirements during the period of rapid growth, particularly when nutrient intake is restricted. There is a need to improve the quality of starchy staples by increasing their protein and micronutrient content. Cereals have higher carbohydrate and less essential mineral contents, hence there is a need to fortify with an animal protein source such as omena which has essential minerals, as this will result in improved nutrient density and high mineral bioavailability. The present study investigated the effects of fortifying wheat- sorghum composite flour with omena (*Rastrineobola argentea*) on the nutrient composition of biscuits. Proximate analyses including moisture content, crude protein, crude fat, ash, carbohydrate and energy, mineral composition of iron, zinc, calcium, and potassium were analyzed for the biscuits. Compositing wheat-sorghum flour with *omena* progressively improved the biscuits protein from 5.54 g/100 g to 14.70 g/100 g, fat from 19.82 g/100 g to 28.50 g/100 g, ash from 0.43 g/100 g to 1.28 g/100 g and energy from 2006 kJ to 2139 kJ. Fortification with omena also improved calcium, iron, potassium and zinc contents. Biscuits fortified with omena present a considerable potential of having both macronutrients and micronutrients necessary in preventing Protein Energy Malnutrition. This study recommends the utilization of affordable fish products like *omena* to improve access to protein and micronutrient-rich animal-source foods by compositing foods other than sorghum biscuits.

Keywords: Undernutrition; *Omena*; Cereals; Biscuits; Fortification

Use of Plantain Leaves and Plantain Pseudo-Stem as Low-Cost Packaging Material Option to Maintain Quality and Reduce Postharvest Losses in Plantain (*Musa paradisica*)

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Plantain, a staple starchy crop in Ghana, is an important subsistence as well as a cash crop. Production and utilisation are affected by postharvest problems that not only lead to losses but also affect the quality of plantain offered on the market. Major areas of postharvest concern for the plantain industry include distribution/transportation, delaying ripening, storage and packaging. Generally, because plantain handlers are reluctant to bear extra costs associated with postharvest activities beyond transporting for sale, any intervention proposed to reduce the postharvest problems of plantain must be affordable. The study aimed at finding affordable packaging treatments which when applied during transportation, handling and storage would help maintain quality. For transportation, plantains cut into hands were packed in 3 package types: wooden box, plastic basket, and paper carton; with 3 lining options: plantain leaves, polyethene sheet or no lining. Quality parameters such as bruising, and peel colour were evaluated by a trained sensory panel. There was a significant reduction in bruises (1.0-1.3) and pulp softening at $P \leq 0.05$ when plantain hands were transported in any of the packages and lined with plantain leaves, as compared to the polythene sheet. Bruising in the wooden box without lining was significantly higher (2.0) than in paper cartons or plastic baskets without lining. The control (no packaging) had the highest level of bruising (4.0) and pulp softening. For storage studies, fingers of plantain were either wrapped in dried and slightly remoistened plantain pseudo-stem (with and without potassium permanganate (KMnO_4)) and placed in black polythene bags or polythene bags with KMnO_4 only. The rate of ripening was monitored by measuring changes in starch content, reducing sugar content, and total soluble solids. Based on changes in the physicochemical parameters, storage in shredded plantain pseudo-stem increased the green life of plantain from 4-7 days (wrapped in polythene sheets alone) to 16 days as evidenced by the slow rate of reduction in starch content and increase in sugar content over the period. The increase in total solids was lowest for the package with pseudo-stem only over the storage period. A combination of shredded plantain pseudo-stem and KMnO_4 shortened the green life and ripening begun after 8 days. Starch content reduced significantly by the 8th day, with the corresponding significant increase in sugar content and total solids. Introducing some form of packaging will help maintain the quality of plantains and reduce postharvest damage to plantain during transit. The use of wooden boxes, plastic baskets and paper cartons lined with plantain leaves or polyethene sheets could be promoted as readily available low-cost packaging for the transportation of plantains. Plantain leaves and pseudo-stem which otherwise would be left to go waste can be put to good use as low-cost packaging materials. These can effectively reduce damage during transit and also help to delay ripening in plantain, with a resultant reduction in post-harvest losses.

Keywords: Plantain, pseudo-stem, packaging, packaging material, quality

Deploying Solar-powered Cold Storage Technologies to reduce Post-harvest Losses: Barriers and Opportunities in Tanzania

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In Tanzania, between 30 and 50 % of fresh vegetables and fruits are lost soon after harvest. Lack of cold storage facilities is one of the leading causes of rapid spoilage of fresh vegetables and fruits before reaching consumers. In recent years, the adoption of affordable, solar-powered cold storage technologies has proved to hold great potential for preventing losses of fresh produce, particularly for resource-poor farmers suffering from excessive food losses. This is particularly important for many Sub-Saharan African countries, including Tanzania, where millions of rural residents lack access to clean cooling technologies and uptake of solar-powered cold storage is limited. It is widely recognized that the effective deployment of solar-powered cold storage technologies can substantially reduce postharvest losses, increase food supply and income for resource-poor farmers while reducing carbon emissions. Findings in Tanzania revealed that the adoption of solar-powered cold storage facilities is constrained by high upfront costs, small market share, lack of financing, weak regulatory, technical, and institutional support. Therefore, the present work will highlight how state and non-state actors can intervene to enhance the dissemination of such facilities to low-income farmers in Tanzania and beyond. Evidence shows that with adequate government support coupled with a favourable policy environment, solar-powered cold storage technologies can be widely adopted by rural smallholder farmers in off-grid locations.

Keywords: Postharvest, cold storage, food losses, small-scale farmers

The need for adoption of improved technologies to address challenges in small-scale cassava processing in Ghana

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The cassava processing industry in Ghana is dominated by small-scale processors who contribute valuably in terms of processed products such as gari, cassava flour, and cassava dough, among others, and as a result play a major role in the postharvest food system of the country. Their activities depend mostly on traditional methods of processing which have limitations in relation to the quality and quantity of the processed cassava products. They also rely mostly on manual labour which can be slow, costly or unavailable. Mechanisation of key operations in processing activities has been identified as a means of increasing production, reducing postharvest losses as well as saving time. Therefore, this study sought to assess the need for adoption of interventions or technologies to address challenges encountered in identified critical points during processing of cassava into a local staple known as gari. Cassava processors in selected parts of the Ashanti and Bono East regions of Ghana were involved in the study. Focus group discussions and semi-structured questionnaires were employed for data collection. Results show that the main technological interventions used by small-scale processors in gari production are the grating machine and screw press. It was however, noted that other key areas that require interventions are peeling and roasting. All the processors currently use manual means for cassava peeling and it was identified as the operation that requires the highest number of persons (that is 15-18 people), to peel about 5-6 tonnes of cassava using about 6-9 hours. The process of manual peeling was identified as the main source of postharvest loss during small-scale processing of gari, resulting in about 13.90 (± 1.49) % loss of fresh cassava which can produce about 178 kg of gari (from 5-6 tonnes of cassava). An effective mechanical peeler was therefore identified as key to facilitate gari processing in terms of operation speed and eliminating the over-dependence on manual labour. It is therefore recommended that such a peeler be developed, evaluated and disseminated for adoption by small-scale cassava processors. Other important developed interventions like mechanical roasters and improved stoves are also recommended to enhance gari processing. Outcome from this study is useful to researchers, investors, processors, policy makers and other stakeholders on the specific aspects of the gari processing to focus on in terms of research and investment.

Keywords: Cassava processing, gari, peeling, drudgery, postharvest losses

Effect of Processing Methods and Gamma Irradiation on the Quality and Shelf-Life of Squid (*Doryteuthis sibogae*)

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Squid meat (Calamari) which is locally known as posena in Ghana, is a delicacy rich in nutrients with perishability and postharvest losses. Squid meat is highly susceptible to spoilage due to its high moisture and protein content, therefore there is a need for immediate processing and preservation after a catch to extend shelf-life. This study was conducted to assess the effect of three (3) processing methods (frying, salted sun-drying and smoking) and the use of gamma irradiations (0, 2, 4, 6 and 8 kGy) on the quality and shelf-life of squid (*Doryteuthis sibogae*) stored for 12 weeks under 22°C and RH of 50%. Processed squid (fried, salted sun-dried and smoked) obtained from Mankessim, Cape Coast and Takoradi, were packaged in zip-lock bags, irradiated and stored for 12 weeks in a 3x5 factorial completely randomized design and replicated 3 times. The studied parameters were microbial load, nutritional content, trace elements, heavy metals, shelf-life and sensory attributes. Results revealed that the application of gamma irradiation significantly ($p \leq 0.05$) reduced the level of microbial contamination (total coliform counts, total viable counts, faecal coliform counts and *Salmonella typhi*) in fried, salted sun-dried and smoked squid samples – making it safe for consumption. However, the non-irradiated squid samples (controls) had a high level of microbial contamination that was above the permissible limit of wholesomeness. Also, irradiation had little or no effect on the level of trace elements and heavy metal contents as well as nutritional qualities of the samples although the fried sample irradiated at 8 kGy had significantly ($p \leq 0.05$) higher protein (21.80%) and ash (17.87%) contents with a reduced level of moisture (3.60%) and free fatty acids (0.82%), maintained the sensory attributes to appreciable levels than the control, with prolonged shelf-life of processed squid samples for 12 weeks with little or no sign of deterioration and pest damage. Sensory evaluation conducted at week 12 also indicated that fried squid irradiated at 6 and 8 kGy possessed higher consumable qualities and acceptability followed by smoked (8 kGy) and salted sun-dried (8 kGy). The introduction of gamma irradiation (6 kGy) on fried squid samples was the best with high levels of acceptability, safety and an effective method of preservation as well as assured microbial, nutritional and sensory qualities as according to Ghana Standards Authority and the FDA standards.

Keywords: Irradiation dose, Postharvest quality (microbial load), Processing methods, Shelf-life.

Reducing Post-harvest Losses in *Dioscorea* spp. to Plant-Parasitic Nematodes Using Abamectin Treated Banana Paper in Krachi Nchumuru District of Ghana

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Nematodes cause extensive losses in almost all cultivated crops such as vegetables, fruits, and root and tuber crops including yam. Yam (*Dioscorea* spp.) is a high-value root and tuber crop with global significance. It is a multipurpose crop providing food, income, medicine, raw material for industries as well as a ceremonial crop with social and cultural relevance. Nematodes are the major pests of yam. The major nematodes that attack yam in West Africa are the root-knot nematode, yam nematode and lesion nematode. A study was conducted using banana paper pre-treated with abamectin for the management of key plant-parasitic nematodes of yam, for increased yield and storability in Oti Region of Ghana. The research was conducted in both dry and wet seasons, comprised of three treatments (banana paper with abamectin (A), banana paper without abamectin (B) and the control which was the farmer practice (FP)), with four replications. Seed yams were wrapped with the banana papers before planting. Before planting, soil samples were taken from the various plots within each farm, to assess the nematode population densities. Samples of seed yams were also selected for nematode isolation. The treatments were applied using the 'wrap and plant' technology. Data was taken on germination percentage. At maturity, the harvested tubers and soil samples were again assessed for nematode density to confirm the efficacy of abamectin in controlling nematodes. Nematode population densities in harvested yams ranged from 1 to 44 for treatments A and B respectively for Chinderi (Site 1) and Lambuisi (site 2) for dry-season trials. However, for the wet season, nematode population densities ranged from 2 to 39 for treatments A and B (Grubi) and Site 1 (Chinderi) respectively. Significant differences ($P = 0.018$) existed among the various treatments during storage periods for Months 1 to 3 among the various sites and seasons. Yams in treatment A generally had higher tuber weights in storage compared to the other treatments for the various sites over the storage period. This 'wrap and plant' technology provides useful information on yam storability and sensory properties.

Keywords: Nematode, Yam, Abamectin, Banana paper.

Tomato Postharvest Handling Practices by Smallholder Farmers in Major Tomato Growing Areas of Kenya and Options for Loss Reduction

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Tomato is an important crop for small-scale farmers in Kenya. It is consumed in households, sold to earn income, and it is an important raw material for industrial processing. Despite the enormous use for tomatoes, postharvest losses have been a major discouragement for the growers as over 50% of the harvested produce is lost due to inappropriate post-harvest handling practices. Reasons for the high postharvest losses are, however, not clearly understood. The objective of this study was to assess the current status of postharvest handling practices by smallholder farmers in major tomato growing areas of Kenya and provide recommendations for postharvest loss reduction for sustained profitability of the crop value chain. Data was collected through structured interviews with 418 tomato farmers (males=296, females=122) in Bungoma, Kajiado, Kiambu and Kirinyaga Counties. The data was analysed using descriptive statistics and analysis of variance. Results show that the main maturity indices for harvesting tomato were colour change (practised by 59.8% of farmers), fruit size (23.5%) and time taken from flowering to fruit formation (13.7%). The main harvesting containers were plastic crates (41.3%), plastic buckets (37.8%), wooden crates (15.1%), sacks (4.6%) and traditional baskets (1.2%). Over 93% of farmers sorted and graded their tomatoes after harvesting. Sorting was applied to discard pest and disease infected tomatoes, whereas grading was based on size - i.e. large, medium and small. Most of the harvested tomato was stored under shade on the farm for 3-6 hours before marketing. No cold chain was used during the transportation of tomatoes to the market. Tomatoes were transported in stacked plastic crates and wooden crates by farmers, leading to losses due to bruising and crushing of the produce. Overall, the postharvest losses across the various value chain nodes were estimated to be over 50%. Age of household head and access to information significantly influenced postharvest handling practices ($p \leq 0.05$). From this study, it can be concluded that, whereas the farmers were aware of the right maturity indices for harvesting tomatoes, the subsequent postharvest handling practices were inappropriate, leading to high losses. The main important factors influencing postharvest losses were harvesting practices, inadequate postharvest information and transportation. Understanding postharvest handling practices would help to devise appropriate strategies for postharvest loss reduction for a sustainable tomato value chain in Kenya. Such strategies include awareness creation on the economic and nutritional importance of tomatoes and development and dissemination of climate-smart postharvest and value addition technologies to all value chain actors.

Keywords: Tomato, postharvest handling, food security, Kenya

Climate-Smart Technologies for Postharvest Loss and Waste Reduction in Banana Value Chain in Kenya

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Banana (*Musa acuminata* L.) is an important crop grown in Kenya, accounting for 32% of the total value of fruits. Banana is a major source of food, livestock feed and income in most parts of the country. It is a rich source of carbohydrates, vitamins and minerals and has long been regarded as ideal baby food. Significant progress has been made by the Kenya Agricultural and Livestock Research Organisation (KALRO) and stakeholders to introduce superior yielding varieties. With increased yields of the improved varieties, there is a need for wider utilisation and an expanded market. However, lack of information on the versatility of banana as a food ingredient and its potential to substantially provide macro-and micronutrients (provitamin A carotenoids) has resulted in under-exploitation of the diverse varieties. Postharvest losses and wastes are high, estimated to be upwards of 30%. To reduce postharvest losses and waste and enhance consumption and commercialisation, climate-smart technologies were inventorised for postharvest handling and value addition of bananas. These technologies included harvesting (maturity indices, bunch bagging, harvesting tools and assembly, stackable crates), sorting and grading, curing and washing, packaging, use of low-cost storage systems (Zero Energy Brick Cooler, Coolbot™), and producing value added products – banana flour, bakery products derived from composite banana flour, banana chips, banana juice, wine, banana jams and jelly. The technologies were introduced to farmers and value chain actors in major banana growing areas of the country. Using participatory and practical hands-on sessions, 82 trainees (males=43, females=39) comprising of agricultural extension officers, lead farmers and service providers were trained as trainers (ToTs) on postharvest handling and value addition of banana into shelf-stable intermediate products. Sensory evaluation of the products showed high consumer acceptability of the value added banana products. These technologies can reduce postharvest loss and waste from over 30% to less than 5%. The ToTs were to train farmers and other value chain actors to invest in banana farming as a viable commercial enterprise. Effective dissemination of the technologies will contribute to a sustained banana value chain by reducing postharvest loss and waste, thereby enhancing the food security and livelihoods of the value chain actors.

Keywords: Banana, postharvest handling, Kenya

Understanding awareness, knowledge, and constraints to adoption of grain hermetic storage in Northern Uganda

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Grain production in Uganda is considered one of the key economic activities responsible for guaranteeing food security and household income of smallholder farmers. Post-harvest losses (PHLs) of grains, however, remain high and threaten their contribution to economic development and food security. Grain PHLs are estimated to be between 10-30% in the country and are attributed to several causes. Storage losses are considered one of the greatest contributors to total grain PHLs. Hermetic storage is being promoted in many Sub-Saharan African countries including Uganda as a chemical-free and sustainable grain protection technology with almost negligible grain storage losses. However, awareness, adoption and use of hermetic storage technologies (HSTs) remain low in Uganda. This study was carried out to understand the knowledge and awareness, utilization, and constraints to the adoption of HSTs by smallholder farmers in Northern Uganda. Three hundred (300) active grain smallholder farmers in the region were purposively selected and used as respondents for a semi-structured questionnaire to understand their knowledge, awareness and constraints to the adoption of different HSTs marketed in the country. 52.3% of the respondents were aware of hermetic storage use for grains. Awareness of HSTs by farmers in decreasing order were SuperGrain bag (36.0%), PICS bag (33.5 %), metallic silo (15.8%), and plastic silo (14.7%). The respondents were not familiar with any other hermetic storage brand marketed in Uganda outside those listed. Of those who are aware of HSTs, only 34.4% have ever used any form of HST. Of those who have used hermetic storage, 34%, 60%, 2% and 12% have used PICS bag, SuperGrain bag, metallic silo, and plastic silo respectively. Lack of availability, high cost, and inadequate knowledge are the three main constraints that hinder the adoption and utilization of HSTs in Uganda. The government, manufacturers of HSTs, and other stakeholders may need to consider improving the utilization of the technologies in the country through addressing these constraints raised by the farmers.

Keywords: grain production, post-harvest losses, hermetic storage, smallholder farmers, food security

Effect of lactic acid fermentation on nutritional and antinutritional compounds in African nightshade

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African nightshade (ANS) is among many underexploited and neglected indigenous vegetables. If adequately utilized, the crop can improve nutritional, sensory, and keeping quality. This study assessed the effect of fermentation on the nutrients and antinutrients composition of fermented *Solanum villosum* (SV) and *S. scabrum* (SS). Both spontaneous fermentation (SF) and controlled fermentation (CF) (*Lactobacillus plantarum* and *Leuconostoc mesenteroides*) were employed. Fermented relish was prepared from the pickle with the addition of cooking oil, onions, pepper, ginger, turmeric and cinnamon. A significant reduction in pH from 7.4-8.2 to 3.1-3.2 and an increase in titratable acidity (TTA) from 0.045-0.072% to 0.85-1.42% was observed in SF after day 30. On the other hand, a significant ($p < 0.05$) decrease in pH from 7.4-8.4 to 3.1-3.5 and an increase in (TTA) from 0.04-0.07% to 0.35-0.4% was observed after 24 h in CF. A slight decrease of β -carotene from pickle to relish in CF (4.0-6.6%) and SF (4.4-6.6%) in all the formulations. The highest β -carotene content of 155.3 mg/100g was observed in SV-SF pickle $p < 0.05$. A significant decrease ($p < 0.05$) in vitamin C for CF (88 - 90%) and SF (94 - 95%) pickles a further reduction in vitamin C was in relish making. Fermentation substantially decreased oxalate levels in SF (89 - 82%) and CF (76-81%) for pickles and 90-92% for relish. Tannin levels reduced by 82 - 86% and 76 - 83% in SF and CF, respectively. Furthermore, a reduction in phytate levels was also observed. Total phenols decreased by 26 - 29% and 39 - 43% in CF and SF, respectively. Fermentation significantly decreased chlorophyll from 52-57.8 g/kg to 31.9-48.3 g/kg. Also fermentation significantly reduced minerals, P (1080 mg/100g -1166 mg/100g to 264-439 mg/100g), Ca (3113-3392 mg/100g to 866-2445 mg/100g), Fe (148-185 mg/100g to 61-82 mg/100g) and Zn (5.5-8.0 mg/100g to 1.3-1.9 mg/100g). Further reduction of minerals was observed in relish making. However, fermentation slightly increase nickel content from 0.26-0.29 mg/100g to 0.3-0.86 mg/100g. Fermentation can preserve ANS, with an increase in β -carotene and reduction in antinutrients. Both CF and SF can be recommended to small-scale farmers, small-scale processors, and households to improve their nutrition and livelihood. However, CF took a short time (3-4 days) to finish than SF (25-30days).

Keywords: African nightshade, fermented pickle, vitamin C, minerals and antinutrients.

Trends and constraints in the utilization of African nightshade (*Solanum nigrum* complex) in Tanzania: A case study of Kilimanjaro and Morogoro regions

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African nightshade (ANS, *Solanum nigrum* complex) is among the most widely distributed and consumed indigenous vegetables in Tanzania. Several challenges hamper the utilization of ANS. This study sought to assess trends and constraints to ANS utilization in Kilimanjaro and Morogoro regions, Tanzania. About 627 farmer's households were involved in the study. Qualitative and quantitative methods were employed to collect information on ANS production, processing, and postharvest handling. The results showed that 72.1% of farmers grow different ANS species, with *Solanum scabrum* vastly cultivated. Also, 79.4% of ANS farmers use irrigation, handheld hoe (97.6%) use pesticides (70.7%), and 64.8% use fertilizer in production. African nightshade is mainly used as food (97.9%), animal feed (41.3%), and medicine (38%). On average, only 5% of ANS sales contributed to family income. Findings show that main constraints to ANS utilization include; pests and diseases (92.9%), lack of knowledge (58%), shortages fertilizer (51%), shortages pesticides (50%), inadequate means of transport (50.4%), lack of extension services (48%), improper postharvest handling (41.4%) and inadequate storage facilities (34%). Postharvest losses accounted for 78.4% loss of ANS. Mitigation measures were; harvesting in small quantities (54.5%) and instant selling (61.9%) of fresh ANS. There was minimal value addition on ANS, e.g., drying (5.3%) and fermentation (1.1%). Moreover, boiling (63.0%) and frying (45.4%) were the typical methods of cooking ANS. More emphasis should be placed on good agricultural practices, providing knowledge to farmers, and supporting inputs such as pesticides, fertilizers, and quality seeds. Furthermore, knowledge on the processing and preservation of ANS is necessary for farmers to improve utilization, reducing losses, and ensuring ANS availability. Also, research should focus on breeding local cultivar, which is resistant to pests and diseases.

Keywords: African nightshade, *Solanum nigrum* complex, cultivation, postharvest handling, processing, preservation, utilization.

Field Crop Loss to Small Scale Mining in Ghana: Coping Strategies for Sustainable Food Supply

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Over the years, small scale mining activities have increased tremendously in Ghana. These have resulted in devastating effects on agricultural production. The intensity of the effects of these mining activities on sustainable food crop production and how farmers have been able to cope with their effects are what this study investigated. The study was conducted in Asutifi North District of the Ahafo Region of Ghana. With the help of a semi-structured questionnaire, and focus group discussions, this study collected primary data from 200 farmers in six mining communities. Descriptive statistics were used to analyse data and the results were presented in bar charts and frequency distribution tables. Thematic and content analysis was also used in the discussion of the findings. The study revealed the effects of small scale mining activities on field crop production to be loss of arable land, shortage of labour for agriculture activities, high cost of foodstuffs and intermittent shortage of food for the household. All these effects stem from the fact that land, water, natural forest and active labour which are key resources for food crop production are affected thereby having implications on sustainable food systems. In the face of substantial loss of field crops due to small scale mining activities, farmers have adopted some ex-post coping strategies to ensure sustainable food supply and food security. The common coping strategies of farmers in the study area include land reclamation, resettlement to different communities, petty trading and supply of labour to miners. Apart from the supply of labour to miners, all the coping strategies can be the surest solution to sustainable food supply and hence these strategies need to be promoted within mining areas.

Keywords: Field crop, coping strategies, galamsey, artisanal small scale mining.

The Effect Of Storage Periods On Selected Nutritional Values Of Pumpkin Fruits (*Cucurbita pepo* Linn.)

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Pumpkin, a member of the Cucurbitaceae plant family is an underutilized crop in Nigeria. Neglected and underutilized plant species (NUS) have been found to have the potential to alleviate food and nutrition insecurities in Africa. Pumpkin, for instance, has bulky fruits with a very long shelf-life. Almost all its parts are used as vegetables at different developmental periods. The pumpkin edible plant parts have between 20 to 30% protein and 80 to 90% antioxidant activities. The seed used as an alternative to "egusi" melon (soup thickener) has over 50% fat. The morphotype "orange" is used as an alternative to the regular tomato, while the morphotype "green" is eaten just like a potato. The crop needs minimal agronomic input to yield optimally and it is drought resistant. Rural dwellers that commonly utilize pumpkin keep the fruits at room temperature for many months depending on the morphotype. The storage period, however, will not leave the fruits the same biochemically. Hence, this study was conducted to evaluate the effects of storage at ambient temperature and relative humidity on the proximate and selected vitamins (A, C and E) of the green and orange morphotypes of pumpkin fruits. Harvested fruits in 2015 were kept for 4 months (January to April). The experiment was a factorial experiment laid out in a completely randomized design (CRD), storage period and morphotypes being the two factors. The experiment was replicated six times, 15 fruits made up a replicate. The nutritional parameters were determined and assessed monthly throughout the storage period using standard analytical methods. The result showed that Vitamin A did not change in content significantly ($P < 0.05$) across the storage periods and morphotypes while Vitamins C and E content reduced by 15% and 18% respectively when the first and the fourth month of storage were compared. Crude protein and fat contents reduced significantly down the storage periods. However, the reverse was the cases of crude fibre and ash contents which increased down the storage periods. The two morphotypes performed similarly across the storage periods except for crude fibre. It is noteworthy that the concentration of Vitamin A in pumpkin did not change after harvest and a number of the evaluated nutrients were not significantly affected for the first 4 months in storage. This development is especially important for the rural dwellers that don't have the means of preserving this fruit vegetable after harvest. What happens to the crops after four months of harvest at room temperature needs to be investigated nutrition-wise. Nigerian women keep pumpkin fruits for as long as a year, once physical deterioration has not set in and hence tissue collapse.

Keywords: Pumpkin fruits, shelf life, room temperature, protein, vitamins

Investigation of Local Antagonistic Fungal Isolates as Potential Bio-Fungicide in the Post-harvest Preservation of Tomatoes

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Globally, there is almost no comparison to the food losses and wastes recorded for fruits. The Covid-19 pandemic necessitating those countries look inwards to combat hunger and improve food security through proactive prevention of postharvest losses. Cell-free supernatants (CFS) of *Aspergillus*, *Alternaria* and *Penicillium* were tested for their preservative abilities using Agar well diffusion assay, on one hand, and direct surface application on the other hand in a complete randomized block design with four treatments. The first to third were treated with cell-free supernatants of five-day grown cultures of *Aspergillus*, *Alternaria* and *Penicillium* and the fourth was treated with distilled water as control, three replications each containing ten (10) fresh, ripe, firm and smooth tomato fruits. Each group was dried and kept at ambient temperature for shelf-life determination. Tomato fruits were recorded spoiled or deteriorated with a rating of 4 (excellent), 3 (good), 2 (fair), 1 (poor) and 0 (very poor). Analysis of Variance (ANOVA) at a 5% level of significance was carried out. All the fungi expressed high antagonistic effects, in-vivo and in-vitro. *Aspergillus* CFS gave 74% protection compared with 28% recorded for the control. The study revealed that spraying tomato fruits with these non-synthetic fungicides could reduce postharvest loss.

Keywords: Antagonistic fungi, Bio-fungicides, Food loss, Tomato, Wastes.

Assessment of Handling Practices, Physicochemical and Microbiological Quality of Honey along the Supply Chain from Gera District to Jimma Town, Southwestern Ethiopia

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Honey is an agricultural product with varied uses as a food, condiment and has medicinal value. The quality and safety of honey supplied to the market is questionable due to mishandling and suspicion of adulteration for unfair economic gain. This study aimed to assess honey handling practices, physicochemical and microbial quality along the supply chain from Gera district to the main market destination (Jimma town) in the southwest part of the country. The first phase of the study (assessment) was carried out using purposive sampling to select the study area, followed by simple random sampling using pretested semi-structured questionnaires and focus group discussions. Information was gathered from a total of 292 sampled members at different points of the value chain (262 beekeeper households, 5 beekeeper cooperatives and 25 retailers). Honey samples collected from supply chain actors and physicochemical and microbial quality data were collected under laboratory in the second phase (laboratory studies). Results revealed that poor handling practices and adulteration at each supply chain actors negatively affects physicochemical and microbiological quality of honey. Moisture content (18.35-19.42%), water activity (0.48-0.61), viscosity (7.45-10.28 Pas), pH (3.41-4.0), titratable acidity (34.01-36.03 meq/kg), ash (0.1-0.23%), electrical conductivity (0.25-0.39 mScm⁻¹), total soluble solids (75.9-77.5 oBrix), water insoluble solids (0.16-2.48 g/100g), diastase activity (6-14 DN) and hydroxymethylfurfural (0.2-27.7 mg/kg) were recorded. The ranges of values for microbiological analyses were 2.7x10¹-2.29x10² and 3.2x10¹-4.57x10² for total aerobic bacterial and fungal load respectively. There were significant difference (p<0.05) among samples collected from supply chain actors in terms of physicochemical and microbial quality evaluated. The physicochemical and microbial quality of honey degraded from producers to retailers in the supply chain and confirmed that there is mishandling practices and intentional adulteration of honey in the supply chain. Linear regression model developed during adulteration test for HMF, diastase activity, pH and titratable acidity had good linearity (R²>90%) which suggest a good predictive capacity of the models. Therefore, extent of adulteration with sugar syrup could be calculated using the models.

Keywords: adulteration, handling practices, honey, microbial, physicochemical

Application of the Analytic Hierarchy Process in the Selection of a Storage Bag for Shea Nuts Storage in Ghana: Case Study of Ullo, a Shea Growing Community in Northern Ghana

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Production of shea nuts in rural shea growing communities in Ghana has been a challenge for local producers since shea nuts are not properly stored during the harvest season due to the use of traditional storage bags which does not provide adequate protection to the nuts. In this regard, there has been the introduction of hermetic bag storage units for possible adoption and utilization by local producers to reap the benefits of efficient storage of shea nuts for sale or further processing during the off-season. To provide a basis for comparison and selection between a traditional storage bag and a hermetic bag, this study applied the analytical hierarchy process to compare among three bags (the PICS hermetic bag, jute sack, and the polypropylene bag) and select the appropriate bag storage unit for possible adoption for shea nut storage in Ghana. The selection was based on three main criteria; technical performance (maintenance of storage moisture of shea nuts, protection against insect damage and mould development), non-technical (local availability, cultural acceptance, and willingness to utilize by local producers) and cost implications from using these storage bags. With the highest priority weight of 0.44 out of 1.00, the hermetic bag technology proved to be a suitable storage unit for adoption for the storage of shea nuts in rural shea growing communities. Comparatively, the jute sack and pp bags scored 0.25 and 0.35, respectively making them less viable for adoption.

Keywords: shea nut, storage technology, adoption, multi-criteria decision making, analytical hierarchy process

Selection of an Appropriate Biomass Burner for Drying Maize in a Column Dryer Using the Analytic Hierarchy Process (AHP)

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Over the past years, several postharvest technologies have been introduced to help smallholder farmers in sub-Saharan Africa reduce crop losses. However, not all of these technologies fit the same application purpose to meet the needs of farmers in different locations. This study, therefore, applied a multi-criteria decision method, the analytical hierarchy process (AHP), to select an appropriate biomass burner based on its technical performance, cost and design criteria to complete the setup of a low-cost column dryer. With a priority value of 0.69 out of 1.00, the KNUST-ABE Biomass Burner was selected over the AFLASTOP Biomass Burner which had a priority value of 0.31 out of 1.00. Based on the results of this study, the AHP multi-criteria decision method proved helpful in the selection of a locally developed biomass burner for a low-cost column drying system.

Keywords: drying technology, biomass burner, multi-criteria decision making, analytical hierarchy process

Evaluation of Hermetic Bag Technology for Storage Preservation of Shea Nuts in Rural Ghana

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Shea nut is a key nutritional and economic food crop produced in rural shea growing communities in Africa. Storage losses are major constraints in the shea nut value chain, with a substantial amount of shea nut lost before its processing and marketing. Hermetic storage bags have proven to be a viable option for the effective storage of grains in sub-Saharan Africa due to their simplicity, low cost, and efficacy. However, little is known on the effectiveness of hermetic storage bags in the storage of shea nuts. In this study, three different storage bags; hermetic bags, jute sacks, and polypropylene (pp) bags were used to store shea nuts with an initial moisture content of 7.3% (w.b.) and 28% insect-damaged nuts over a 30-week storage period. Each of the storage treatments was made up of 12 bags of 20 kg shea nuts of which samples were taken from 3 bags after every 6 weeks. The quality of the stored shea nuts was assessed based on moisture content, insect infestation and damage, and mould presence and aflatoxin contamination. Temperature and relative humidity of the ambient condition was monitored versus the microclimatic conditions in the storage bags over the storage period. The moisture content of shea nuts was maintained in hermetic bags as a function of ambient temperature and relative humidity conditions since nuts in the hermetic bag varied within 1 percentage point as compared to 3 percentage points for nuts in the jute and pp bags. Insect damage of shea nuts in hermetic bags varied averagely about 2% more of the initial compared to 54% and 52% in jute and PP bags, respectively. Percentage weight loss due to insect damage was maintained at 4.5% in the hermetic bag, 10.1% in the jute sack and 11.6% in the pp bag. Carbon dioxide concentration monitored over the storage period in the hermetic bag was below 6% indicating low microbial activity in the hermetic bag over the storage period. Hermetic bag technology has proven to be a viable option for the quality preservation of shea nuts, and recommendation for its adoption.

Keywords: shea nuts, post-harvest losses, quality preservation, hermetic storage technology, Sub-Saharan Africa

Impact of Hermetic Maize Storage Technology Adoption on Smallholder Farmers' Income in Gatsibo District, Rwanda.

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The growing food demand occasioned by the rising global population is a major issue of global concern. It calls for an increase in food production to meet the global food demand. While studies have revealed that more than 33% of the food produced globally is lost through postharvest operations along the food supply chain, lack of proper storage facilities and food handling practices are among the main causes of food losses. Therefore, the use of appropriate storage technologies is important to curb food losses and ultimately ensure food and nutrition security. Thus, this study aimed to examine the impact of adopting hermetic maize storage technologies (HST) on smallholder maize farmers' income in the Gatsibo District, Rwanda. Furthermore, it investigated the factors affecting smallholder maize farmers' decision to adopt Hermetic storage technologies using an endogenous switching regression (ESR) on a random sample of 301 smallholder maize farmers from the Gatsibo District of Rwanda. The results revealed that the common maize storage technologies used among smallholder farmers were polypropylene bags, chemicals, hermetic bags, and silos. Only 40.5% were HST adopters. Household size, training, access to credit, distance to input provider, and the household head's experience in maize production were the major factors influencing farmers' decision to adopt HST. The occupation of the household head, number of plots reserved for other crops, training, household size, age of the household head, and household maize self-sufficiency goal significantly influenced income from stored maize for both HST adopters and non-adopters. Overall, adoption of HST had a positive and significant impact on income from stored maize, among those who adopted. The study recommends that the government of Rwanda and other stakeholders should support the dissemination of HST to facilitate access. Thus, increased access to institutional support services such as training, credit access, input supply, should be a major part of efforts aimed at promoting the use of hermetic maize storage technologies among smallholder maize farmers, and to increase their effectiveness in improving household income through loss reduction.

Keywords: Hermetic Storage Technology, Post-harvest storage losses, Smallholder maize farmers, adoption, income

Aspergillus Colonization and Aflatoxin Contamination of Post-harvest Maize in East Africa: Systematic Review and Present Status

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Maize (*Zea mays* L.) is an economically important cereal crop in sub-Saharan Africa, particularly in the East African region. Maize is primarily grown in tropical and warm temperate areas, and it has a high nutritional and dietary value compared to other agricultural and food crops. The cereal offers many benefits in numerous households including, dietary provision, poverty reduction, animal feed supply, food security and foreign exchange. Despite its widespread use, maize production has been challenged by many factors, most common are post-harvest losses and mycotoxins such as aflatoxins. Given that maize consumption is expected to rise by 16 % by 2027 as a result of rising livestock and human populations, it is deemed critical to addressing the aflatoxin threat as soon as possible. Reviewing of literature related to aflatoxin contamination, occurrence and distribution across East Africa endeavours to prepare a comprehensive review paper. The review article focuses on analyzing the aflatoxin menace in the context of three East African countries; Kenya, Uganda and Tanzania at the post-harvest level. An elaborate analysis will be conducted to synthesize the aflatoxin scenario in the aforementioned countries with regards to prevalence, frequency of occurrence, quantification, exposure levels and mitigation strategies. Peer-reviewed articles used to prepare this review will be downloaded from PubMed, Research4Life, Google Scholar, EBSCOhost, CrossRef and Scopus. Selection of articles will be done based on their content, specifically, evidence of aflatoxin discussion at length in the context of either one of the three East African countries. The review article will provide an in-depth analysis of the current situation regarding aflatoxin contamination and containment measures across East Africa. It aims at providing ample information on the adverse effects of this mycotoxin, in the human, animal and agricultural spheres. It is anticipated that the review piece will emerge as an educative and enlightening read regarding aflatoxin contamination to farmers, animal nutritionists, scientists and scholars across East Africa and beyond.

Keywords: Maize, aflatoxins, postharvest losses, food security, East Africa.

Colletotrichum gloeosporioides Damage in Avocado (Persea americana): Integrated Phyto-sanitary Approaches towards Sustainable Postharvest Management - Review

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The avocado industry of Kenya is more focused on export market destinations, implying that higher volumes of this fruit target the global markets for sustainable income generation. Besides other factors, one major threat to avocado postharvest management for maintenance of high-quality fruits in Kenya is anthracnose (caused by *Colletotrichum gloeosporioides*). As the export market of avocado fruits reaches saturation, it will be necessary to source alternative markets to absorb the surplus. To access such markets, longer shelf life and transportation durations are critical. In addition, effective treatment of avocado against anthracnose disease at the post-harvest level remains critical towards sustaining their quality attributes. Physiologically mature avocado fruits are highly susceptible to deterioration by anthracnose infection among other factors which include, soft landing, uneven ripening, decay and mechanical damage. Suitable post-harvest treatment of avocado is hence, necessary. Development of avocado postharvest management practices using eco-friendly and non-chemical techniques to prevent anthracnose is a suitable alternative to maintaining their post-harvest quality. The huge postharvest losses incurred in avocado fruits due to infection by anthracnose can be reduced significantly using physical (hot water treatments, electrolyzed oxidizing water treatment, light-emitting diode and ultraviolet radiations and postharvest temperature management) and biological approaches (essential plant extracts, biodegradable polymers and plant defense elicitors). Consequently, this review provides a summary of physical and biological techniques for sustainable postharvest management of anthracnose based on the published research findings.

Keywords: Avocado, *Colletotrichum gloeosporioides*, phytosanitary, postharvest, management

Effect of Pretreatments and Solar Tunnel Dryer Temperature on Proximate and Bioactive Components of Pumpkin (*Cucurbit maxima*) Pulp Powder

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Pumpkin (*C. maxima*) is rich in nutrients, adapts well to local conditions and grows in a wide range of agro-ecological zones. However, it is one underutilized crop due to a lack of enough information about its nutrient contents. Furthermore, the large size of the fruit makes it impossible to use the fruit for one-time cooking, and the leftover parts are susceptible to substantial post-harvest loss. The loss is high due to the lack of a refrigerator in most households to store the remaining portions of the fruit. Production of the fruit is also seasonal and only available for few months. However, the production of shelf-stable value-added products from the pulp reduce the postharvest loss, overcome limitations associated with storage and make the product available throughout the year. Therefore, this study was carried out to investigate the effect of pre-drying treatments and solar tunnel dryer temperature (solar tunnel drier zones) on the proximate and bioactive components of pumpkin pulp powder. Solar tunnel drier of 16 m long divided into three zones considering temperature and RH variation along with the dryer. The experiment consisted of three levels of solar tunnel dryer temperature (45 ± 3.38 , RH 34.58 ± 3.67 , 54 ± 3.70 , RH 31.36 ± 3.40 and 65 ± 3.20 °C, RH, $24.16 \pm 3.40\%$ representing three zones (I, II, III) and four levels of pretreatments (control, 1% citric acid, 2% salt solutions and 2% salt blanched at 65°C for 20 min) laid out in a 3×4 factorial arrangement using Randomized Complete Block Design. Pretreated slices (2mm) dried at three zones of solar tunnel dryer at above-indicated temperatures to a constant moisture content of three subsequent measurements. Results showed that, moisture content of dried powder varied from 6.4-8.2%, 4.7-6.2% in total ash, 1.1-4.2% in crude fat, and 2.4-4.2% in crude protein. The higher ash content could be corresponding to mineral elements concentration in the powder. Slices dried at the highest solar drier temperature resulted in a higher crude protein value pretreated with a 2% salt solution. From the bioactive component the highest total phenolic content, beta carotene, L-ascorbic acid and total antioxidant activity were recorded for sample dried at 54 ± 3.70 °C pretreated with the same salt solution. Dryer zone I representing relatively the lower temperature results in inferior results both in proximate and bioactive compositions. Therefore, the creation of a more homogenous drying temperature and RH along with the driers through mechanical mixing could result in a more uniform drying condition for a quality product.

Keywords: bioactive, proximate, pumpkin, solar dryer, blanched

Mango postharvest technologies: An observational study of the Yieldwise Initiative in Kenya

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Several studies have evaluated the effects of postharvest technologies on postharvest loss (PHL) incurred at a single stage of a food value chain. However, very few studies have assessed the effects of multiple technologies on PHL incurred at various stages of a food value chain. This study evaluated the effects of five technologies (harvesting tools, cold stores, plastic crates, fruit fly traps, and ground tarps) promoted by the Rockefeller Foundation Yieldwise Initiative (YWI) in Kenya on PHL incurred at three mango value chain stages (harvest, transportation, and point of sale). After an extensive screening of the YWI data, the Kruskal-Wallis statistical test was used to compare each YWI promoted technology to smallholder farmers traditional practices. Results indicated that plastic crates used to transport or store mangos and fruit fly traps used to attract and kill fruit flies were statistically significant ($p < 0.05$) in reducing PHL at the point of sale. Meanwhile, no statistical evidence of PHL reduction was observed from smallholder farmers using harvesting tools, cold stores, and ground tarps. Cold stores were the least adopted of the promoted technologies due to their high costs of implementation and utilization. While this study asserts that increased technology adoption is associated with PHL reduction, further research is needed to identify additional factors that favour a technology's efficacy in reducing PHL in similar food value chains. Furthermore, an online interactive mango PHL dashboard was created (<https://phldashboard.shinyapps.io/phldashboard/>) to explore average mango PHL as a function of various factors and their combinations.

Keywords: postharvest technologies, mango postharvest loss, Yieldwise Initiative

Postharvest Standard Operating Procedures; The basis for loss reduction, new trading systems, financing and training

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Standard Operating Procedures for the postharvest handling of fruits and vegetables can significantly reduce food losses and be designed to fit food systems of any kind. These food systems include smallholders as well as emerging middle-sized farmers or large corporations. They can be designed to fit any kind of market type/-requirements/-distance or transport transit time. They also form the basis for innovative developments in the sector. These postharvest SOPs, with a scope from harvest planning until supply to the final B2B client (market, wholesale or retail), involve technical applications, handling procedures, responsibilities, time- and temperature management and meeting market requirements. SOPs can be extended with data registration procedures for certification and traceability if so required. Following optimal conditions for perishables in terms of temperature, time and handling, significantly reduce product damages and spoilage, increase shelf life and increase the distance of markets to which can be supplied. Standardization of postharvest handling leads to consistency in quality and supply. Postharvest SOPs form the basis for any new form of trade- and marketing system that can be introduced like for example E-Commerce or replacing traders and middlemen for Logistical Service Providers (LSPs). In the case of E-commerce, the buyer wants to rely on receiving the quality he/she expect without a physical inspection of the produce. SOPs form the basis for this procedure. In the case of LSP, the farmer keeps ownership of the product during the handling and shipping process and must rely on the LSP to handle his/her products correctly. SOPs are the tool for this procedure and can include data registration actions to make them suitable for Distributed Ledger Technology (DLT)/ blockchain application in the fresh fruit and vegetable commerce that includes smart contracts for automated payments. Once this is in place, farmers build a fully reliable commercial track record which can be used by banks or funds to finance investments based on track-record, rather than on collateral. That leads to an innovative and reliable financing system, can be fully automated, is suitable for any investment level and is very scalable. As a result, postharvest SOP development is the basis for innovative developments in marketing farmer output and funding food supply chain investments. The SOPs also form the basis for standardization of training on postharvest handling and dissemination of postharvest knowledge in value chains, all contributing to food loss reduction. Wageningen University and Research (WUR) is involved in the development of SOPs for fruit and vegetable crops in several countries, including their use for DLT/blockchain applications and training.

Keywords: Quality, loss reduction, blockchain, financing, training

The Journey Towards Reducing Post-Harvest Losses in Uganda Through Developing Intermediate Technologies for Small-Scale farmers in Uganda

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The agricultural sector in Uganda employs 70% of the population and contributes 22% of the country's Gross Domestic Product (GDP). The sector comprises 89 % small-scale farmers (cultivate on less than 5 acres of land). Post-harvest losses (PHLs) in Uganda are estimated at 41% (maize), 33% (millet), 26% (beans), 33% (sorghum), 31% (groundnuts), 22% (cowpea), 17% (sweet potatoes) and 19% (cassava) partly due to the rudimentary inefficient methods used in threshing, shelling, storage, and drying. Also, most small-scale farmers cannot adopt the existing post-harvest technologies due to their high initial, operational, and maintenance costs, and impracticability to specific geographic locations. PHLs among small-scale farmers can only be solved with intermediate technologies, which bridge the gap between high and low-end existing solutions. Therefore, the objective of this technical paper is to document the framework used by Badaye technologies to develop intermediate technologies from the idea to the implementation stage. Pedal-operated cleaner developed specifically for small-scale farmers in rural areas of Uganda was used as an example to show how the stated steps are applied. This document will serve as a reference to other companies and stakeholders interested in reducing PHLs associated with small-scale farmers through developing intermediate technologies.

Keywords: Food security, Post-harvest losses, Intermediate technologies, Machine design, Seed cleaner

Molecular Characterization of Larval Morphotypes of Beet Webworm Moth *Spoladea recurvalis* (Fabricius) (Lepidoptera: Pyralidae) as a Panacea to Postharvest Loss of Amaranths in Africa

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The Beet Webworm Moth (BWM), *Spoladea recurvalis* (F.) is the most economically important pest of amaranths causing up to 100% loss if control measure is delayed. Besides amaranth, BWM also infests groundnut, beetroot, sugar beet, quinoa, watermelon, cucurbits, garden dahlia, carrot, cotton, beans, aubergine and spinach. The extent of damage caused by BWM is characterized by high mobility, high fecundity, ability to thrive in different host crops and great capacity of larval to develop resistance to synthetic insecticides used in its management. The BWM species will be collected on amaranth plants from 15 different locations covering three agro-ecological zones in Ogun State and will be identified with molecular markers. However, early detection of BWM from different agroecosystems is crucial for implementing control measures. In addition, the pest exhibits varying larval morphotypes in different crop ecosystems. Color morphs have been implicated to exhibit varying degrees of susceptibility against different insecticides indicating the presence of strong genetic variability with an adaptive significance for the BWM. This study therefore will be carried out to identify larval morphotypes of BWM on preferred hosts and to characterize these morphotypes using molecular markers. A dendrogram of similarity coefficients and cluster analysis will be used to identify host preference affinity. Genomic DNA will be extracted from twenty-five larval morphotypes using the modified CTAB method and its purity will be checked using a Nano-drop spectrophotometer. Thereafter, they will be amplified with selected fifteen BWM in specific SSR primers containing polyacrylamide gel (10%) and will be visualized in silver stain (2%) solution. Cytochrome Oxidase-I (CO-I) region of the DNA will be subjected to Polymerase Chain Reaction (PCR) amplification. DNA barcoding will be used to confirm the identity of the BWM. The clear and distinct bands of the morphotypes formed will be used for developing DNA fingerprints for individual larval morphotypes. Based on the presence or absence of bands, the Dice coefficient of similarity will be calculated. A dendrogram of similarity coefficients and cluster analysis will be used to identify host preference affinity among amaranth's family. Dissection of representative morphotypes' guts will be carried out to ascertain the occurrence of microbiota aiding better survival of the BWM. Data will be collected on parameters such as larval prothoracic setal arrangement, the structure of male genitalia. Also, morphometric parameters of larva, pupa and adult along with the frequency of larval morphotypes on amaranth crop will be collected from each of the selected locations for constructing morphoclusters based on multivariate analysis techniques.

Keywords: Beetworm Moth (BWM), *Hymenia recurvalis*, Deoxyribonucleic acid, Cytochrome

Oxidase-I, DNA barcoding, SSR markers, Polymerase Chain Reaction, Electrophoresis.

Improving Postharvest Operations and Efficiency in Northern Ghana: The Case of Maize Threshing Machines

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Ghana's agriculture sector is being transformed to strengthen its potentials to increase income and food security, create jobs, and provide raw materials for industry and export. Therefore, matching technologies are required to increase the efficiency of farmers graduating to commercial agriculture. Most of the time, drudgery-prone farm operations are performed by women; a trend requiring cogent interventions to reduce such burden. In this study, maize postharvest operations were studied using focus group discussions, key informant surveys and field measurement of threshing efficiency characteristics. Overall, the farmers were engaged in multiple cropping, for which reason postharvest operations inevitably coincided. This exerts stress on farm labour to accomplish timely postharvest operations. From a myriad of socio-economic reasons (multiple cropping, inadequate farm labour, no access to threshing machines), late harvesting remains a challenge in the production chain. The risks from late harvesting are insect pest infestation, termite damage, lodging, and bush fire. At harvest, grain moisture content was within safe limits (~8 to 14 %), and moisture gradually decreased from October to March. Farmers who employed threshing machines spent 6 to 10 days/ha (~48 to 80 hr/ha) to complete harvesting to storage operations compared to manual operations of 18 to 22 days/ha (~144 to 192 hr/ha). Albeit, the use of threshing machines recorded higher losses (3.4%) but lower physical purity (97.5%) compared to manual threshing (98.8%). The most strenuous operations were harvesting (55.5%), de-husking (20%) and shelling (24.4%). Frequently stated advantages of threshing machines were time-saving (33.3%), energy-saving (28%), cost-saving (22.2%), low postharvest losses (11.0%), and risk reduction (4.4%). Most prioritized constraints requiring attention were scarcity of threshing machines (11%), dwindling labour (9.1%), high cost of labour (8.9%) and high cost of procuring machines (8.6%). Demand for multi-purpose crop threshers (rice, maize and soybean) was high across the districts, although the cost of acquiring such threshers was beyond most farmers. Payment options such as work-and-pay ownership may be suitable if the government and other partners were ready to intervene.

Keywords: Sustainable intensification, gender and drudgery, harvesting, threshing losses, agricultural mechanization.

Improved Precooling Technology for Extending Shelf life of Perishable Agri-Produce in Kenya

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The nutritional composition, market quality and storage life of perishable agri-produce may be seriously compromised within a few hours of harvest unless the crop has been cooled promptly to control deterioration. The major problem during storage is the change in the quality parameters of the produce, especially the physical characteristics such as; colour, flavour, texture, and freshness which have a significant influence on market prices. The deterioration of fresh agricultural food products can alter their nutritional composition and attract the growth of hazardous microbes which may pose health risks to consumers. To extend the shelf life, enhance food safety, attain high-value market destinations and maintain nutritional qualities, agri-produce need to be properly stored. The major factor in the storage environment is the management of temperature and relative humidity. Although refrigeration is the most commonly adopted method of maintaining the freshness of agri-produce at the household level, it greatly compromises the quality of perishable produce such as tree tomato, guavas, mangoes and tomato since they are susceptible to chilling injury. Lack of power supply and little income of farmers in the peri-urban and rural communities makes cooling systems that use electricity expensive. Zero energy cooling occurs when air, that is not too humid, passes over a wet surface; the faster the rate of evaporation the greater the cooling. This technology reduces the storage temperature and increases the relative humidity within the optimum level of storage thus keeping the agri-produce fresh. It is used for the short-term storage of fruits and vegetables immediately after harvesting. The technology is cheap and can be used to prolong the shelf life of agricultural produce. The efficacy of this technology is determined by the humidity of the surrounding air. This paper reviews the theory, impact, principles, and methods of zero energy brick cooling chamber, optimum storage temperature, relative humidity and shelf life of perishable agri-produce.

Keywords: Postharvest, Zero energy cooler, shelf life, relative humidity.

Hub and Spoke Innovation Model for Scaling Postharvest technologies: A Case Study of Small-scale Mango Processing Technologies in Kenya

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Value addition through processing is one of the interventions that can be used to reduce the high postharvest losses in fruits and vegetables, estimated to be 40-50%. However, many small-scale processors have low levels of processing capacity due to limited access to expertise, technologies and finances. As a result, the small-scale processors struggle to meet the market demand (quality and quantity) and are often outcompeted by imported products. To address these challenges, there is a need for a strong food processing support system to help small-scale processors grow their businesses, create more jobs, and serve as a market-pull for farmers. Such a support system requires access to appropriate processing technologies and the technical know-how required to produce consistently high-quality products for target markets. Therefore, the University of Nairobi Postharvest Research Team deployed the 'hub and spoke' technology adoption model (developed and refined by Purdue University), to disseminate technologies for small-scale processing of fruits and vegetables and build the capacity of the processors. At the hub which is located at the University of Nairobi, simple technologies for small-scale wet and dry processing of fruits and vegetables were installed for demonstration and hands-on training of small-scale processors (spokes). The installed technologies include a simple juice processing line which is equipped with a blancher, pulper, pasteurizer, pump, mixing tank and filling tank for wet processing. Installed dry processing technologies include a solar tunnel dryer (locally adapted) and Dehydrays™. The hub supports the spokes through training on good manufacturing practices, product development and/or improvement and agribusiness skills. The hub has so far supported three spokes to establish small-scale processing units equipped with the same technologies at the hub. The supported spokes whose main commodity is mango fruit include Karurumo Smallholder Horticultural Farmers (Embu County); Masii Horticultural Cooperative (Machakos County) and the Association of Kenya Mango Traders (national). Members of the spokes have received practical training conducted at the hub and their premises, on the processing of various wet and dry products from fruits (mainly mango) and vegetables. With continued research and technical support from the hub, the spokes are expected to continue the development of nutritious, safe and high-quality market/consumer demanded products. The spokes also serve as demonstration centres where other processors visit to learn about new technologies and innovative products from fruits and vegetables. This model is expected to result in diffusion of the technologies from the spokes, leading to more adoption in the rural areas which may not have access to the hub.

Keywords: Hub, spoke, processors, innovation, postharvest, mango

Reducing Postharvest Losses-a Panacea to Sustainable Food Security in Nigeria (a Conceptual Review)

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The problem of post-harvest losses among smallholder farmers in developing countries is a recurring phenomenon that affects the socio-economic well-being of farmers. It also determines the achievement of sustainable food security in a given country. Food losses occur during harvesting, handling, processing, marketing, packaging and storage of agricultural produce. In Nigeria, post-harvest losses have risen to over \$9 billion annually which is estimated to be about 50% of foods produced in the country. Crops like fruits and vegetables experience more than 50% of such losses. To this effect, the paper contains a conceptual review on nature, causes, impact and strategies involved in managing postharvest losses of food crops and products in Sub-Saharan Africa with particular emphasis on Nigeria. Relevant texts, journals, online articles and other publications were selected and reviewed in preparing the paper. The review reveals that post-harvest losses occur at different stages of the value chain and they differ based on the type of crops involved. Fruits and vegetables undoubtedly incur the greatest percentage of loss. It also reveals that a significant reduction in post-harvest food loss in Nigeria can reduce the need for food importation and significantly increase food availability in the country. Therefore, the challenges of managing post-harvest losses are not insurmountable. Suffice it to say that what is needed here is to create awareness among farmers through capacity building, extension services and practical demonstrations of post-harvest losses mitigating technologies to ensure quick adoption and wider acceptance. Similarly, relevant stakeholders should collaborate to develop a sustainable and workable eco-system for managing post-harvest losses through value-added market-driven programs.

Keywords: Post-harvest Losses, Food Security, Food Crops, Food Loss Management, Nigeria

Edible Coating Preservation for Tropical Fruits: A Sustainable Health and Eco-Friendly Technique

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In Nigeria, like other developing countries, tropical fruits are grown in large quantities. These fruits have a relatively very short shelf life and can only stay fresh at ambient temperature for 3-5 days after harvest. Postharvest losses in tropical fruits may occur anywhere in the supply chain, from the point of harvest to the point of consumption. Fruits remain as living tissues up until the time of consumption and are expected to maintain freshness and nutritional quality all through their shelf-life. Fruits are important sources of essential nutrients in the human diet, hence there is always a demand for fresh, nutritious, and high-quality fruits by consumers. Most tropical fruits possess a natural waxy layer on the surface called the cuticle and this waxy layer generally has a low permeability to water vapour. This layer is most times partially removed or altered during postharvest handling and storage. Applying an external coating enhances this natural barrier and creates a durable layer. Chemicals such as fumigants, ethylene inhibitors, agrochemicals are commonly used to reduce postharvest losses in fruits. Gamma irradiation at low doses has also been used to increase shelf life and reduce fruit decay. The use of chemicals calls for food safety concerns as they are unhealthy to the consumers. Recently, edible coatings have demonstrated the capability of prolonging the shelf life of fresh food produce by regulating the transfer of moisture, oxygen, carbon dioxide, aroma, and taste compounds in the produce. The health and eco-friendly nature of edible coating make it a suitable preservation method and sustainable biodegradable packaging material for tropical fruits. Edible coatings have the potentials to reduce postharvest losses in tropical fruits and the technique can be adopted by fruit farmers and processors. The work aims to review the concept of using edible coating technology to extend the shelf life of tropical fruits and the recent advances.

Keywords: Shelf life, Postharvest, Packaging, Biodegradable, Quality.

Effect of Coolbot™ Cold Storage and Modified Atmosphere Packaging on Shelf Life and Postharvest Quality of Kale.

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Kale (*Brassica oleracea* var. *acephala*) is a highly nutritious leafy vegetable widely cultivated and consumed in Kenya. However, kales are highly perishable with a shelf life of 1-2 days at ambient resulting in high postharvest losses. The shelf life of perishable produce such as kales can be extended through cold storage. This study, therefore, aimed to evaluate the effectiveness of CoolBot™ cold storage in combination with modified atmosphere packaging to preserve quality and extend the shelf life of kales 'Collards' freshly harvested from the University of Nairobi farm. The experiment was set up under two different agro-ecological zones in Juja sub-county, Kenya at an altitude of 1300m-1500m MSL, with a total annual rainfall of 799mm & average temperature of 19.6°C and in Kabete sub-county, Kenya at an altitude of 1500m-1800m MSL, total annual rainfall of 1000mm & temperature range of 13°C-23°C. At each experimental site, the homogenous batch of freshly harvested vegetables was divided into four batches which were subjected to four different treatments (storage conditions). The treatments included kales packaged using Xtend™ MAP or not packaged and either stored in the CoolBot™ cold room (5±2°C, 75±20% RH) or at ambient room conditions (25±10°C, 50±15%RH). The experiment was laid down as a completely randomized design with a factorial arrangement of treatments and replicated three times. A random sample was taken daily from each of the four storage environments and used to determine cumulative weight loss, yellowing, wilting and color changes. Biochemical analysis was also done to determine the changes in vitamin C and beta-carotene content. The ambient temperatures varied widely within a range of 16.1-32.9°C and 14.5-26.3°C during the storage period for Juja & Kabete experimental sites, respectively. CoolBot™ cold storage extended the shelf life of kales by 6 days & 5 days without MAP and 12 days & 13 days with MAP, in comparison to storage at ambient conditions for Juja and Kabete sites, respectively. The slow rate of deterioration under cold storage (with and without MAP) was evidenced by delayed yellowing, reduced weight loss and wilting compared to ambient conditions in the two experimental sites. Under cold storage, MAP packaged kales lost 28.3% & 36.4% while unpackaged kales lost 40.2% & 47.8% of their initial vitamin C content for Kabete & Juja sites respectively. This was significantly lower ($P \leq 0.05$) compared to 64.9% & 70.4% loss of initial vitamin C content by ambient stored kales in Kabete and Juja experimental sites. The results demonstrate a synergistic effect of CoolBot™ cold storage and MAP in preserving quality and extending the shelf life of kales.

KEYWORDS: CoolBot™, Xtend, Kale, Postharvest Quality, Shelf life

Comparative Evaluation of the Effects of Pretreatments on the Nutritional and Chemical Properties of Ginger Leaf-Based Herbal Tea

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There is increasing awareness and acceptance of herbal teas because of their contribution to nutrition and health. The use of ginger (*Zingiber officinale*) leaves as tea in some communities has been reported. While many research efforts have focused on ginger rhizomes, there is a limited report on ginger leaves' nutritional, antioxidant properties and also what effect application of different heat pretreatments will have on the final product. The present study sought to develop a ginger leaf-based herbal tea and examine the effects of postharvest pretreatments such as steam blanching before drying, hot water blanching before drying and directly drying on the nutritional and chemical properties of the tea. Fresh green leaves were sorted, washed and drained. A batch of the leaves was evenly steam blanched at 100°C for 5 minutes before drying, another set was dipped in boiling water at 100°C for 3 minutes and the last batch was dried directly at 55°C under standard conditions. The dried leaves were milled, packed in tea bags and a sample each was evaluated for its proximate, mineral, vitamin C, phytochemicals and antioxidant properties following standard procedures. The results showed that steam blanching significantly ($p < 0.05$) increased the protein, fat, sodium, potassium, saponin and the antioxidant potential (ferric reducing antioxidant power) compared to those that were hot water-blanching before drying, those dried directly as well as the fresh leaves. However, vitamin C, tannin, phytate, oxalate and zinc contents decreased significantly when compared with the fresh leaves. The free radical scavenging activity examined using DPPH activity, phenols and flavonoids did not vary significantly between the steam blanched and fresh leaves. These findings showed that steam blanching of ginger leaves before drying it for consumption as a functional beverage is beneficial in terms of nutrient and antinutrient properties compared to hot water blanching before drying and direct drying.

Keywords: Tea, pretreatments, steam blanching, ginger leaves

Evaluation of the effect of Harvest Stage and Nitrogen Fertilization on Postharvest Shelf life of Black Nightshades (*Solanum nigrum*) and Kales (*Brassica oleracea* var. *acephala*).

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Vegetables are crucial components of the human diet because they fill the nutritional security gap and are widely available for both low- and high-income earners. However, most vegetables, especially the leafy type are highly perishable with a short shelf life. This affects their availability and contributes to high post-harvest losses estimated to be 9-25% in Kenya. The high losses in vegetables are attributed to various preharvest, harvest and postharvest factors. This study aimed at investigating the effect of nitrogen fertilization and harvest stage on the postharvest shelf life of two popular leafy vegetables in Kenya; kales (*Brassica oleracea* var. *acephala*) and black nightshades (*Solanum nigrum*). Kales and black nightshades were planted in the University of Nairobi, field station. Four levels of nitrogen were applied at the rates of 0.0 g (control), 0.60 g, 1.2 g and 1.80 g per plant in black nightshades and 0.0 g (control), 4.0 g, 8.0 g and 12.0 g per plant in kales. The vegetables were harvested at three different harvest stages; 4 weeks, 6 weeks and 8 weeks after transplanting. The experiment was arranged in randomized complete block design with a factorial arrangement of the treatments (nitrogen levels and harvest stage). The harvested vegetables were kept at ambient room condition with a temperature of 20°C and 55% relative humidity. Data were collected every day for quality-related parameters including color change, wilting index and cumulative weight loss until a predetermined end-stage. The results showed that kales and black nightshades harvested at eight weeks had a longer shelf life of three days and two days for kales and black nightshades respectively. Hue angle for black nightshades and kales reduced significantly in days at different harvest stages. Black nightshades that were subjected to nitrogen level 4 at harvest stages 1 and 2 had the highest wilting index of 3 based on a 5-point hedonic scale. The highest cumulative weight loss (29.8%) was recorded on day 2 for kales subjected to nitrogen level two and harvest stage 1. Kales subjected to nitrogen level 2 for the first harvest showed the best color at a hue angle of 135.3° with the lowest wilting index of two at day three based on a 5-point hedonic scale. Early harvesting of vegetables leads to poor keeping quality vegetables hence poor nitrogen management, as well as improper harvesting stage, affects the quality of vegetables at harvest as well as their longevity, therefore, leading to postharvest losses.

Keywords: Harvest stage, Nitrogen fertilization, Postharvest losses, Pre-harvest factors,

Comparison of some Quality Parameters of Dried Fruit and Vegetable Crops using Open-Air Sun Drying and a Novel Portable Solar Dryer

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The preservation of crops through drying is vital to storability and increasing the shelf life of processed crops for some time. The quality of dried crops can be compromised during open-air sun drying as the crops are susceptible to air-borne particles, microorganisms, insects, bird droppings, and roaming animals. The adoption of the solar drying method is low due to the maintenance and handling operations and the extra cost of solar dryers which still pose a challenge to smallholder farmers who often use the open-air sun drying method. This study evaluated the performance of a novel portable solar dryer (DehytrayTM) in comparison with the open-air sun drying method on tarpaulin using okra, pepper and plantain. The study was carried out in Ibadan, Oyo State, Nigeria. Fresh crops were used for the drying experiment and were divided into two portions – blanched (soaked in NaCl solution of 7 g/100 g for 1-2 mins) and unblanched. The first portion of crops was blanched before slicing and then sliced unblanched crops were placed as a thin layer on tarps for the open-air sun-drying method and in the DehytrayTM. Water activity less than 0.60 was the benchmark used to indicate that the crops were dry and good for storage. Some food quality parameters such as phytosanitary, color change and insect count were determined for dried crop samples. The phytosanitary was carried by physical inspection and visual observation for foreign materials. There was a significant association ($p < 0.05$) between the impact of drying methods on color change of dried okra, plantain and pepper, respectively. There was a significant association ($p < 0.05$) between the impact of drying methods and phytosanitary conditions of dried okra, plantain and pepper, respectively. After 7 weeks of storage, 20 and 10 drugstore beetles (*Stegobium paniceum*) were found in the sun-dried unblanched and blanched okra samples, respectively, while no insects were found in the okra dried using DehytrayTM. Furthermore, for plantain, 15 and 6 red flour beetles (*Tribolium castaneum*) were found in the sun-dried unblanched and blanched samples, respectively while no insects were found in all samples dried using the DehytrayTM. No insects were found in dried pepper samples (unblanched and blanched) for both drying methods. The simple assemblage, maintenance and handling operations using the DehytrayTM make the drying process of crops easier while ensuring the quality of dried crops.

Keywords: DehytrayTM, postharvest, insects, solar drying, food security.

Efficacy of chitosan edible coating functionalized with four medicinal plants extracts in alleviating shrivel and maintaining the quality of purple granadilla

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The high perishability of the purple granadilla fruit (*Passiflora edulis* var. Ester) limits its marketability and profitability. These losses are a result of high respiration and ethylene rate as well as fruit shriveling. This work investigated the ability of chitosan edible coating (2% w/v) functionalized with 2% of 0.1 mg/L of four medicinal plant extracts in alleviating shrivel and maintaining the quality of purple granadilla fruit. The medicinal plants used included water berry leaves (*Syzygium cordatum*), large sour plum leaves (*Ximenia caffra*), black-jack leaves (*Bidens pilosa*) and fever-tea leaves (*Lippia javanica*). These plants are known for their high antimicrobial and antioxidant capacity and have been used traditionally for food preservation. Granadilla fruits (600) were dipped in the different composite coatings for 3 min and subjected to cold storage conditions ($8\pm2^{\circ}\text{C}$ and $90\pm5\%$ relative humidity [RH]) for 32 d. Control fruits were only dipped in distilled water. Sampling was done every 8 d after cold storage plus 5 d of simulated marketing conditions ($22\pm5^{\circ}\text{C}$ and $65\pm5\%$ RH). Compared with the control group, chitosan composite coatings, regardless of medicinal plant extract used, showed promising efficacy for postharvest preservation of the investigated granadilla cultivar. However, their efficacy varied with the different medicinal plant extracts applied. Fruits coated with chitosan functionalized with *Lippia javanica* had the lowest respiration rate ($60.1\pm1.59\text{ mL CO}_2/\text{kg}\cdot\text{h}$), while those coated with chitosan functionalized with *Syzygium cordatum* exhibited the lowest ethylene rate ($39.5\pm3.88\text{ }\mu\text{L C}_2\text{H}_4/\text{kg}\cdot\text{h}$), the highest TSS ($16.43\pm0.40^{\circ}\text{Brix}$), TA ($14.73\pm0.26\%$), yet the highest TSS/TA (1.74 ± 0.096) was observed from chitosan functionalized with *Bidens pilosa*. Granadilla fruits coated with chitosan functionalized with *Bidens pilosa* had a relatively lower weight loss ($51.67\pm3.04\%$), lowest shrivel incidence ($20.00\pm2.63\%$) and the lowest rind color intensity (9.66 ± 0.82), while fruits coated with chitosan functionalized with *Lippia javanica* exhibited the lowest hue angle (43.8 ± 5.67). The results obtained from this study showed that the prepared chitosan coating functionalized with the different medicinal plant extracts can alleviate shrivel and maintain the quality of the investigated granadilla cultivar. It also has the potential to be developed into a new edible coating that can be adopted by the industry and commercialized.

Keywords: *Passiflora edulis* var. Ester; shrivel; perishability; climacteric; edible coating

Predicting Oxygen Depletion during Grain Storage using Hermetic Bag Technology

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Hermetic storage is an alternative technology that effectively controls insect activity in stored grains, oilseeds, and pulses without using pesticides, thus preserving product quality. Grain moisture content will stabilize while oxygen (O₂) level reduces, and carbon dioxide (CO₂) increases through respiration of the commodity, insects, and fungi. One growing type of hermetic storage technology that uses gas impermeable film as a liner inside a woven polypropylene (PP) or jute sack is the hermetic storage bag. It is a growing innovative technology that aims to improve smallholder farmers' food safety and security. Despite the increasing adoption of this technology in Central America, Sub-Saharan Africa, and Asia, more research is needed to address and understand the factors influencing the effectiveness of these hermetic liners. One factor is how these bags achieve and maintain a low-oxygen environment and effectively preserve stored grains without chemicals. In this study, a spreadsheet summary dashboard and calculator were developed to predict oxygen depletion in hermetic storage bags as a function of insect, fungi, grain respiration, and bag liner properties. Oxygen consumption of maize is calculated at different moisture contents and temperatures using the dry matter loss equation. In contrast, oxygen consumption by maize weevils is calculated as a function of its different development stages. The oxygen transmission rate of single and double liners is utilized to quantify the gas transmission into the liners during storage. Results confirm that insect respiration dominates oxygen depletion in maize stored at safe storage moisture contents of 13-14% while grain and fungi respiration is negligible. The number of days before oxygen concentration inside the bag reduces below 5% to kill adult insects was determined for different scenarios of grain moisture and temperature, insect infestation, and hermetic bag liner type. Results provide the basis for a better understanding of the science behind the hermetic storage bag technology and ensures the science continues to support the successful adoption of this critical storage technology among smallholder farmers. The spreadsheet will be further modified to accommodate different grain types and insect species.

Keywords: Grain respiration, hermetic storage bag, maize weevils, oxygen depletion, oxygen transmission rate

Analytic Hierarchy Process Applied to the Ranking of Commercially Available Hermetic Bag Liners

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Hermetic bags are a storage technology that uses gas impermeable film as a liner inside woven polypropylene (PP) or jute sacks. The impacts of hermetic storage bags on food security and safety have been well established for more than ten years. It can effectively control insect activity in stored grain and thus preserve grain quality. Grain moisture content is stabilized while oxygen (O₂) concentration is depleted, and carbon dioxide (CO₂) increases through respiration of the stored commodity, insects, and fungi. With the increasing adoption of hermetic bag technology by smallholder farmers in low-income countries, various brands of hermetic bag products are becoming available in the market. Manufacturers and distributors make claims about the performance of their product brands and their efficacy in controlling biological activity. Thus, research is needed to understand the factors that influence the effectiveness of hermetic gas barrier liners.

This study used the analytic hierarchy process (AHP) method as a decision-making tool based on multicriteria analysis for ranking six commercially available hermetic storage bag liner products (AgroZbag, Elite, PICS, SuperGrainbag, Storezo, Zerofly bag) in low-income countries in Sub-Saharan Africa, Central America and Asia. The overall idea of the method is to make a pairwise comparison of the alternatives based on previously defined criteria and sub-criteria, such as key engineering properties, aging properties, and environmental impact. The bag liners were tested for tensile strength, dart impact failure weight, tear force, and permeability (oxygen transmission rate, water-vapor transmission rate) following American Society for Testing and Materials (ASTM) standard test methods. The aging experiment was conducted in an environmental chamber set at 35°C temperature and 70% relative humidity to estimate the changes in the liner properties after six months of use. The environmental impacts were assessed from the cradle to the grave using the Sustainable Minds Life Cycle Analysis (LCA) software. Results provided an analytic approach to rank hermetic storage bag products using science-based decision criteria.

Keywords: Analytic hierarchy process (AHP), engineering properties, environmental impacts, hermetic storage bag, life cycle analysis (LCA)

Field evaluation of hermetic and synthetic pesticide-based technologies in smallholder sorghum grain storage in hot and arid climates

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Field trials to evaluate six grain storage technologies under hot and arid conditions were conducted in two locations in Zimbabwe over two storage seasons. The technologies included three hermetic technologies (Purdue Improved Crop Storage bags, GrainPro Super Grain bags, metal silos); three synthetic pesticide-based treatments; and untreated control, all using threshed sorghum, *Sorghum bicolor* (L.) Moench grain. Sampling was done at eight-week intervals for a period of 32 and 40 weeks during the first and second storage season, respectively. Highly significant differences ($p < 0.01$) occurred between hermetic and non-hermetic treatments regarding grain damage, weight loss, insect pest populations, and grain moisture content; with the hermetic containers exhibiting superior grain protection. Grain damage and weight loss were low in hermetic treatments compared to pesticide-based treatments. *Tribolium castaneum* Herbst managed to develop in metal silos, deltamethrin-incorporated polypropylene bags and a pesticide treatment containing deltamethrin 0.13% and fenitrothion 1%, while *Sitotroga cerealella* Olivier developed in a pesticide treatment containing pirimiphos-methyl 0.16% + thiamethoxam 0.036%. Mechanisms of survival and development of these pests in the tested treatments and under similar climatic conditions need further investigation. The findings of this study show that hermetic technologies can be successfully used by smallholder farmers in developing countries as alternatives to synthetic pesticides for protecting stored-sorghum grain under hot and arid climatic conditions to attain household food security.

Key words: Hermetic storage; organic grain storage; modern grain storage

Field evaluation of alternatives to synthetic pesticides in cowpea (*Vigna unguiculata* (L.) Walp) grain storage under contrasting climatic conditions

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Stored cowpea is highly prone to damage by storage insect pests, chiefly *Callosobruchus rhodesianus* (Pic) and *Callosobruchus maculatus* (F.), leading to high postharvest losses in sub-Saharan Africa. Farmers incur these high losses despite heavy investments in synthetic pesticides and/or pesticidal plants to control these pests. Consequently, farmers respond by pesticide over-application, exposing themselves to increased risks of pesticide poisoning and potential development of insect resistance. A field efficacy trial was conducted to evaluate alternative, grain storage technologies for use in cowpea grain storage. The trial consisted of seven storage technologies: hermetic metal silos, Super Grainbags™, Purdue Improved Cowpea Storage (PICS) bags, ZeroFly® storage bags, Actellic gold dust®, crude *Colophospermum mopane* Kirk ex J.Léonard fresh leaves and untreated control. The trial was conducted in two districts of Zimbabwe over a period of 40 weeks, under smallholder storage conditions using CBC2 cowpea variety. Sampling was conducted at eight-week intervals to determine grain moisture content, grain damage, grain weight loss and total insects per kilogram of grain sample. Seed germination trials were conducted at the end of the storage trials to determine effect of storage technologies on seed viability. Hermetic and Actellic gold dust® treatments were significantly efficacious ($P < 0.001$) for long term storage and recorded significantly higher ($> 70\%$) seed germination compared to other treatments. *Colophospermum mopane* suppressed pest build-up for a period of four months only. Hermetic facilities are an effective alternative to synthetic pesticides under smallholder farming conditions and therefore recommended for long term cowpea grain and seed storage. Modalities for availing the technologies should be put in place to ensure farmer access.

Keywords: Hermetic storage, crude pesticidal plants, bruchids, synthetic grain protectants

Postharvest Loss Initiatives in Palm Oil for TRIDOM with Focus on Cameroon

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In Cameroon, over the past 20 years, the rapid expansion of oil palm cultivation has happened at the expense of its forests, part of the TRIDOM wildlife conservation area within the Congo Basin. In Southwest Cameroon, a top palm oil-producing region in the country, 67% of oil palm expansion from 2000-2015 happened through deforestation. In 2019, Cameroon had a crude palm oil deficit of ~100,000 MT. This high demand is driving a boom in the unregulated non-industrial palm oil sector and is becoming a foremost source of deforestation. The non-industrial sector is driven by smallholders who are responsible for 50% of production but use 70% of the area. The problem tree analysis identified three key factors impacting smallholders driven deforestation as high domestic demand, low yields, and inefficient extraction rates. The average yield of fresh fruit bunches (FFB) for smallholder producers is 8 MT/ha and the palm oil extraction rate is 0.9 MT/ha with no kernel oil extraction. However, the industrial producers achieve 15 MT FFB/ha, 3.1 MT/ha palm oil, and 0.4 MT/ha of kernel oil. To look at the problem of the non-industrial sector's low productivity through the lens of food loss and waste (FLW), Agribusiness Associates Inc. (ABA) conducted this study for WWF in 2020. ABA used Value Chain Analysis (VCA) and Commodity Systems Assessment Methodology (CSAM) to conduct focused crop-level assessment and to provide evidence for system-wide issues, constraints, and opportunities. VCA included a literature review and stakeholder interviews to perform a comprehensive value chain analysis for the palm oil sector. CSAM used a holistic approach to identify postharvest problems and looked at the entire value chain including preharvest factors and supporting institutions. CSAM field data was collected through surveys, interviews of value chain actors, observations of harvesting and handling practices, and direct measurements of quality and quantity losses along the chain. Data were collected from 10 farms and 10 mills situated in three palm oil production basins. Analysis revealed that the postharvest losses in palm oil primarily occurs on-farm and during processing. On-farm loss is relatively small, 5-10% (equivalent to 1% Crude Palm Oil (CPO) loss) and is caused by the harvesting of under-ripe fresh fruit bunches. However, processing losses are very high, 9-15% of total CPO production. Many farmers use artisanal mills for oil extraction. These mills have varying oil extraction rates (OER) of 12% for a manual mill and up to 16% for a semi-motorized mill. These are well below the agro-industrial mills average of 21%. The low extraction rate is the primary driver of food loss in the palm oil sector. Investing in processing equipment will result in improved OER and higher palm oil production without the need for increasing production area, the key reason for deforestation. Further, providing agronomic and postharvest training along with high-yielding planting material and related inputs for rejuvenating older plantations through a partnership between conservation organizations and farmers can result in the sustainable development of the oil palm sector in Cameroon.

Keywords: Cameroon, palm oil, postharvest loss, value chain analysis (VCA), commodity systems assessment methodology (CSAM)

Green Nanomaterials for Post-Harvest Management of Fruits and Vegetables

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Globally, approximately 1,906,000,000 tonnes of fresh fruits and vegetables are produced annually while Africa produces about 187,708,319 tonnes according to Food and Agriculture Organisation (FAO) data. Fruits and vegetable (FV) production is increasing in Africa due to demand globally. However, almost one-third of the produced FV is lost before being sold/consumed. Most fresh FV contain more than 60% water and thus are highly perishable; hence, they are likely to have more post-harvest losses or high post-harvest management costs. Researchers suggest that FV post-harvest losses in Africa are as high as 80% of the total production depending on the type of FV. This has been attributed to lack of post-harvest management skills and appropriate technology. Currently, decreasing post-harvest wastage using the findings of novel scientific researches such as nanomaterials can be the best solution to this problem of lack of post-harvest management skills for FV. Nanotechnology, from Nano filters for water purification in Ethiopia and the United Republic of Tanzania to Nano catalysts and Nano sensors in Egypt and South Africa, is broadening the scope of nanotechnology and addressing some of the development challenges that Africa faces today. Therefore, this research paper examines through existing literature, the nanomaterials utilized for post-harvest management of FV. It further, identifies the nanomaterial utilized, the FV being managed and the function of the nanomaterial. Furthermore, the study identifies the green nanomaterials that can be utilized for post-harvest management of FV in Africa hence sustainable food systems.

Keywords: Africa, Food Security, Nanotechnology, Fruits and vegetable (FV)

Food Waste Management in Reducing Economic Burden of Post-Harvest Loss (Phl) in Africa

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Post-harvest loss (PHL) is a more urgent problem in Africa. Food production is currently insufficient for the expanding population in Africa and as high as 30%-50% of the food produced is lost along the food supply chain. PHL not only has severe environmental and health consequences but it is a major threat to food security and economic stability in Africa. Based on existing evidence in literature, the aim of this review is to illuminate the economic severity of PHL, proposing food waste management (FWM) as an efficient, multisectoral intervention in reducing the consequences of PHL in Africa. Case studies and white papers of various organizations that addressed PHL in Africa as well as studies that discussed the application of FWM as an intervention in various countries of the world were searched for and systematically reviewed. Every year, Africa loses up to US \$4 billion to PHL. Some countries have implemented FWM through donation of excess food to the needy to ensure food security and recycling of food wastes to produce profitable products such as compost and biogas. Denmark, France, Japan and South Korea have successfully mitigated the socioeconomic impact of PHL with FWM by up to 100% while saving up to US \$600,000 as in the case of South Korea. FWM is a promising and sustainable intervention that should be implemented in Africa as it can ensure food security while offsetting the economic loss incurred by PHL in Africa.

Keywords: Post Harvest Losses, Socioeconomic impact, Food waste management, Food loss, Africa

Available and Affordable Postharvest Loss Reduction Technologies: Experiences from Ethiopia

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More than 50% of fresh fruits and vegetables never make it to consumers due to postharvest losses and over half of these losses occur after the produce leaves the farm. These losses are due to lack of suitable technologies to transport, store, preserve, and process fresh fruits and vegetables especially during high production seasons resulting in the inability of low-income consumers to afford such produce. The harvested produce are usually exposed to poor storage conditions such as high temperatures and low relative humidity condition as they await collection by the middlemen, wholesalers, or retailers. The wholesalers and retailers also either sell the highly perishable produce directly to the consumer or temporarily store it under ambient conditions. Because of the high temperature and low humidity conditions in Ethiopia, physiological weight loss (PLW) and postharvest decay of fruits and vegetables are one of the serious problems associated with fresh produce. The growing and marketing of tomatoes in the country is complicated by the unavailability of simple, low-cost, affordable and environmentally friendly postharvest loss reduction technologies. The current study therefore, was conducted to assess the available and affordable postharvest loss reduction technologies in Ethiopia for profitability and maintaining the quality of fruits and vegetables. The study was done by using the cost benefit tools on existing postharvest technologies of Zero Energy Cooling Chamber (ZECC), Charcoal Cool Room Storage (CCRS), Appropriate Onion Storage and Reusable Plastic Crates. Inside the zero energy-cooling chamber, the dry bulb temperature and relative humidity varied from 17.1 to 23.2 °C and 83.2% to 96.4%, respectively, during the storage period. Inside the Charcoal Cool Room Storage (CCRS), the dry bulb temperature and relative humidity varied from 24 to 25 °C and 83.2% to 86.6 %, respectively during the storage period. In Appropriate Onion Storage, less than 10% PWL was recorded after a six-month storage period. This suggests that The Appropriate Onion Storage user would be able to earn an additional +54,600 Ethiopian Birr (ETB) premium profit for each six-month storage. The farmer could therefore earn 53 times the cost of her/his investment in the ZECC during that period, which equals an increase in income of 18,330 ETB per year. The reusable plastic crates users would be able to earn an additional +5,574 ETB premium profit on each load. The Reusable plastic crates investment pays itself within three-round loadings if one truck or 5040 kg of tomatoes is harvested and packed in one round time. The Technology can benefit farmers by allowing them to sell their products in off-seasons, reduce postharvest loss, and reduce market fear loss. It also benefits consumers by increasing food availability and lowering food costs during the off-season. In general, these technologies are very effective for farmers, retailers, and wholesalers to extend the shelf life of fruits and vegetables at an affordable price and benefit the consumer by obtaining the vegetable at a relatively stable price over a long period of time.

Key words: Postharvest technologies, cost benefit, shelf life, tomato, onion

Postharvest losses of tomatoes and the impact of reusable plastic crate technology on profitability of tomato fruits in Ethiopia

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Nearly 20-50% of loss occurring in fruits and vegetables production happen from harvesting to fork. This loss is due to lack of suitable technologies to transport, preserve, and process the produce during high production seasons. Tomato (*Lycopersicon esculentum* Mill) is the most prominent and well-known fruit cultivated in Ethiopia. Tomato production is preferred by farmers because of its multiple harvests, high profitability, and its potential to improve the income and nutrition of households. The growing and marketing of tomatoes in the study area, Eastern Shewa, is complicated by high post-harvest losses. Wholesalers and retailers experience lots of challenges in ensuring high quality fruits for the consumers during storage. The farmers, wholesalers, and retailers also do not operate any intermediate improved packaging materials to obtain better prices by reducing postharvest loss of tomatoes. This study was therefore conducted to investigate the postharvest losses of tomatoes and the impact of reusable plastic container technology on the profitability of tomato fruits. The Commodity System Assessment Methodology (CSAM) and the cost benefit tool were used. During transportation of tomatoes in wooden boxes, up to 6.5 kg of tomatoes were damaged in each box and more than 5 quintals of tomatoes were lost in one round load. The investment cost for wooden crates were 2,520 Ethiopian Birr (ETB) and reusable plastic crates were 16,700 ETB for one truckload (5040 kg). Based on this study, it showed that the reusable plastic crate users would be able to earn an additional +5,574 ETB premium profit on each loading. The reusable plastic crates investment pays itself within three-round loadings if one truck or 5040 kg of tomatoes is harvested and packed in one round time. If the direct marketing (Reusable plastic crates) were used at 50 capacity for two years, the Return On Investment (ROI) would be 16.45 times the cost of the technology, which equals an increase in income of 144,9240 ETB per year. Postharvest losses of tomatoes were reduced by 2% when handled with reusable plastic crates technology. The reusable plastic crates can be cleaned and used more than 100 times before they need to be replaced. Reusable plastic crates are very effective for farmers, retailers, and wholesalers in reducing postharvest losses and improving profitability.

Key words: Reusable plastic crates, wooden boxes, cost benefit, tomato

Colletotrichum musae of Banana (Musa spp): Current State of Knowledge and Phyto-sanitary Practices towards minimizing Post-harvest Losses - Review

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Banana fruits are essential components of human diet as a source of numerous nutrients and contributes to Kenyan economic growth through the Horticulture subsector. This fruit is laden with dietary carbohydrates. It is also rich in potassium for a healthy heart and control of high blood pressure and is therefore highly valued as a food security pillar for both rural and urban households. The banana crop equally sustains livelihoods through income generation for smallholder producers and has a high potential for economic growth through foreign exchange earnings. The continuous fruit-bearing cycle of this together with its potential for staggered production both guarantee consistency and the sustainability of supply for the ever-growing demand. These desirable attributes together with the roles of banana plants in environmental conservation make it a suitable crop for both agro-economic growth and conservation of the agricultural resource base. Anthracnose is a major disease affecting banana and lowers the quality of the fruit and shelf life. The significant drawbacks occasioned by *Colletotrichum musae* in fruit production include reduced yields and high production costs. In many production practices, synthetic fungicides had been widely applied to manage fungal pathogens of fruits and other field crops prior to the adoption of Montreal Protocol—an international agreement for protection of the ozone layer. The setbacks of fruit-borne fungal pathogens from *Colletotrichum* spp including high procurement costs for fungicides and acquisition of resistance by plant fungal pathogens, climate change effects, outbreak of new plant pathogens, and rise in consumer concerns about environmental hazards as well as food chemical residue levels are becoming increasingly evident. These necessitate the use of integrated fruit borne disease management strategies in banana crop production. This paper reviews the taxonomy, epidemiology and pathogenic diversity of *Colletotrichum musae* and ecofriendly approaches towards sustainable management. Such approaches include the use of sanitation, soil solarization, bio-fumigants, anaerobic soil disinfection, soil steam sterilization, biological control and non-synthetic Phyto-fungicides in a system-based approach.

Keywords: Banana, *Colletotrichum musae*, Phyto-sanitary, post-harvest management

Major Constraints to Adoption of Improved Postharvest Technologies among Smallholder Farmers in Sub-Saharan Africa and South Asia: A Systematic Literature Review

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Reducing post-harvest losses could be a sustainable solution to enhance food and income security of smallholder farmers in developing countries. While various research institutions have come up with a number of innovative postharvest technologies for reducing postharvest losses; most of them have not been extensively adopted by smallholder farmers. Despite this gap, the synthesized information about the major constraints of postharvest technology is scarce. This study has been conducted to fill this gap and show the implications of the findings for future postharvest research. The developed search strategy retrieved 2201 studies, however after excluding duplicates, title, abstract and full article screening, a total of 41 documents were identified. The major findings are: (i) there is an outstanding deficiency of systematic evidence of the effect of climate change, off-farm income and sources of postharvest information on adoption of improved postharvest technologies; (ii) there is very limited information on adoption constraints pertaining to matters of policy, rules and regulations; (iii) there is very thin literature on behavioural constraints associated with limited adoption of improved postharvest technologies; (iv) most of the studies focused on postharvest storage technologies (47%) followed by overall postharvest management practices (25%), processing technologies (19%) and packaging technologies (3%). Much of the information was found on cereals (58%), especially maize (44%); (v) geographically, Sub-Saharan Africa accounted for 79% of the reviewed interventions, while South Asia occupied only 21%. The findings of this review are intended to guide various postharvest technologists and decision-makers for addressing the challenge of huge postharvest losses.

Keywords: Constraints, postharvest loss, postharvest technology, smallholder farmer

Reducing Orange Flesh Sweet Potato (OFSP) Losses and Waste: An Evaluation of Triple-S Technology in Northern Ghana

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Food losses and waste coupled with the unavailability of vines at the time of planting have a negative effect on the Orange Flesh Sweet Potato (OFSP) production. Although, employing technology and appropriate strategies could help enhance OFSP productivity. Some organizations, notably, USAID-Resilience in Northern Ghana (RING) and the International Center for Sweet potato (CIP) have promoted a storage technology known as Triple-S (Storage in Sand Sprouting). However, less is known about how Triple-S technology has helped improve the productivity of OFSP. This study examines how the use of Triple-S has helped to improve access to vines and reduced food loss and waste. The study explored primary data collected from three communities in the East Mamprusi Municipality of the North East Region of Ghana. The study adapted a food waste pyramid to analyze the impact of Triple-S in reducing losses and waste associated with OFSP production. The study employed a mixed method - quantitative and qualitative instruments to collect information from selected participants for the purpose of data and analysis. The study respondents were interviewed about their experiences with the Triple-S and its potential to contribute to food security by reducing waste and making vines available for continued production. The paper, argues that the Triple-S technology plays a dual role of contributing to reducing food loss/waste and ensuring availability of vines in the study area. The study established a link between food waste reduction and the Triple-S technology. The study finds that households involved in the use of Triple-S reduced losses associated with OFSP and enhanced access to vines for continuous production, whilst off-farm storage via Triple-S helps increase the shelf life of stored OFSP by households that employed the technique appropriately. Of the respondents interviewed, 68% agreed that the technology reduces food losses/waste, while 71% stated that the technology increased access to vines. Respondents, however, identified the main challenge associated with the technique to be the paucity of sea-sand, the medium of storage employed by the technique. The study was the first to assess losses and waste associated with OFSP through the food waste pyramid, and the paper bridges research gaps around sustainable solution to vines unavailability and food losses and waste associated with OFSP using the concept of food waste pyramid. The study recommends the need for intensifying and championing households' adoption of the Triple-S technology in order to have a greater impact on reducing food waste and losses associated with OFSP production.

Keywords: Triple -S Technology, Food losses/waste, OFSP, Waste pyramid and Food security

Effects of Mode and Timing of Calcium Application on Tissue Calcium and Shelf Life of Mango Fruits

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Mango (*Mangifera indica* L) production in Kenya supports about 200,000 farmers directly and many other beneficiaries. Despite this, its production faces post-harvest losses due to the fruits' short shelf life in ambient conditions. Calcium nutrition is associated with better keeping quality and a longer shelf life due to its role in maintaining cell integrity, strengthening the cell wall and membrane structure. An experiment was conducted to compare the effect of calcium applied as calcium chloride at different concentrations and different stages of fruit maturity on the fruit shelf life. 'Van Dyke' mango fruits were sprayed or immersed in calcium chloride (0.5%, 1% 1.5% or 0%) at physiological maturity or 15 days later. The effect of the treatments on the fruits shelf life was determined from the changes in peel firmness (Newtons), total soluble solids (0Brix), pulp colour (Hue angle 0), beta carotene (mg/100ml) and respiration (CO₂ ml/kg/hr) which were determined at day 0 (initial) and then every 2 days up to 8 days of storage in ambient conditions (25°C ± 2°C and 70% ± 5% RH). Calcium concentration (µg/mg) in the fruit tissue and the relationships with shelf life was also determined. Fruits immersed in calcium chloride at maturity had a higher retained peel firmness (10.6 N, 10.3 N), pulp color (37.45, 36.78), lower total soluble solids (14, 13.8), in seasons I and II respectively, reduced carbon dioxide evolution (30.7 ml/kg/hr), higher beta carotene and flesh calcium concentration than other treatments. Fruits sprayed at physiological maturity exhibited better results in the studied parameters than those sprayed 15 days later. Flesh calcium content reported a positive correlation with flesh firmness ($r = 0.913$, $r = 0.852$), peel color ($r = 0.828$, $r = 0.841$). Application of calcium chloride, 1.5% by immersion is recommended for improved shelf life. However, further research needs to be done on the effect of calcium chloride on the organoleptic attributes of fruits.

Keywords: Mango, shelf life, calcium, organoleptic, post-harvest losses, post-harvest immersion

Nutrient composition of fish protein powder developed from *Brycinus nurse* (Rüppell, 1832)

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Nurse tetra, *Brycinus nurse* is small-sized pelagic, potamodromous species found mainly in African freshwater lakes. Catch statistics indicate that *B. nurse* fishery is one of the emerging commercial fisheries on Lake Albert. Despite the huge harvest, sun-drying and deep-frying remain the principal methods of preservation of *B. nurse*. However, these methods are weather dependent and characterized by low processing capacity with high post-harvest losses. Therefore, the objective of the study was to determine the proximate and mineral composition of the newly developed fish powder and to compare it with Nile tilapia powder already on market. Fish powder was developed from fresh fish and was analysed for nutritional composition following standard protocols. Mineral contents of samples using the atomic absorption spectrophotometer. Protein and ash contents also varied significantly between fried fish and fish powder ($P < 0.05$), with the highest values observed in the fish powder product with 50.4% and 12.3%, of the protein and ash, respectively. The results demonstrated that fish powder had significantly higher levels of calcium (35.1 ± 0.35 g/kg); phosphorous (20.55 ± 3.53 g/kg); iron (125.7 ± 0.28 mg/kg); zinc (75.7 ± 0.14 mg/kg); and manganese (13.2 ± 0.35 mg/kg), compared to either raw or fried samples. Significantly higher protein content (66.7%) was recorded in tilapia powder than *B. nurse* powder (50.4%). The protein in the developed fish powder was more concentrated than in the original fish flesh and can be fit for human consumption. Accordingly, this fish protein powder could therefore serve as a good source of nutrients for the poor particularly in rural and urban areas where limited economic resources prevent dietary diversity.

Keywords: *Brycinus nurse*, fish powder, Lake Albert, Pelagic fish

Assessment And Characterization of Existing Postharvest Handling Techniques of Malay Apple (*Syzygium Malaccense* [L.] Merr & Lm Perry) in the Mount Cameroon Region

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The Malay apple is grown in the Mount Cameroon Region for its edible fruits and used as an ornamental, shade tree or windbreak, as well as for traditional medicine. The characteristics of the Malay apple have led to interest in its potential commercialisation and transformation into wine, jam, and juice. However, the Malay apple suffers huge qualitative and quantitative postharvest losses in storage and handling. A situation which is exacerbated by the high water content of the fruit, lack of storage facilities, poor transportation network, inadequate training on postharvest handling and lack of government support on the production and management of indigenous fruits. The current study aimed to generate relevant information on the postharvest handling and storage of Malay apple in the Mt Cameroon Region as the first step towards transformation and commercialisation of the fruits. Structured questionnaires, farm surveys and study of relevant literature on the subject were used for this study. Of the 200 respondents, the demographic group most involved in the production of Malay apple is aged from 41-50 years, with those adults over 61 years old being the least involved in this activity. Women accounted for 60% of the producers of Malay Apple. It was revealed that there are two varieties of Malay apple in the Mt Cameroon Region; the red and white fruit colour forms. Maturity indices of Malay apple include fruit size, colour and bird feeding prevalence. The fruit harvesting methods include hand harvesting, tree shaking, use of a long-range pole, shooting with stones, and gravity falling of fruits. Hand harvesting, which recorded the least number of damaged fruits (12%) is the most preferred harvesting technique used in the Mt Cameroon Region. Malay apples are packaged in baskets, jute bags and buckets. The bucket ranked first (60%) as the most used packaging material. Storage of Malay apple in well-ventilated and cold environments was revealed to be the best storage method employed by 40% of respondents as opposed to 5 % for refrigerator storage. The postharvest value chain of Malay apple showed that most losses were perceived to occur at harvest (40%), followed by storage (35%), marketing (15%), and transportation (10%). Based on pair-wise ranking, Malay apples are used because they are multifunctional. However, the high water content causes a fast deterioration of Malay apples and chilling injury symptoms were evidently shown by the fruits turning brown and rotting when stored at low temperatures. This study has generated baseline information that can be exploited to extend the shelf life of Malay apple and promote entrepreneurship in the Mt Cameroon region via the transformation of the fruits into wine, jam and juice.

Keywords: Postharvest handling, postharvest loss, fruit storage, transformation, Malay apple

Edible coatings for the sustainability of the fruit industry: case studies on strategic industry-university partnerships in South Africa

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The South African fruit industry sits far from its various export destinations, hence the need for effective postharvest strategies to deliver good quality produce. However, globally, environmental and human health-related concerns are growing about the use of fungicides and plastic in postharvest food preservation. This has spurred partnerships between industry and academia in the search for novel technologies. Edible coatings present themselves as a novel, environmentally friendly postharvest technology that can maintain quality, extend shelf life, and replace the use of synthetic fungicides and plastics. The first experiment focused on quality maintenance in plums ('African Delight™'). Fruit were treated with GA 2%, GA 5%, GA 10%, GA 5% + pomegranate seed oil and GA 5% + ascorbic acid in a commercial packhouse. Postharvest quality attributes were evaluated during a simulated export regime, including a cold storage shipping period ($-0.5 \pm 2^\circ\text{C}$ and $90 \pm 5\%$ RH for six weeks) and a subsequent shelf life period ($20 \pm 2^\circ\text{C}$ and $80 \pm 5\%$ RH for 15 d). In the second case study, newly formulated commercial coatings for shelf life extension of oranges (cv. Valencia). Fruit were treated with naturcover plus 3%, naturcover citricos 2%, polyorange and deccolustre at the rate of 1 litre per ton of fruit by spraying, ensuring total fruit surface coverage. Fruit were stored for 8 weeks at -0.5°C and $94 \pm 3\%$ RH. Quality evaluations were performed at 2-week intervals at cold storage and a subsequent shelf life period ($20 \pm 2^\circ\text{C}$ and $70 \pm 5\%$ RH for 3 d). In both experiments, uncoated fruit were used as a control. Performance was based on the coatings' ability to maintain fruit physicochemical attributes, suppress ethylene production and respiration rate, and control decay and physiological disorders in fruit. In plums, the coatings suppressed respiration and ethylene production. GA 10% performed best, resulting in a significant ($p < 0.05$) delay in physicochemical changes during storage, such as fruit softening, loss of acidity and darkening of the peel colour. A descriptive sensory analysis described plums coated with GA 10% as having unripe to semi-ripe sensory attributes at 5 d shelf life, compared to control plums characterized with a ripe to overripe sensory profile. GA 10% showed a potential to extend the shelf life of 'African Delight™' plums by 5 d. However, all coatings were unsuccessful in significantly reducing shrivel development throughout storage. In the orange trials, the investigated commercial coatings retained fruit quality and extended shelf life of the fruit compared to control (uncoated fruit). In particular, polyorange alleviated chilling injury in the fruit. It is also worth noting there were no significant differences in the ethanol content between coated fruit and control after 8-week storage, suggesting that the coatings did not result in fermentation in fruit. In summary, given the technology readiness level of edible coating application for postharvest preservation in stone fruit and oranges, the South African horticulture sector has shown a great interest in optimising, adopting and scaling up edible coating technology for sustainability of the industry.

Keywords: edible coating; postharvest losses; collaboration; industry; environment; impact

Functional properties and food applications of African star apple (*Chrysophyllum albidum*)

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African star apple (*Chrysophyllum albidum*) is an unexploited indigenous fruit that grows wild in many parts of tropical Africa. The trees are heavily laden with fruits which are primarily consumed in fresh form. The sweet, pleasantly acidic fleshy fruit pulp is relished as a snack and the fruit peel is sometimes chewed to turn it into gum. Reports revealed that the African star apple fruit is rich in macronutrients, micronutrients and dietary phytochemicals especially carbohydrates, lipids, vitamin C, carotene, potassium, calcium, iron, zinc, phenolics and flavonoids. This could potentially make a significant contribution to improving human health, nutrition, food security and income of the rural communities where they are commonly found. The fruit also has a broad range of medicinal purposes in ethnomedicine. Furthermore, the fruit pulp can serve as an excellent source of industrial raw material for formulating diet soft drinks beverages, jam, stewed fruit, marmalade, syrup, and jelly. However, significant postharvest losses are experienced due to inadequate utilization, storage and processing facilities. The economic importance of the African star apple fruit could be enhanced by improving the postharvest systems through optimizing preservation techniques and agroprocessing, making the fruit available in different forms for consumption and industrial use.

Keywords: underutilized fruits, phytochemicals, nutritional composition, postharvest loss, value addition

Postharvest Deterioration and Biochemical Changes in Biofortified Cassava Stored in an Evaporative Cooling Structure

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Cassava root lacks dormancy, hence the ease of its deterioration a few days after harvest. This manifests with the onset of postharvest physiological deterioration (PPD) and other biochemical changes which are activated as responses to physiological stress induced in the roots. This study evaluated changes that occur in biofortified cassava roots during storage. Twelve (12) months old biofortified cassava roots (TMS 01/1368) were stored in an Evaporative Cooling Structure (ECS) for twelve weeks. Some cassava roots were also stored outside the ECS, this sample served as the control sample. Cassava roots were randomly picked every two weeks from the ECS for analysis, while samples stored outside the ECS (control) were picked daily. The samples were evaluated in terms of quantification of scopoletin, discolouration, enzyme activities [superoxide dismutase (SOD) families and catalase] and changes in soluble sugars (glucose, fructose, sucrose and raffinose) fortnightly. The results showed no visual sign of PPD in the stored cassava roots during the twelve weeks of storage in the ECS. Scopoletin increased from 13.70-32.11 mmol/g though low compared to the control sample (103.47 mmol/g) at Day 8. The enzyme activities decreased across the storage period while the soluble sugars generally increased. ECS curtailed the PPD while the biochemical changes were observed to be minimal compared to cassava stored outside the ECS, therefore, extending the shelf life of the biofortified cassava roots. ECS is thus suitable for extending the storage life of biofortified cassava.

Keywords: postharvest, physiological deterioration, biochemical, evaporative cooling structure

Impact of Tillage Practices on Growth and Yield of Crop- Can It Reduce or Increase Food Loss?

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Food loss at the earliest stages of crop production has continued to be a major concern to farmers and related international bodies. One of the reasons for food loss at the earliest stages include: environmental stress, soil infertility and inappropriate tillage practices. This has led to this study investigating the effect of two tillage practices on maize growth and selected soil properties of an Ultisol. The study was conducted on two experimental plots during the early and late cropping season of 2014. The first plot was manually cleared to have a zero-tillage plot while the second plot was ploughed twice and harrowed once for conventionally tilled plots. Each experimental plot had three 23.0 m x 2.5 m blocks with an alley of 1.0 m between blocks and 1.0 m within plots. Seeds of the test crop were sown at three seeds per hill at 75 cm x 50 cm planting distance and each plot weeded manually using hoe at two weeks intervals till harvest. The soil properties were collected before and after each planting season. The soil pH, particle size distribution, organic carbon, bulk density, base saturation, and exchangeable cations were determined using standard methods. The growth parameters measured were plant height, stem girth and number of leaves. Yields were also measured at the end of each planting season. At the end of the experiment, zero tillage plots had the highest plant height (161.07cm) and number of leaves (12) compared to conventional tillage with 132.10 cm and 11 respectively. Zero tillage also had higher soil values when compared to conventional tillage. Zero tillage had a higher soil organic carbon (34.94 g kg⁻¹), CEC (8.30 cmol kg⁻¹), and a higher bulk density (1.38 g/cm³) when compared to conventional tillage with 30.59 g kg⁻¹, 7.39 cmol kg⁻¹, 1.35 g/cm³ respectively. Statistical significant differences were observed between the means. The highest mean grain yield was observed in zero tillage with (1.71t/ha) while conventional tillage had a lower grain yield with (0.97t/ha). Significant difference was observed between the means. This study concluded that zero tillage was a better alternative for crop growth and soil maintenance of an Ultisol. This would ensure that when such appropriate tillage (zero tillage) practice is applied on Ultisols during crop production it would prevent or reduce food loss.

Keywords: Conventional Tillage; Maize; Ultisol; Yield; Zero Tillage

Food Loss and Waste in Fish Value Chain: Addressing the Information Gap through an Online Repository

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Food loss and waste in the fisheries sector is estimated to be 35 percent per year. This equates to significant lost income to fishers, processors and traders and has a detrimental effect on food and nutrition security. In May 2019, with support from the Norwegian government, FAO began the development of an online repository (<http://www.fao.org/flw-in-fish-value-chains/en/>) that provides access to fish loss and waste related information that can be used to inform policy affecting all stages of the fisheries value chain from harvest to consumption. The information is designed to assist policy-makers, development practitioners, non-governmental organizations (NGOs) and value chain actors to develop multi-dimensional solutions to food loss and waste in the sector. The repository addresses a recommendation from the 32nd Session of the Committee on Fisheries (COFI), July 2016, for better availability and quality of information on food loss and waste in fish value chains. The repository supports the implementation of key macro policy instruments such as the FAO CCRF and the African Union Malabo Declaration and New Partnership for Africa's Development (NEPAD) Comprehensive Africa Agricultural Development Plan (CAADP). Two years after it was launched, several information was gathered using Google analytics. The repository has received almost 35,000 visitors and has had over 42,000 sessions globally. In Africa, the number of visitors and sessions reached more than 3,600 and 4,800, respectively, which is around 10 percent of the global statistics. The repository has a global reach and was already accessed by visitors from 213 countries and territories. The top ten countries with the most website visits are in Asia, Europe and the Americas. Nigeria is the only country from Africa that is included in the top ten, making up about two percent of total website users. In Africa, most visitors have been from Nigeria, Kenya and South Africa, respectively. However, if we are to look at the session duration, Cape Verde, Mauritania and South Sudan, respectively, lead. The majority of the users from Africa have found the webpage through an organic search or an online search engine. Furthermore, most of the users from Africa have visited the sections on Value Chain, Processing and Storage, Artisanal Fish Salting, Freezing. Several parameters such as access to, and the high cost of, internet in the region may have impact user numbers and distribution. Access could be particularly problematic for small fishing communities and the fishers, processors and small and medium entrepreneurs resident there. However, other stakeholders including the government, private sector, research and academic institutions can play a role to narrow the information gap. With the information available in the repository webpage, policy-makers, development practitioners, non-governmental organizations (NGOs) and value chain actors will have the ability to facilitate the development of solutions to food loss scenarios on the ground at the targeted points of the supply chain, as well as at policy level.

Key words: fish loss and waste, fish value chain, global food loss and waste reduction, policy guidance

Bruise susceptibility and quality attributes of banana affected by mechanical impact and storage

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Mechanical damage is one of the important factors leading to postharvest damage in bananas. Mechanical damage can occur by distributors along the supply chain and by consumers in the supermarkets. Consequently, the susceptibility to impact bruising in a banana fruit is an essential postharvest quality attribute that needs to be taken into account. Therefore, the study aims to investigate the time-dependent bruising incidence and its subsequent physiochemical alterations of a local banana cultivar of "Cavendish" (*Musa sapientum*) (AAA) group due to bruising kept at three different storage conditions (5°C, 13°C, and 22°C) at 2 days intervals for 12 days. Banana fruits are damaged by impact by using the pendulum test method by applying different impact energy levels (low, medium, and high). To identify the magnitude of bruising, equivalent drop height corresponding for each impact energy (E_i), bruise area (BA), bruise volume (BV), and bruise susceptibility (BS) were identified. Also, the colour, firmness, electrolyte leakage (EL) of banana peel were evaluated. The assessment of pulp's total soluble solids (TSS), titratable acidity (TA), TSS: TA, pH were conducted. The headspace gases like respiration and ethylene production rate were measured. The results showed that increasing the impact energy can increase bruise measurements such as bruise area, bruise volume, and bruise susceptibility of banana fruits. The damage was varied between impacted bananas of different levels. Low impact energy showed the lowest damages in banana fruits. Furthermore, storage at low temperature (13°C) reduced the severity of bruise damage and the changes in the physiological attributes of bananas during storage. Storage at ambient temperature (22°C) increased the occurrence of damage. Chilling injuries were highly observed in banana fruit stored at 5°C. Overall, understanding the impact of mechanical damage (bruising) on the quality attributes of bananas and applying low temperature (13°C) for storage to reduce the damage are considered as important strategies for reducing postharvest losses in bananas.

Keywords: Banana; Mechanical damage, Bruise susceptibility, Storage, Impact energy

Effect of Harvest Maturity Stage and Storage Media on the Harvest Quality of Tomato (*Lycopersicon esculentum* Mill)

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Tomato (*Lycopersicon esculentum* Mill) fruits are highly perishable, requiring appropriate pre and postharvest handling for long shelf life. The experiment was conducted in the Horticulture Department Laboratory of the Federal University of Agriculture, Abeokuta, to determine the harvest maturity index and storage conditions on postharvest shelf life of tomatoes. Tomato fruits of variety Beske, Ibadan local and Roma VF were harvested at the breaker, turning and full ripe stages and stored in four storage media under different temperatures: Block-in-Block at 27°C, 27°C; Pot-in-Pot at 25°C, 26°C; Wooden Ventilated Box Media at 30°C, 27°C and Open shelf (control) at 28°C, 27°C in 2012 and 2013 respectively. The resulting treatment combination were replicated three times in a Completely Randomized Design. Fruit quality parameters (firmness, colour change, freshness, weight loss and shelf life) and proximate contents (moisture content, dry matter, fat content using Soxhlet Extraction Method, crude fibre, crude protein, total carbohydrate, vitamin A using spectrophotometric method based on UV Inactivation, ascorbic acid (Vitamin C) using DCPIP Dye and thiamine) were determined on 2 sampled fruits per treatment before and after storage. Qualitative data were transformed using the square root method. The initial and final means of proximate content values were compared using paired t-test. Fruits of Roma VF grown with 5tha-1 poultry manure had the lowest percentage decrease in vitamin C of 0.9, 0.5 (Block-in-Block); 1.9, 0.7 (Open shelf) while fruits grown with NPK 20-10-10 harvested at full ripe stage had the highest of 4.6, 4.7 (Block-in-Block); 10.8, 10.4 (Open shelf) in 2012 and 2013, respectively. Fruits of Beske produced with NPK 20-10-10 harvested at the breaker and turning stage had the least shelf life at (11,12); (11,12) days in Block-in-Block; (9,10); (9,10) days in Open Shelf days while those produced with 5tha-1 poultry manure had the longest shelf life at (20,20); (13,14) days in Block-in-Block; (12,14); (11,12) days in Open Shelf in 2012 and 2013, respectively. This study concluded that fruits harvested at the turning stage and stored in Block-in-Block maintain fruit quality and extend storage life relative to open shelf. It is recommended that tomato fruits could be harvested at the turning stage for long shelf life. The Block-in-Block for tomato fruit storage is recommended based on its cost and efficiency.

Keywords: Harvest Maturity Stage, Storage Media, Harvest Quality, Tomato

“Improved fried fish display shelves for women in the fried fish chain along Coastal Kenya: “The Mama Karanga box”.

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The fried fish chain along the Kenyan Coast is mainly driven by women known as “Mama karangas”. They display the fried fish in the market places from 5 pm to 11 pm using traditional wooden fish display boxes. The fish is laid on either bare wood or newspapers inside the boxes while lighting is provided by paraffin tin lamps locally known as “Korobois”. These “Korobois” emit smoke, posing a health hazard to the women and their clients, keep potential clients away, increase carbon footprint associated with kerosene combustion and cause post-harvest losses when the paraffin spills on the fish. A questionnaire-based study was conducted to assess the status of the fried fish chain along the Kenyan Coast. The objective of the study was to introduce an improved fried fish display box that is more hygienic and without smoke emissions. The research questions were: (a) Would an improved fried fish display box lead to less smoke emissions and (b) Would an improved fried fish display box improve sales due to improved hygiene and income? The study informed the fabrication and distribution of the improved “Mama karanga” box among 25 women in Kwale county to address the drawbacks associated with the use of the traditional display shelf. The “Korobois” was replaced by an eco-friendly rechargeable solar lamp, the inside of the box was lined with a food-grade aluminium sheet for ease of cleaning, and the top was covered with nylon mesh for improved ventilation. A follow-up questionnaire-based survey was conducted to evaluate the impact of the innovation on the value chain. The cost of paraffin per day @ USD 0.37 was reduced to nil. Nearly all the women (85.71%) that used “Korobois” experienced respiratory disease attacks like flu, chest pains and body aches attributed to smoke inhalation. This figure was reduced to zero after adopting use of the improved “Mama karanga” boxes. This is because they no longer used the kerosene lamps that emitted smoke which caused the diseases. The initial expenditure of USD 16.13 used to cover an of average 2 hospital visits per month was subsequently diverted to other uses. 77% of Mama Karanga women gained new customers. A trader sold an average of 12 kgs of fish per day earlier, and this rose to 15kgs after adoption of the use of improved fried fish display shelves leading to increased profits. An average stock increment of 3kg per of fish per trader was thus realized. Losses due to accidental spillage of paraffin and paraffin smell on the fish were eliminated. The carbon emissions associated with kerosene combustion among the traders using the improved box was reduced to nil. The use of the “Mama karanga” box by the women fish traders has resulted in increase in customer volumes, improved safety and hygiene of displayed fried fish products, improved health of the traders and the customers’ as well ease in cleaning of the box.

Key words: fried fish, kerosene combustion, post-harvest fish losses, fish quality, Coastal Kenya

Effective Hermetic Storage Solution in Preventing Postharvest Losses of Food Grains

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Postharvest losses mainly occur naturally by microbial attack, infestation, enzymatic action, and chemical degradation. Fumigants like methyl bromide and phosphine (Magnesium or Aluminum phosphide) are widely used to control insects of various kinds. Chemical fumigants show resistance to insects, leave residue in the food grains and are toxic to humans and the environment. But the problem is that without these chemicals, food grain will be wasted a lot. Proharvest hermetic is a multilayer high barrier hermetic bag with its ultra-low oxygen permeability (OTR) of less than 2cc/m²/day and MVTR less than 2g/m²/day. Proharvest hermetic bag creates a modified atmosphere (i.e. depletion of oxygen in the hermetic bag and with the parallel rise in carbon dioxide). Hence, superior levels of carbon dioxide arrest the growth of the insects. As a result, population growth ceases, and damaging infestations don't develop (eggs, larvae and pupae ultimately die). Test on Proharvest bags of 25 kg capacity was used with the infestation of a known number of insects. By week 5, 100% mortality of adult insects inside the bag was observed (monitored by naked eye detection/evaluation) under an average standard tropical temperature of 27 degrees Celsius and 65% relative humidity monitored with the help of a weather app. Grains such as rice, horse gram, millets, pulses stored in proharvest hermetic bags for more than 14 months were safe without the use of any chemicals. Proharvest hermetic bags come in various capacities of 25kg, 50kg & 100kg). Proharvest hermetic bags provide a superior barrier for oxygen and moisture; hence it gives protection from fungi toxins. Organic storage of all agricultural commodities, the use of insecticides or fumigation is possible in this bag. Proharvest bags were supplied to the Indian Institute of Food Processing Technology (IIFPT) to evaluate their performance. Based on the trials conducted using millets, it was a success for over a storage period of 12 months.

Keywords: Grain Storage Pests, Postharvest losses, Proharvest Hermetic Bags, Fumigation, Aflatoxin.

An Economic Framework for Post-Harvest Loss Reduction

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In a world where more than 700 million people suffer from food insecurity and caloric deficiency, excessive post-harvest loss (PHL) represents a missed opportunity to use food already available to reduce hunger, while increasing food quality/safety, nutrition, and market opportunities. While the magnitude of loss today is concerning, it is even more distressing that excessive PHL and its associated negative impacts are NEW topics of global interest. In 1975, then US Secretary of State, Henry Kissinger, made detailed the need for global efforts to reduce PHL. Following his exhortation, the UN General Assembly adopted a resolution calling for at least a 50 percent reduction within ten years. However, today, we still struggle to mitigate PHL of both cereals and perishables. The purpose of this paper is to present an alternative decision framework to the prevalent notion that simply documenting the extent of loss will drive effective interventions to reduce PHL. A case example is provided illustrating application of the framework within the Iringa Hope cooperative in Tanzania. This decision framework focuses on documenting the costs and benefits of specific interventions. As noted by the Pontifical Academy of Sciences (2019), “while FLAW (food loss and waste) reduction has huge benefits, the costs of action cannot be ignored when aiming for effective and efficient solutions”. A corollary factor relates to the adequacy of information for decision-making purposes. While better accuracy is desirable, agri-food system managers and farmers must make timely decisions. As noted by Bradshaw (2019), “actionable insights are the holy grail of any business’ data”. Given the sparse nature of available data on PHL, emphasizing methods that can provide timely insights at low cost is an important goal. This concept is central to the decision approach illustrated in the work described here. The featured case study compares a “base case” (use of practices traditional in the region) with interventions that Iringa Hope is evaluating and implementing. The results examine the effects of key interventions that have the potential to materially reduce loss. Extensive use of hermetic storage bags (both for totally subsistence farmers and for those who sell part of their production in commercial channels) is one key intervention. A second scenario examines the economic impact of harvest-time loans which allow farmers to store and sell their maize at later in the marketing year. Finally, the implications of establishing a large warehouse facility to allow better year-round access for buyers will be estimated.

Key words: Economic framework, decision making, post-harvest loss

Inclusion of *Andrographis paniculata* Leaf into Wheat-Pearl Millet based Flour Blends: An Index Effects of the Inclusion and Blends Nutritive Values.

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Strategic incorporation of medicinal plant parts into regular food staples such as whole grains, to develop food that supplies health benefits beyond basic functions, has the potentials to improve the nutritional properties of such composition. *Andrographis paniculata* (A.P) leaf is a medicinal plant part known to be a powerful immune booster with healing properties. Nevertheless, these products have no known inclusion into food matrix for specific health application. Since plants have served as a valuable starting material for drug development, they should do likewise in the food matrix, if strategically incorporated. Therefore, the study investigated the influence of the inclusion of varying proportion of *Andrographis paniculata* leaf flour (APLF) on the proximate and mineral composition of wheat-pearl millet- based flours and evaluation its possible implications to human health. *Andrographis paniculata* leaf was harvested from a farm in Akure, Nigeria, while its taxonomical identification was verified at the Forest Research Institute (FRIN), Ibadan, Nigeria, with the herbarium number 112176. Flour blends were prepared using whole wheat flour, whole pearl millet flour, and A. paniculata leaf flour. The recommended combination ratio (50:50) of wheat flour (WF) and pearl millet flour (PMF) was adopted as the blending baseline while graded levels of A. paniculata leaf flour of 2, 4, 6, 8 and 10% were respectively included in the blending baseline to obtain wheat-pearl millet-*Andrographis paniculata* flour (WPMAPF) blends. In the formulation, the inclusion of A. paniculata leaf flour was carried out to replace the wheat and pearl millet flour respectively on equal basis. The flour blends with 0, 2, 4, 6, 8 and 10% (WPMF, WPMAP1, WPMAP2, WPMAP3, WPMAP4, and WPMAP5) inclusion were evaluated for proximate composition and mineral constituents using standard methods. The results from flour blend evaluation showed that the inclusion of A. paniculata leaf flour generally led to an increase in the crude protein, crude fibre, ash and food energy values of the blends were observed to increase as the percentage of inclusion of A. paniculata leaf flour increased. The crude protein value obtained for WF, PMF, and APLF were 17.27 g/100g, 12.17 g/100g and 25.75 g/100g. PMF had the least crude protein content of 12.17 g/100g, APLF had the highest crude protein content of 25.75 g/100g. There was significant difference $p < 0.05$ between WF, PMF and APLF in terms of protein content. The protein content of 25.75 g/100g observed for the APLF could be implicated to bring about improvement in the protein content of the flour blends. The protein content of the flour blends were 15.02 g/100g, 15.54 g/100g, 15.59 g/100g, 16.36 g/100g, 16.64 g/100g, and 16.74 g/100g. Sample WPM had the least protein content of 15.02 g/100g, while WPMAPLF5 had the highest value of 16.74 g/100g. The flour blend without the inclusion of A. paniculata leaf flour (WPMF) exhibited the following mineral composition: Ca (90.43 mg/100g), P (218.21 mg/100g), Fe (18.45 mg/100g), Na (38.98 mg/100g), K (217.85 mg/100g), Zn (3.39 mg/100g), Cu (0.60 mg/100g), Co (2.59 mg/100g), and Mn (3.0 mg/100g). However, the mineral composition of the flour blends (WPMAP1, WPMAP2, WPMAP3, WPMAP4, WPMAP5) as the inclusion of A. paniculata leaf flour increased, showed that a significant increase occurred in calcium (Ca), phosphorus (P), sodium (Na), cobalt (Co), and phosphorus (P), while a significant decrease was similarly observed in iron (Fe), potassium (K), copper (Cu), and manganese (Mn). Lead (Pb) was generally absent in all the flour blends. The result of the Mineral to mineral molar ratio of the raw materials and the blends such Ca:P, Na:K, and Cu:Zn were also evaluated. The Ca:P molar ratio of the flour blends ranged from 0.41 to 1.79 which was found to increase as the percentage of inclusion of A. paniculata leaf increased. The study revealed that, the incorporation of *Andrographis paniculata* leaf flour resulted into flour blends with improved nutritional value, increased protein content, better energy value, and improved essential mineral constituents.

Keywords: *Andrographis paniculata* Leaf, Flour Blends, Index Effects, Nutritive Values, mineral ratio

Interventions for reducing crop postharvest losses in sub-Saharan Africa: a systematic evidence synthesis and gap map

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Minimising the amount of food lost or wasted at or after harvest, is an unequivocal dimension of building sustainable food systems. Sound decision-making surrounding which technologies, tools, practices, training, or other types of interventions to invest in to reduce postharvest losses (PHLs) has to be evidence-based. However, keeping abreast of the complex and rapidly growing bodies of knowledge and research evidence, which are estimated to double every nine years, is undoubtedly challenging. Using robust methods for evidence synthesis, we systematically reviewed the existing evidence-base on PHL-reduction interventions for 22 crops across 57 countries in sub-Saharan Africa and South Asia from the 1970s to 2019. This work was part of the Ceres2030: Sustainable Solutions to End Hunger project which aimed to identify the most promising investment solutions for achieving Sustainable Development Goal 2 of zero hunger by 2030. This search strategy identified a total of 12,907 peer-reviewed and grey literature documents. Following a two-stage double-blind screening process using strict exclusion and inclusion criteria to identify field-tested PHL-reduction interventions which small-scale producers and their associated value chain actors can use to reduce losses, just 334 of these articles were included. From these, we extracted data describing the intervention, its focal crop, country, postharvest activity stage, its efficacy in reducing PHLs, and any other outcomes. This synthesis revealed that storage technology interventions mainly targeting farmers dominated the evidence-base (83% of the articles). Within sub-Saharan Africa, the cereals were the most studied crop group (54.9% of interventions), with maize alone accounting for 44.6% of the studied interventions. While the root and tuber, legume, fruit and vegetable crop groups accounted for just 19.9%, 11.5%, 7.5%, and 6.2% of studied interventions, respectively. Geographically, most of the PHL-reducing interventions had been studied within West or East Africa with Nigeria, Ghana, Kenya, Ethiopia, Zimbabwe, Benin and Tanzania accounting for 10 or more studies each, while 23 countries had no studies. The storage-dominated evidence base confirmed that interventions which increase the use of hermetic bags or containers, or admixture of grain with appropriate protectants (for example, some synthetic chemicals or diatomaceous earths) are effective at reducing PHLs for cereals and legumes. Improved handling practices, packaging containers, choosing the right time and tools for harvest and evaporatively-cooled or cold storage were effective at reducing losses for fruits and vegetables. Use of cool well-ventilated structures also kept losses low in root and tuber crops. However, the review indicates a need for systematic assessment of interventions across the entire value chain, for more participatory study and of a more diverse range of food crops. The lack of study of training, finance, infrastructure, policy, and market interventions highlights the need for study of interventions that go beyond tangible technology or handling practice changes. Additionally, more studies connecting the impact of PHL reductions to social, economic and environmental outcomes are needed. This review supports decision-makers with policy formulation and prioritisation of PHL reduction investments.

Keywords: postharvest loss reduction; systematic scoping review; sustainable food systems; food loss and waste

Cost-Benefit Analysis of Purdue Improved Crop Storage Bags for Maize Storage among Smallholder Farmers in Northwest Ethiopia

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In Ethiopia, postharvest losses caused by insects are a major challenge in crop production systems. Stored maize is highly susceptible to insect pests during storage. Storage loss affects the livelihood of small-scale farmers leading to food insecurity and loss of income. Therefore, the objective of this study was to assess the cost-benefit analysis of Purdue Improved Crop Storage (PICS) bags on maize storage in Northwest Ethiopia. Cross-sectional data was collected from 392 randomly selected households from both users and non-users of PICS bags, using stratified sampling technique. Structured questionnaire, key informant interviews, focus group discussions, individual in-depth interviews, and field observations were used to gather the data. A cost-benefit analysis was computed to evaluate the viability of PICS bag for maize storage. Similarly, binary logit regression model was used to identify factors that affect the use of PICS bags. Descriptive and inferential statistics were employed to analyze the data. The benefit-cost ratios (BCR) of insecticide with ordinary bags and the PICS bags were greater than one, but PICS bags resulted in more than two folds higher values as compared to insecticide with ordinary bags. The net present value (NPV) at 15% discount rate in 2018 was 20.73 USD and 25.35 USD per 100 kilograms of stored maize when insecticide was applied to ordinary bags and PICS bag, respectively. Sensitivity analysis with a 10% cost increment and up to 50% price discount showed that both technologies would still be viable for maize storage. However, PICS bag had higher NPV and BCR; making the technology more viable than insecticide with ordinary bags. The results of binary logit model indicated that educational level, gender, awareness, training, accessibility to the technology, perception of the technology, involvement in leadership activities in the community, and total income of the household positively influenced farmers' decision to use PICS bags, whereas, price negatively affected the use of the PICS bags. PICS bags had clear economic advantage over insecticide with ordinary bags for maize storage in Northwest Ethiopia. Efforts should be made to disseminate PICS bags and improve access for strengthening food security and increasing income of maize farmers in Northwest Ethiopia.

Keywords: Grain storage, insect pest losses, hermetic bag, benefit cost ratio, smallholder farmers

Storability of Low and Highly Infested Maize in Purdue Improved Crop Storage (PICS) Bags

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Storage insect pests such as weevils cause 30-60% losses in stored maize in Malawi. While some control methods focus on preventing infestation, they may lack efficacy if the grain is already infested; especially with insect species that can chew through storage containers. Purdue Improved Crop Storage (PICS) bag is a good example of an innovative postharvest technology that reduces grain losses. The aim of this study was to assess the efficacy of PICS bags against the larger grain borer (*Prostephanus truncatus*) and the maize weevil (*Sitophilus zeamais*) on stored maize. Low and highly infested maize were used in two separate experiments. In the first experiment, before artificial insect infestation, maize was disinfested by solarization. Approximately 25kg of low-infested maize grain were put in four PICS bags and eight polypropylene (PP) woven sacs in September 2012. Maize in four PP bags was treated with Actellic while the other four bags were not. PICS and PP bags were randomly stacked on top of each other. A follow-up (second) experiment used the highly infested maize to assess whether PICS bags would arrest further insect development and damage. A total of 12 bags (8 PICS bags and 4 PP) filled with highly infested maize was used for this experiment in May 2013. PICS and PP bags were kept in separate storage rooms to minimize potential external damages on PICS bags. After 6 months of storage of the low-infested maize in PICS bags, grain weight loss was less than 2% and germination was 35%. However, grain stored in PP bags had an average weight loss of 20% and 5% germination. Maize stored in PP bags was significantly damaged and highly infested by several pests. Maize stored in PP bags was significantly damaged and highly infested by several pests. The limited infestation in PICS bags observed after 6 months of storage was due to insects migrating from grain in PP bags to holing PICS bags from outside. The follow-up experiment of storing highly infested maize for 60 days showed an average grain weight loss of 4.5% compared to 17.39% in PICS and PP bags, respectively. No holes due to insect pests were made on PICS liners from inside or outside of the bags. Keeping PICS bags stored separate from PP bags containing maize infested with *P. truncatus* would limit insects' ability to damage PICS bags. These results indicate that PICS bags are effective in preserving low and highly infested maize with insect pests.

Keywords: *Prostephanus truncatus*, *Sitophilus zeamais*, hermetic storage, PICS bags, Malawi

Harvest-tenure Promotes Innovative Technologies, Tools, Practices and Training to Reduce Postharvest Loss

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Across the African Union (AU), drylands are a huge and with the fragile ecosystem that is home to a large and often hungry population. Insufficient access to mechanized postharvest equipment leads to poor harvest handling practices, high postharvest and input loss (PHL), and low prices during glut. Elsewhere, innovative mobile storage technologies and tools, enable harvest-tenure or the right to practice stored grain Integrated Pest Management (IPM). Mobile storage optimizes IPM over the sun and ambient air drying in-field. It also prevents mould and theft, whilst the transport has time to haul heavy loads. On-farm vented, raised and metal storage units also enables IPM to monitor fumigation effect on insect and rodent pests. IPM practices minimize PHL, maximizes incomes as grower's process surplus produce at the market. A trial in Ghana organized and compared qualitative data from elsewhere and the AU to illuminate staple grain PHL, carbon emissions due to lost inputs and off-the-shelf science, vented and metal mobile storage. The trial applied three qualitative comparison methods: evaluate the value of inputs lost by organizing and reviewing research data; trialling mobile storage to observe how Ghana's input and warehouse agribusiness reacted to mobile storage with the utility to store, monitor and process nutrition; and identify potential roadblocks to reducing PHL with mobile storage. Trials indicate that, unlike warehouses, the cost of mobile utility storage decreases, as capacity increases over the time. It also facilitates drying in-field allowing growers to manage crop moisture to earn better price. On-farm open area offer growers a flexible capacity to store loose or in sack/bag and inventory of multiple crops simultaneously. This is in stark contrast to how non-residual fumigation for pest control in the sack/bag requires insecure build/maintain redundant stationary warehouses. At marketplaces, the growers and traders understand that raised floors mitigate abiotic problems. Ability to relocate the vented storage is cost-effective and the floor of the unit is conically shaped for easy cleaning. Trials indicated prejudice for inputs exacerbate malnutrition and carbon emissions, and stationary warehouses are a roadblock to reducing imports, increasing exports and foreign exchange reserves. Trials also indicated that growers, especially youth and women will learn which options reduce PHL, cost-effectively. In addition, measuring, monitoring and quantifying mould postharvest with IPM will progress development to address causes, extent and impact of food loss - the metrics of PHL which deliver surplus nutrition sustainably. Scaling up harvest-tenure will increase assets that reduce PHL on the drylands and establish grower rights to benefit from increasing foreign exchange.

Keywords: agribusiness, grain, postharvest loss, harvest-tenure, nutrition.

Effect of triple-layer hermetic bags on the biochemical and physicochemical characteristics of whole and degermed maize flour in Uganda

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Maize flour constitutes the highest proportion of diets for both adults and children in Uganda. Maize flour is commonly stored in woven polypropylene (PP) bags, plastic buckets, and low-density polyethylene bags both at wholesale and retail levels. These packaging materials do not provide adequate protection to the stored maize flour against biochemical reactions. This study aimed at assessing the effect of packaging material and storage duration on biochemical (moisture content, free fatty acids (FFA), peroxide value (PV), titratable acidity (TTA) and physicochemical (protein, fat, ash, crude fibre, carbohydrates, energy, water absorption capacity (WAC) and sensory) qualities of whole and degermed maize flour. The maize grains were procured from the Kisenyi market in Kampala City and milled using a locally fabricated hammer mill. Two types of packaging materials were tested: woven polypropylene (PP) and Purdue Improved Crop Storage (PICS) hermetic bags; stored at room temperature (25±5°C). Biochemical and physicochemical qualities of maize flour were determined at two-month interval for a six-month storage period. After six months, the mean protein content decreased by 18% and 11% in degermed maize flour and by 15% and 9% in whole maize flour stored in PP and PICS bags, respectively. The fat content in whole maize flour decreased by 48% and 30% in PP and PICS bags, respectively. Free fatty acids (4.3%) and titratable acidity (4.2 %) of whole maize flour packaged in woven polypropylene bags were higher than free fatty acids (1.8%) and titratable acidity (3.8%) of flour in PICS bags. A similar trend was observed in degermed maize flour. The moisture content, fat, protein, FFA and TTA were significantly affected by storage time and packaging material whereas ash did not vary significantly. Sensory scores of porridges made with whole maize flour stored in PP bags significantly decreased after four months of storage with an overall acceptability score of 5.1 compared to 6.2 for flour stored in PICS bags; based on a 9-point hedonic scale. The PICS bags did not significantly affect the overall acceptability of porridge. Both whole and degermed maize flour, stored in PICS bags had better physicochemical and biochemical properties than those stored in PP bags over the study period of six months. Thus, the triple-layer hermetic PICS bags can be effectively used to preserve the quality of maize flour during storage at the wholesale and retail levels in local markets in Uganda.

Keywords: Postharvest management of maize, flour storage, packaging material, quality preservation, nutritional properties.

A scalable, digital platform for grain storage and trading eliminates postharvest losses and allows smallholders and rural entrepreneurs to increase incomes

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In most countries of Sub-Saharan Africa, the price for staple crops is low around harvest time. Prices rise significantly and are at peak during the lean season. Smallholders usually sell some or all of their grain despite the low prices. Typical margins are very low. The drivers for this behaviour are postharvest losses caused by a lack of adequate storage facilities and the need for liquidity to cover loans and expenses. The typical downstream value chain is a chain of traders that buy and aggregate grain for economical storage, treatment and handling in urban centres. Smallholders and the village economy do not benefit from rising prices after the harvest. Many development projects have focused on hermetic on-farm storage to address this problem. These projects and extensive research have shown that hermetic storage effectively abolishes losses during storage. However, adoption is driven by public funds and the overall market share remains very low. Saving Grains is a social business and in 2021 we have trailed a scalable solution that enables the village economy to benefit from seasonal crops price increases in Ghana. Our customers are village entrepreneurs that buy hermetic bags and equipment enabling loss-free storage at their homes or small warehouses. They use our app to buy grain from smallholders of their community and speculate on grain price increases. During the lean season, they sell, either to their community or external traders. All transactions are conducted through the app and mobile money payments. Entrepreneurs typically invest \$2,000 and we provide a matching loan resulting in gross profits of 80% in the first and 100% in subsequent seasons assuming average grain price development. We also experience very high demand from frequently illiterate female entrepreneurs with much smaller investment amounts of around \$200 that operate in groups to share equipment and lower initial investment costs. Smallholders benefit by continuing to sell at prevailing market prices coupled with an automated payout of a share of the trading profits in the lean season. Our scalable business model eliminates postharvest losses through hermetic storage, promotes a circular village economy and generates higher incomes from the cultivation of food commodities for smallholders.

Keywords: Digital, hermetic bags, scalable solution, social business, staple crops, circular economy, rural value creation, smallholder income

Evaluation of Post-harvest losses and potential for use of off-grid power systems in the Fisheries value chain in Kenya

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The fisheries sub-sector contributes 0.5 % of the national GDP and to improved livelihoods through employment creation and its contribution to the attainment of food and nutritional security in Kenya. The total volume of fish landed from capture fisheries in 2017 was 135.1 thousand metric tonnes, valued at US\$ 230 million. Despite this contribution to the economy, the sector experiences challenges of high postharvest losses, low investment in technology, unreliable and expensive on-grid power, inadequate off-grid cold storage infrastructure and little value addition. This study was done to assess production capacity, post-harvest losses, and potential for uptake of off-grid cooling technologies among small scale fishers in Lamu and Lake Naivasha. It was done between January and March 2020. Data were collected from the main value chain actors (fishers, traders, and processors), supporters (manufacturers/sellers of solar systems) and enablers (extension staff, and NGO's). A semi-structured questionnaire was used to collect data from 44 fishers in Lake Naivasha and 42 in Lamu. This was done at 4 fish landing sites at Lake Naivasha and Lamu respectively. Members of Beach management units were involved in the identification of respondents in each of the two areas. The mean annual household income from fishing was US\$ 4,263 at Lake Naivasha, which was 83% of net household income and 5,528\$ in Lamu, which was 97 % of net household income. Postharvest fish losses were high in Lamu at 62 and 26 % for pelagic and demersal fish respectively, while losses at Lake Naivasha were 1.8% for tilapia and carps and 17% for catfish. The losses translated to a revenue loss of US\$ 720 thousand and 17,900 per annum for Lamu and Lake Naivasha fisheries, respectively. The high losses reported in Lamu were caused by an unreliable on-grid power supply and an inadequate supply of ice for fishers and traders. Recommendations from this study were that small scale traders at Naivasha can be facilitated to purchase solar-powered freezers. The country government and/or other partners need to collaborate with the private sector to facilitate the provision of collective off-grid cooling systems and appliances in Naivasha town, and to provide small-scale traders with cooling appliances. In addition, the government in Lamu needs to establish partnerships with the private sector (PPP) to install solar-powered ice-making machines with the capacity to manufacture ice for fishers and fish traders (dealers) in all islands in Lamu County.

Keywords: Fishers, Beach Management Units, Lake Naivasha, Lamu, Off-grid power.

Maturity Indices of Specific Mango Varieties produced at medium altitude agro-ecological zone in Kenya

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The high postharvest losses (40 – 50%) reported in the mango value chain are partly attributed to a lack of reliable maturity indices. Harvest maturity is dictated by the intended use and the target market for the fruits. The indices are used to determine harvest maturity in mango fruits including chronological, physical, physiological and biochemical vary with the mango variety. The main objective of this study was to establish maturity indices of three commercial mango varieties namely 'Van dyke', 'Kent' and 'Tommy Atkins' in Embu County of Kenya. A total of fifty-four mango trees of the three varieties were randomly tagged at 50% flowering in three selected small-scale farms in Embu County. For each variety and maturity stage, five fruits were randomly sampled from the pool and analysed for physical (size, density, firmness, colour), physiological (ethylene production and respiration rate) and biochemical (°Brix/Total Soluble Solids (TSS), total titratable acidity (TTA) and their ratio) indices of maturity. The results showed that although size increased as the fruits developed, it was not a reliable index of maturity since some small-sized fruits attained advanced maturity (stage 4) earlier than others that were large-sized. The weight (mass) of the fruits fluctuated as the fruits developed and a similar trend was observed on the specific gravity. The specific gravity for 'Van dyke' variety was 1.189 g cm⁻³ and 1.162 g cm⁻³ for stage 1 and stage 2 respectively while for 'Kent' variety; 1.226 g cm⁻³ and 1.259 g cm⁻³ for stage 1 and stage 4 respectively. The fruits' flesh firmness decreased gradually with maturity from a mean firmness of 40.54 N (stage 1) to 6.84 N (stage 4). 'Tommy Atkins' exhibited the lowest firmness levels (6.84 N) at stage 4. 'Kent' variety had the lowest ethylene at all stages which ranged from 0.1123 µL kg⁻¹ hr⁻¹ to 0.2943 µL kg⁻¹ hr⁻¹. 'Tommy Atkins' variety had the highest respiration rate of 21.40 mL kg⁻¹ hr⁻¹ at stage 1, which increased gradually to 32.10 mL kg⁻¹ hr⁻¹ at stage 4. The TSS: TTA ratio increased from a mean value of 25.57 (stage 1) to 105.5 (stage 4). The highest TSS: TTA values (for all maturity stages) were reported in the 'Kent' variety. The results reveal significant differences in maturity indices of the three mango varieties despite similar physical indices. This study confirms the unreliability of physical maturity indices such as size and shape in establishing the right harvest stage of mango fruits. Therefore, a combination of flesh colour, peel and flesh firmness, computational, physiological and biochemical maturity indices is required to establish the accurate harvest maturity for mango fruits.

Keywords: 'Van dyke', 'Kent', 'Tommy Atkins', ethylene, respiration

Economic Analysis for Threshing/Shelling Machine Service Provision to reduce postharvest loss in Ethiopia.

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The Sasakawa Africa Association (SAA) has been addressing challenges related to the neglected post-harvest sector in Ethiopia since the 1990s. SAA has been involved in improving the traditional storage structures and introducing handheld and motorized crop shelling and threshing machines to rural farmers. However, postharvest agricultural technologies are poorly adopted by the farmers although the traditional threshing methods often result in high grain losses and low-quality produce coupled with labor-intensive and cost-inefficient business ventures. This study was conducted in May 2020 to determine the socioeconomic benefits of the threshing/shelling machine service provision as a business enterprise to help improve the adoption of the business enterprise. A total of eight youth group shelling/threshing service providers in four woredas of Oromia and Amhara regions in Ethiopia were selected for the study. The Bako model maize sheller and dehushing machines were assessed in a unimodal rainfall production region whereas the multi-crop thresher was evaluated in a bimodal rainfall production region. Both primary and secondary data were documented through Focus Group Discussion (FGD) and Key Informant Interview (KII) methods. Data analysis was carried out using Pivot Table Statistical Analysis tools. Descriptive analysis and discounted economic parameters such as Net Present Value (NPV), Internal Rate of Return (IRR), Benefit-Cost Ratio (BCR), and investment payback periods were used for determining the profitability of the businesses. The result from the unimodal area showed that the multi-crop thresher generated a negative NPV (USD -339) with an IRR value of -13% and a BCR value of 0.87. On the contrary, in the bimodal area, the NPV was found to be positive (USD2511.1). The BCR was 1.21 with an IRR of 21%. The cost-benefit analysis of the Bako model maize sheller machine resulted in gross revenue of USD16, 109.75 within the economic lifetime of the machine. Concurrently, the NPV was positive (USD 8703) with a BCR of 3.48, and an IRR of 248%. On the other hand, the analysis of the dehushing machine showed an NPV value of USD3915, BCR of 1.44, and an IRR of 44%. With the potential working capacity of the dehushing machine, the NPV was USD8735.2, with a BCR of 1.86 and an IRR value of 86%. The partial budget analysis of the farmers revealed that the threshing machine reduced the threshing costs by USD158.2 (51.9%) per hectare of land when compared to the conventional traditional threshing method. Based on the minimum food energy requirement, the maize grain that was lost through conventional traditional shelling would have fed 2541 individuals or 565 households, whereas, for teff crop, the loss would have fed 3,889 adults or 864 households throughout the year. Based on the findings, to improve adoption of the agro-processing machines, we recommend scale-up the introduction of the machines in the bimodal rainfall regions with two harvesting seasons and where the machines are used most of the year-round to generate better profits.

Keywords: Postharvest loss, shelling, threshing, dehushing, economic analysis

Tomato fruit skin defects and their contribution to postharvest losses

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Tomatoes are susceptible to several skin defects at different stages in the supply chain. Currently, detailed information about the different types of surface defects, their etiology and their contribution to fruit losses along the supply chain is limited. Defects can be attributed to biotic and abiotic factors that can be further defined as static or progressive. Our objective was to study the association between skin defects and postharvest losses encountered during a supply chain lacking cold storage. Tomatoes were procured from various sources, characterized for skin defects and stored at 25°C and RH of 58%. Tomatoes (cv Tori) obtained from four different growers had almost no fruit with fully intact skin and with skin defects that were comprised of wounds, abrasions, impact damage and healed cuts. The fruits had an average shelf life of 16, 17, 19 and 24 days and fruit loss was attributed mainly to shrivelling, decay on unhealed wounds and impact damage. A cluster type tomatoes (cv Ikram) characterized by exceptional firmness had an average shelf life of 27 days, fruit loss was attributed mostly shrivelling. The major skin defects, wounds, impact damage and shrivelling were sampled for effects on the fruit microbiome during postharvest storage at 25 °C. Overall, in this study, we show detailed characterization and identification of tomato skin defects and that variation in genetics among cultivars can have a major contribution in avoiding losses under ambient conditions. Shriveling constitutes a major progressive skin defect that can be avoided by cold storage but when it is lacking, proper packaging could be a promising solution. Ongoing research focuses on the influence of skin defects on the tomatoes' microbiome.

Keywords: Tomatoes, Postharvest, Defects, Tissue Microbiome

Comparative Assessment of Dried Moringa Leaves for Diet Supplementation in Sub-Saharan Africa: A Case Study of Nigeria

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Moringa oleifera is an under-utilized vegetable plant known for its nutritional and medicinal properties. Current post-COVID-19 pandemic realities necessitate increased utilization of Moringa, with minimal postharvest losses. Thus, this study was conducted to compare the effect of different drying conditions on microbiological safety and assess shelf stability of dried Moringa leaves of Nigerian ecotype. Freshly harvested leaves were divided into four (4) parts and dried differently; sun-drying at a day temperature of about 42°C for 7 hours, oven-drying at 45°C for 6 hours, shade-drying for 2 days while the last part was combined sunshade drying. The second batch of fresh leaves was sun-dried and double-packaged in polythene pouches into rigid plastic plates that were subsequently stored in the dark at room temperature. Microbial enumerations of all freshly dried samples and the stored samples were conducted at monthly intervals for five (5) months. Proximate composition, chlorophyll, iron, and ascorbic acid contents were determined using standard methods. The results showed no microbial growth on all freshly dried samples, irrespective of drying methods. Similarly, the result of shelf stability indicated acceptable levels of microbial growth throughout the storage period. The proximate composition result indicated that storage length significantly ($p < 0.05$) affected the proximate composition of the samples. Moisture content increased with increasing storage time from 4.18 ± 0.28 to 6.33 ± 0.29 ; while protein, ash (total minerals), crude fiber, fat, and carbohydrates contents all decreased to varying degrees with increasing storage time, from 36.10 ± 0.51 to 35.40 ± 0.50 , 4.45 ± 0.17 to 4.10 ± 0.00 , 6.55 ± 0.40 to 6.13 ± 0.05 , 3.85 ± 0.11 to 3.67 ± 0.00 and 44.87 ± 0.44 to 44.37 ± 0.44 , respectively. This decrease is within an acceptable standard that compares favorably with the levels that are found in other leafy vegetables. The chlorophyll content decreases with increasing storage length from 110.24 ± 6.21 to 56.37 ± 2.24 , with a similar trend in iron and vitamin C contents. Hence, these results indicate that Moringa leaves can be dried with easily available methods of sun-drying, oven-drying, and shade-drying for storage, while still maintaining acceptable standards of food safety and nutritional status. Therefore, dried Moringa leaves and powder can be exploited for commercial purposes in areas of abundant production for continuous distribution in Nigeria.

Keywords: Moringa leaves, post-COVID supplementation, under-utilized vegetables, postharvest preservation, comparative assessment

Evaluation of some Selected Mango Varieties for Fruit Powder Production In Ghana

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Mango is an important fruit, which receives high patronage in Ghana. But the highly seasonal and perishable nature of the crop, apart from being a constraint to both farmers and processors, also deny consumers the opportunity to enjoy the fruit all year round. Use of the stable powder form of mango can serve to fill the gap during the mango off-seasons. This study, therefore, evaluated the fruits of four major mango varieties (Keitt, Kent, Palmer and Local) grown in Ghana for their suitability for fruit powder production. The fresh fruit pulp and reconstituted freeze-dried powder of the varieties were analyzed for physicochemical characteristics. The study revealed that Keitt, Kent and Palmer (exotic varieties) had significantly ($p \leq 0.05$) high pulp content of 68%, 66% and 63% respectively indicating the potential for high fruit powder yield. Acceptable levels of total soluble solids, titratable acidity, ascorbic acid and beta-carotene contents were observed in the fresh fruit and the freeze-dried powders of the varieties. There was no significant ($p \leq 0.05$) difference in the Yellowness Index between fresh fruit pulp of Keitt, Kent and Palmer and their respective reconstituted freeze-dried powder. These three mango varieties exhibited considerably good quality in terms of physical and chemical characteristics for processing and utilization as fruit powder. The production of high-quality mango powder from these varieties could therefore serve as a substitute in the mango off-seasons and also reduce postharvest loss.

Keywords: Mango powder; Off-seasons; Freeze-drying; Substitute; Postharvest loss.

SUBTHEME 4

TRADE, BUSINESS AND ECONOMIC TRANSFORMATION OPPORTUNITIES IN POSTHARVEST SOLUTIONS

2021

3RD ALL AFRICA POSTHARVEST CONGRESS & EXHIBITION, BOOK OF ABSTRACTS

Theme: Postharvest Loss Reduction for Sustainable Food Systems



Opportunities and Challenges in Processed Local Fruits and Vegetables: the Case of Small-Scale Food Processors among Kenya Farmers

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Despite high levels of insufficient food and nutrition security, Kenya's annual losses among small-scale farmers have been reported to be as much as 75% in various perishable food commodities, particularly locally produced fruits and vegetables, which are among the neglected crops. According to research, despite being industrially neglected, locally grown fruits and vegetables are highly nutrient-dense, resilient across various agroecological zones, and productive, but they lack good processing qualities. They are susceptible to high pest and disease infestations due to insufficient good agricultural practices, resulting in poor marketability. Collectively, this results in meagre income generation for farming households during the glut, as well as widespread losses. However, if proper postharvest handling and processing are implemented, the nutritional and economic benefits of such crops can be realized. Although mangoes are one of Kenya's most likely profitable fruits, they are minimally processed. Similarly, vegetables, such as tomatoes and exotic and African leafy vegetables, are subjected to extensive farm and postharvest handling losses. The purpose of this study was to develop farmer groups' (n>100) capacity regarding good manufacturing practices and commercial product development. The current study resulted in the development and market testing of a variety of local mango fruit and vegetable products among various farmer groups trainees, demonstrating a promising strategy for capitalizing on the nutritional benefits of these crops by increasing marketability while ensuring shelf-stable products well beyond their season. Compared to the fresh fruits and vegetables, which fetch between USD10 – 30 per ton, processed fruits generate as much as USD689 to 5,520. To accomplish these objectives, this research aided in the adoption of good manufacturing practices and the standardization of over ten shelf-stable nutritious processed products with high commercial viability among selected rural small-scale processors who have scaled up some of the products and penetrated the market, thereby ensuring the ventures' sustainability. The current outputs should be disseminated to additional farmers, manufacturers, and consumers and implemented to reduce high loss rates and promote commercialization, processing, and preservation of local fruits and vegetables. This will result in a significant income contribution from food crops to rural households. Although, in the long run, this will benefit both farmers and consumers through access to shelf-stable processed products after their seasons are over, a collaborative effort is essential to ensure that small-scale processors maintain the quality and safety of the processed products. Additionally, marketing channels must be established in urban and peri-urban areas, where consumer preferences for nutritious novel value-added products are most likely niche.

Keywords: Processing, fruits, vegetables, postharvest, farmers

Exploring Circular Bioeconomy of Selected Vegetables Postharvest in West Africa.

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Assuring a sustainable food system in developing countries requires adopting a circular approach and adjusting the crop production system. A circular bioeconomy integrates the reincorporation of production side-streams and residues as secondary raw materials in the production process. This new approach calls for a thorough look at trade, business, and economic transformation opportunities in crops and postharvest losses. Considered as the granary of fruit and vegetable for the rest of the world, essentially European countries, West African countries disposed of a great potentiality in those crops production but are facing the great challenges of postharvest loss due to the non-transformation of those products and climate change conditions. This study uses the gap analysis method to explore bioeconomy and postharvest loss of selected vegetables (eggplants, tomatoes, onions, and cabbage) in Ghana, Nigeria, Senegal and Togo. . This method is a qualitative analysis approach based on secondary data available in the public domain (computer search of keywords for scientific literature and some statistics from FAOSTAT). With the data from the literature, we applied the outcome tracking approach to identify circular bioeconomy effect in trade, business, and economic transformation opportunities in crops and postharvest losses. Applying interdisciplinary circular bioeconomy and blending traditional and conventional models along the value chain of vegetable transformations can be the best bet for creating a wide array of natural livelihood-sustaining systems leading to socio-cultural, economic, and environmental benefits. Our result shows a relevant circular bioeconomy potentiality that offers these vegetables in terms of trade, business and economic transformation for postharvest loss reduction for sustainable food systems in Ghana, Nigeria, Senegal and Togo. It suggests the local transformation of vegetables into new food products, Agri-business development using clean technology (solar mailing for tomatoes transformations), and using organic waste as bio-fertilizer. All these ensure jobs creations opportunities in the trading of new food products. The present work fits into the fourth subtheme (trade, business and economic transformation for postharvest loss reduction) of the 3rd All Africa Postharvest Congress and Exhibition (AAPHCE) and will be an oral presentation. For future study, primary data (survey) can be conducted to better explore, the circular bioeconomy of a specific vegetable postharvest in a specific West African country.

Keywords: Bioeconomy, Circularity, Gap analysis, Food systems, Vegetables.

Trade, Business and Economic Transformation Opportunities at Postharvest: the Case of the Sorghum VC in Northern Ghana

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Staple food grains such as maize, rice and sorghum are crucial in assuring food and nutrition security in many African households, especially in smallholder households and among the urban/peri-urban poor. The majority of African households are also dependent on these value chains for their livelihoods, not only at the level of production but also in a range of trading activities and artisanal processing of all types. The industrial uptake of smallholder-produced grains can also catalyse sustained growth in output and productivity and boost smallholder producers' income. However, a major problem hindering this is the high level of postharvest losses (PHL), in the form of quantity losses and variability in quality. This paper/presentation illustrates, using the case of the sorghum value chain (VC) in Ghana, how the adoption of PHL-reducing practices and technologies can open up opportunities for industrial uptake of agricultural commodities, thereby catalysing sustainable and inclusive growth. Using secondary data from the African Postharvest Losses Information System (APHLIS) and a rapid assessment of losses by farmers participating in outgrower schemes in the sorghum VC in Northern Ghana, estimates were made of the potential reduction in PHL at different stages at which the farmers had adopted loss-reduction technologies and practices. Projections were then made for the PHL reductions achieved if most smallholder farmers in the VC adopted the loss-reduction technologies and practices. Further to this, a quantitative value chain analysis (VCA) framework is applied to assess the impact of the loss-reduction on farmers and other actors in the sorghum VC.

Evidence from the study shows that adoption of available and affordable technologies can lead to tangible reductions in PHL, with significant positive impacts on smallholder households and at the macro-level. There is evidence of improved food security and positive net income effects in smallholder households as a result of increased availability of sorghum grain for household consumption and/or sale. At the macro level, the financial value and overall national nutrition implications of the loss reduction are also quantified and more visibly attest to the need for investing in PHL reduction. Further evidence from the VCA shows high potential to increase the VC's contribution to agricultural GDP as opportunities for value addition emerge for grain aggregators, traders and artisanal as well as industrial processors. Based on these results, the authors recommend investment by governments, donors and private actors in PHL-reduction technologies/practices in agricultural VCs because of the positive income and food security impacts and broader, quantifiable economic gains. There is, however, the need to validate these results through more robust PHL measurements linked to the adoption of available technologies.

Keywords: Smallholders, value chains, processing, GDP contribution and postharvest loss-reduction.

Promising Climate Smart Business Cases for Smallholder Rice Farmers in Nigeria by Introducing Mechanization

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Rice plays a pivotal role for the food security of more than half of the world's population. In West and East Africa, too, rice is one of the most essential basic foodstuffs. Nigeria is Africa's largest producer of rice. Nevertheless, the country still depends heavily on rice importations. Smallholder farmers produce over 90% of Nigeria's rice on averagely less than two hectares. The production methods are traditional, with low use of improved technologies and mechanization.

Globally approximately one-third of all food produced is lost or wasted before being consumed. Food loss and waste (FLW) is not only a threat to nutrition security, farmer livelihoods, and resource use efficiency. It also represents a threat to our climate. FLW induced Greenhouse Gas emissions (GHGe) represent about 8% of the total anthropogenic GHGe. Rice accounts for as much as approximately 10% of those FLW induced emissions. Due to its significant emissions, rice can be classified as a hotspot product. In Nigeria, it was measured that from harvest at smallholder rice farms to the factory, ~35% of the harvested rice is lost. Harvesting and threshing are detected as stages in the supply chain with the highest losses. The introduction of mechanization is identified as potentially impactful interventions for loss- and GHGe reduction. To assess the impact of mechanization Wageningen University and Research (WUR), in cooperation with Olam Rice Nigeria, conducted a controlled experiment in Nigeria in which mechanized rice harvesting and mechanized threshing were introduced on smallholder farms. The yield from mechanically harvested and threshed sample plots of rice was compared with the yield from sample plots harvested and threshed manually. The result of the study shows that introducing mechanized harvesting and mechanized threshing is the optimal scenario. Annually almost half a ton (479 kg) food loss reduction per hectare, equivalent to approximately 14 %, of the yield can be achieved. Mechanization is thereby increasing farmers income by approximately USD 200 per hectare and year. Moreover, the introduction of mechanization can avoid GHGe per unit food available for consumption, equivalent to 1.7 ton CO₂-eq. production-related greenhouse gas emissions per hectare. This includes the effects of the reaper and thresher fuel use, making a strong case for farm mechanization as a climate positive intervention. The introduction of mechanization can also reduce approximately 200 labor hours of farmers. With a reaper costing ~USD 2,100 to buy and a thresher ~USD900, the upfront cost is ~USD 3,000. Reducing losses by investing in mechanization therefor provides an attractive return of investment. This can be done via service provision or a group of for instance 15 farmers can spread the upfront cost over 3 harvests or more. Based on this work the researchers give the policy advice that mechanization should be part of agricultural development strategies for reducing losses, improving food security and improving farmers' incomes.

Keywords: Food loss reduction, rice, greenhouse gas emissions, Nigeria, mechanization

Farmers Opt-out of Storage because its Risky - a New Explanation for a Long-Standing Puzzle

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In developing countries, staple cereal grain prices exhibit regular, seasonal price fluctuations in rural markets. Thoroughly documented (Kaminski et al., 2014, 2016), this pattern has been shown to relate to seasonal hunger, malnutrition, and food insecurity among small farmer households (Sahn, 1989; Christian and Dillon, 2018). A contributing factor: these households have often been unable or unwilling to exploit inter-temporal arbitrage opportunities for storable commodities (maize, rice). Instead, they are observed to sell their output when prices are low and often repurchase the same commodity for family sustenance later in the year when prices are substantially higher (Barrett, 2007). Explanations for this pattern of behavior have centered on liquidity constraints and transaction costs (Stephens and Barrett, 2011) as well as inadequate storage technologies (Burke et. al, 2019). We propose a new explanation for the commonly observed “sell low, buy high” behavior among small farmers in developing countries. We analyze the distribution of seasonal price increases and the risk management implications for smallholders. We show that storage is associated with a critical probability of negative relative returns, even when those returns are in expectation quite high on average. Our analysis uses 20 years of data from 831 markets in 25 African countries to demonstrate that the market price in the lean season (the assumed “high price” season) often fails to exceed the prevailing price in the harvest season (the “low price” season). The probability of negative returns to storage across seasons is 29%. We develop a two-period model that demonstrates that the possibility of negative returns can induce risk-averse households that both produce and consume staple cereals to select out of grain storage, despite credit availability or food security incentives. Our results have implications for policies and interventions related to promoting intra-annual storage to exploit lean season sales. Focus on average patterns of seasonal prices in the literature has meant that researchers have missed an important risk relevant to small farmer and small trader decision-making related to post-harvest grain storage. These are, years in which the lean season price fails to rise above the price at the time of harvest. Our insight that storage implies a nontrivial probability of negative relative returns is consistent with farmers opting to sell immediately post-harvest if they have no hedging options. In the end, the result is analogous to explanations related to binding seasonal liquidity constraints, because those cause returns to lean-season sales to be relatively lower than returns to current sales. But the mechanism that we identify is different from previous analyses and models, arising from a different financial market failure. Our findings suggest the importance of analysis and interventions related to insurance and options associated with storage and lean season sales, both for small farmers and small traders in these markets.

Keywords: Maize prices, risk aversion, commodity markets, smallholder farmers

Market-based Approaches for Postharvest Loss Reduction in Northern Ghana

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The conventional wisdom in the 1970s and 1980s was that agricultural modernization, through technology adoption, was the solution to reducing global postharvest loss. Today, it is assumed that postharvest losses in cereals are higher among smallholder farmers who adopt traditional agricultural methods. According to the World Bank, the success of these technology interventions for postharvest loss reduction is inconclusive in Africa. Some studies conclude that postharvest loss is reduced with technology adoption, while others suggest that technology adoption and transfer do not affect postharvest loss. They may even increase it. For example, it has been found that increases in food productivity may lead to market surpluses that, given the low adoption of storage technologies, may result in greater postharvest loss. The uncertain outcomes in Africa regarding the impact of technological solutions on postharvest loss have prompted others to consider market-based approaches and interventions to reduce loss. Some market-led strategies include assuring demand from anchor buyers, purchasing from smallholder farmers through links created with processors and traders, reducing the distance between smallholder farmers and the markets, and creating alternative markets for excess production. This research examines the impact of one market-based approach, contract farming, on reducing postharvest loss in Northern Ghana. This presentation focuses on answering these research questions- Do farmers who participate in contract farming arrangements have less postharvest losses in comparison with farmers not participating in contract farming? The research adopts the mixed methods methodology in analyzing the results of a 2019 survey in Ghana that included about 400 farmers, four farming organizations, selected members of the academic community, several civil society groups, and government and private sectors representatives. The results show that farmers that participated in formal contract farming schemes experienced lower postharvest loss than farmers who did not. One caveat is that the research also found that farmers participating in informal contracting schemes experienced greater postharvest loss than farmers in formal schemes or no schemes. Given the opportunities that contact farming presents to increase production, reduce loss, and increase farmers' household income, there is room to improve the challenges facing farmers and principals of these contract schemes. Also, as contract farming participation increases, there is a need to create or modify the existing bodies of law to accommodate these changes. In developing these laws, it is recommended that the government set up an organization that will include farmers, agents of contract farming schemes and tribal chiefs. This will ensure that the voices of all the stakeholders in the agricultural sector are considered and heard in the formulation of the laws.

Keywords: Postharvest loss, Contract Farming, Law, Maize

Business Opportunities for Improving Food Safety and Postharvest Loss in Ethiopia, Rwanda and Senegal

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Feed the Future Business Drivers for Food Safety project (BD4FS), funded by USAID and implemented by Food Enterprise Solutions (FES), aims to strengthen capacities of food business actors to make them agents of positive change towards improved food safety and reduction of pre-consumer postharvest loss. Considering the nutritional and economic importance of perishable fruits and vegetables in Africa, BD4FS initiated studies to identify key issues for perishable horticultural crops within food systems in selected Feed the Future countries. We worked closely with small- and medium-sized enterprises (SMEs) to learn what the existing practices are for food safety and to understand barriers and enablers for adopting safer food practices. This research also explored the links between food safety, food loss, food waste, nutritional value, and market value.

Collaboration and co-creation with businesses and other food systems actors are key to our approach, as are engaging youth and women entrepreneurs in building a strong and safe food system. Our 5-step approach: discover, design, deploy, document, and disseminate - "D-5" - is done in partnership with local stakeholders. With in-country collaborators in Senegal and subject matter experts, we completed the discovery phase through a food safety situational analysis (FSSA), a Commodity System Assessment Methodology (CSAM), and a review of existing protocols for measuring pre-consumer postharvest loss for horticulture. We then co-designed a strategy for engaging SMEs by identifying, selecting, and involving food businesses eager to implement safer food practices. We developed a BD4FS postharvest loss tool for businesses to measure food loss. Preliminary scoping through literature review has also been completed in Ethiopia and Rwanda.

Key food safety issues identified in Ethiopia, Rwanda, and Senegal include (1) absent or inconsistent cooling of perishable horticulture products at all points in the supply chain and (2) inadequate access to water, sanitation, and hygiene (WASH) services. With this finding, particular focus has been given to cleanliness and cooling to improve product quality, safety, and shelf-life. We have initiated a training series in Senegal that concentrates on our unique "cool & clean" approach for perishable foods to improve temperature control and hygiene. With the insight of our Senegalese partner SMEs, we are also understanding incentives and promoting affordable financial services for capital investment in cold chain logistics and innovative food safety technologies. Further, we are engaging businesses to test the BD4FS postharvest loss tool in Senegal.

Our strategy of engaging SMEs in co-discovery and co-design in Senegal is being adapted to be relevant and appropriate for each BD4FS partner country - considering local challenges, opportunities, and topics of importance. Findings from this work are informing actionable interventions for BD4FS to build capacity and incentivize SMEs to improve food safety and reduce the postharvest loss for perishable horticulture products in Africa.

Keywords: food safety, postharvest loss, horticulture, food business, SME

The Drivers of Smallholder Market Participation in the Sahel, Niger

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Farmer market participation promotes economic growth and helps to reduce poverty and hunger. This paper aims to examine the drivers of household market participation using data collected from rural households in the agricultural regions of Niger. First, we used the binary probit model to assess the factors influencing smallholders' decisions to participate in crop sales. Second, we analyzed the determinants of the quantity of crop sold employing the Tobit model. The probit model revealed that being a male-headed household, age, literacy level, access to credit and market, crop production, farm income, and migrant-headed household positively influence farmers' decisions to participate in crop sales. However, household size and assets, farming experience, and experience of drought have a negative effect on smallholders' decisions to participate in crop sales. Meanwhile, the results of the Tobit model showed that farm size, access to credit, membership, contact to extension services, the quantity of crop produced, being a migrant, and age of household head are factors that have a positive effect on the amount of crop sold. In contrast, household size, attending training, access to market, and experience of drought negatively influence the quantity of crops sold.

This study encourages farmers to use drought-tolerant, climate-resilient crops to increase production. The government and other rural development agencies should facilitate farmers' access to credit and market to ensure active household market participation.

Keywords: Smallholder; Market participation; probit; Tobit; Niger

SUBTHEME 5

**FINANCING POSTHARVEST LOSS REDUCTION INITIATIVES;
BUSINESS CASES/MODELS IN POSTHARVEST LOSS
REDUCTION; INNOVATIVE FINANCING MECHANISMS FOR
UPSCALING POSTHARVEST INTERVENTIONS**

2021

**3RD ALL AFRICA POSTHARVEST CONGRESS &
EXHIBITION, BOOK OF ABSTRACTS**

Theme: Postharvest Loss Reduction for Sustainable Food Systems



Climate change perceptions and adaptation by Sebei pastoralists, Mt Elgon, Uganda

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Mountain communities like Sebei of Mount Elgon that mainly rely on agriculture for their livelihood are disproportionately vulnerable to climate. In this study, we assessed local perceptions regarding climate change, its impacts and coping strategies employed by the pastoral communities. The study was undertaken in the Kween district of Mount Elgon. A cross sectional survey was undertaken using structured and semi-structured interview questionnaires. Our results show that the majority of respondents perceive that climate has changed and that rainfall and temperature patterns have become highly variable. The coping strategies employed that are unique in this study included increased utilization of veterinary services and products, and use of banana suckers and maize plants as alternative fodder for livestock. The climate change adaptation practices employed were largely driven by indigenous knowledge and were largely paid for using available resources at the household level. The coping strategies were highly seasonal and can potentially be scaled to communities with similar agroecosystems. Weather forecasts and climate change information that is reliable and accessible needs to be delivered to these Mountain communities to enhance adaptation practices. Interventions ought to leverage on the current coping strategies to enhance livelihoods within this area.

Keywords: Climatic changes, adaptation, pastoralists, mountains

Business Models in Postharvest Loss Reduction

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The main challenge currently facing humanity besides the Covid-19 pandemic is feeding of the estimated 9 billion people by 2050. The annual global food wastage of 1.3 billion tons valued at US\$ 2.6 trillion impedes food security and precipitates climate change. Therefore, there is a need to increase food production to feed the ever growing population. Grain losses in sub-Saharan Africa are about 50% with an estimated value of US\$ 4 billion. Although reducing food wastage is one approach to increase food availability, global funding to agriculture remains skewed towards research and production at the expense of postharvest management. Of the funding which is allocated to agriculture globally, only five percent goes to addressing food loss and waste. Therefore, there is a need to develop business models for the channeling of funding towards addressing postharvest losses. A study was conducted to investigate and explain the factors responsible for the low adoption of technology for addressing postharvest losses by smallholder farmers in Zambia. Empirical data was collected using the case study strategy. The study adopted the Unified Theory of Acceptance and Use of Technology Framework. Data collected from 100 smallholder farmers in Choma, Katete and Kalomo districts of Zambia were analysed using a statistical package for social scientists and the grounded theory approach. The study findings are presented as factors responsible for the low adoption of technologies for reducing postharvest maize losses. These factors included lack of information and knowledge of the available technologies and associated benefits, perceived cost, non-availability of technology close to where the smallholders are located, and challenges of operating the technologies. Furthermore, there was inadequate financing of postharvest activities at the national level. With support from literature the study findings were used in developing the Community Agrodealer and Farmer Cooperative Postharvest Business Models for financing and increasing technology adoption. The Community Agrodealer Postharvest Business Model was developed out of the Community Agrodealer Model. This model involves financing institutions, and manufacturers and suppliers of technology channeling their finance and innovations through community agrodealers to smallholder farmers. The model has brought on board training and extension providers. The Farmer Cooperative Postharvest Business Model was developed out of the Cooperative Model. The farmer cooperatives were considered to be suitable business models because these institutions are owned and controlled by members to meet their economic, social, and cultural needs and aspirations through a jointly owned and democratically controlled business. Additionally, input and marketing cooperatives are established by farmers to undertake supply of inputs, marketing of produce and facilitate access to finance and technology. Application of the Community Agrodealer and Cooperative Business Models has improved awareness creation of available postharvest loss reducing technology among smallholders. Furthermore, suppliers of technology have reported an increase in the demand for hermetic technology such as PICS bags by farmers. Under the Cooperative Business Model, payment for the technology obtained on credit is done using the stop order system by the cooperative.

Key words: Postharvest losses, hermetic storage, food loss and waste, technology

Economic and Financial Analysis of a Flatbed Dryer for Maize Drying Using Biomass Heat Source

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The use of low-capacity drying systems suitable for smallholder maize farmers in Ghana can contribute substantially to the reduction of postharvest losses of maize. However, unavailable information on the cost-effectiveness of such drying systems for decision-making by farmers and potential investors is lacking. This study sought to assess the financial and economic feasibility of a 3-tonne capacity flatbed dryer using maize cobs as a biomass heat source for drying of maize. A cost-benefit analysis was done using net present value (NPV), benefit-cost ratio (BCR), internal rate of return (IRR), and payback period (PBP) to measure the financial viability of the dryer operation and the profitability of the investment. The results show that the total capital expenditure required to establish the drying system is GH 35,000 (US\$6,140) with a running cost of Gh 3,080.80 (US\$540) per 4-month operational period in a year. Using an economic utilisation period of 15 years, the investment in the dryer was determined to be viable with an NPV of GH 64,487 (US\$11,313) and IRR of 54%. At a drying charge of \$1.75/bag of maize, the results show the initial capital invested in the set-up of a drying service can be recouped in a PBP of 1.84 years at a BCR of 2.65. This is an indication that an investment in 3-tonne capacity dryer systems and providing drying services is a viable and profitable business opportunity. The findings have implications in addressing maize post-harvest losses at the smallholder level and will support employment creation, especially among the youth and women in rural maize growing communities in Ghana.

Keywords: Flatbed biomass dryer, maize drying, economic analysis, revenue generation.

Adoption and Impact of Hermetic Storage Bags - Experimental Evidence from Smallholders in Ethiopia

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Hermetic storage bags are a simple and effective technology for smallholder farming households to reduce postharvest storage losses and to improve food security. Despite these benefits, hermetic storage bag adoption remains low. We posit that a lack of trust in the technology and limited affordability of hermetic storage bags constrain adoption. Using a blocked cluster randomized control trial with 1500 smallholder farmers in four districts (woredas) of Ethiopia, we evaluated the effect of two types of interventions on hermetic storage adoption rates: 1) providing farmers with one free hermetic storage bag five months ahead of a purchase offer (to increase trust in the technology), and 2) offering farmers to purchase hermetic storage bags at a discounted price (45 ETB, about 1 USD) instead of the distributor's recommended retail price (65 ETB) to improve affordability. The adoption rate was measured as the share of farmers who purchased at least one hermetic storage bag. We found that offering farmers hermetic storage bags at a discounted price had a large positive effect on adoption rates, irrespective of having received a free trial bag or not. At discounted prices, we found an adoption rate of 66.9% (farmers without a free trial bag) and 69.3% (farmers with a free trial bag). In contrast, at the distributor's recommended retail price, our results show an adoption rate of 11.2% (farmers without a free trial bag) and 10.4% (farmers with a free trial bag). While we did not detect significant effects of providing a free trial bag on adoption rates, we found, however, that providing a free trial bag had rapid and significant effects on household welfare. Five months after receiving one free trial bag (reflecting the start of the lean season), households of trial bag recipients had reduced food insecurity (23.5% reduction in the number of food insecure households, on average), higher grain stocks (127 kg, on average), and relied less on markets to purchase additional food. The effects of a free trial bag on household welfare materializes fast, but the effects of providing a free trial bag on adoption may take longer to develop (as building trust may require time). Taken together, our results demonstrate a large, untapped potential to increase the adoption of hermetic storage bags among smallholder farmers. Our results highlight that reducing retail prices of hermetic storage bags is a key and immediate opportunity to support the adoption of hermetic storage bags. Options in this regard include more efficient distribution and retail systems, a conducive policy and tax environment, and enhanced competition among hermetic storage bag technology distributors. Such measures can be augmented with free trial bags when rapid positive household welfare effects are desired.

Keywords: Post-harvest losses, hermetic storage, adoption, market potential, food security

Business opportunities to reduce post-harvest loss of nutritious foods: Modelling the return on investment of field-ready technologies in Nigeria

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Levels of post-harvest loss of fresh fruit and vegetables are high, particularly in low- and middle-income countries, and lead to lower food accessibility and affordability. Reduction of post-harvest loss could therefore have a major positive impact on increasing the affordability and accessibility of nutrient-dense fresh fruits and vegetables. While technologies to do so exist, their financial viability for the firms that would need to adopt them has not always been clear. This paper sheds light on this topic by analysing the costs and benefits of three innovations within the context of Nigeria's tomato value chain: reusable plastic crates to transport fresh fruit and vegetables to market, solar-powered cold rooms to store them, and refrigerated trucks to transport them to market. For the crates and cold rooms, we considered both own-use and lease cases. A stylised cost-benefit analysis for each technology and use case was done based on data obtained from five Nigerian companies. To take account of the uncertainty, we developed a baseline scenario for each technology based on the data provided by the companies, and then varied the key assumptions to test the robustness of the results. The results suggested that five of the six technology-business model combinations represent viable economic investments for food system firms, at least under certain circumstances, while the other (e.g., a 10 MT cold room rented as a service in a rural setting) would require subsidies or loans to make it viable. Unfortunately, it can be very difficult for agri-food firms to access financing in settings such as Nigeria, indicating an important area for future intervention.

Keywords: Post-harvest loss, financial modelling, return on investment, reusables plastic crates, solar-powered cold room, refrigerated truck.

Willingness to accept compensation for a shift to contamination free vegetable production by urban and peri-urban farmers in Nairobi, Kenya

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The quality of harvested leafy vegetables is governed by numerous factors including safety for human consumption. Accordingly, post-harvest losses in terms of quality deterioration could be caused by chemical contamination. The unacceptable levels of pesticide residues in harvested vegetables are a cause of acute and chronic health effects to consumers and farmers. Quality assessment by experimental studies on harvested vegetables from farms in urban and peri-urban areas of Nairobi have reported pesticide residues above the World Health Organization (WHO) maximum residue limit. In this case, the post-harvest losses do not start after harvesting but are an implication of on-farm practices in pest control. Pesticide use in urban and peri-urban vegetable farming helps increase production in decreasing crop acreage due to the high urban population growth. However, adoption of the integrated pest management (IPM) approach by farmers could reduce contamination levels and health risk exposure whilst still maintaining high production. The IPM approach has also been proven to be ecologically sustainable and cost effective. Even though there are numerous benefits associated with the use of IPM technologies such as cultural practices, mechanical and biological control, their adoption is still very low among vegetable farmers who continuously use chemical pesticides only. Despite the growing literature on post-harvest losses in leafy vegetables, pesticide residues levels and the farm practices farmers can adopt to reduce these levels, there is still a dearth of empirical information on whether farmers are willing to adopt these practices and if so, what is the minimum monetary compensation they are willing to accept for the voluntary uptake. This study therefore sought to contribute to literature by filling this gap in knowledge. Double bounded logit model was used on data to determine farmers willingness to accept compensation for the adoption of on-farm food safety practices. Empirical results showed that the average willingness to accept (WTA) compensation amounts were KShs.1074 (US\$11) for sticky traps and KShs. 1436 (US\$14) for pheromone traps. These were higher than the initial bid amounts for all practices. These amounts are proxies for the economic cost of food safety and reducing post-harvest losses in leafy vegetables which starts at the farm level. However, average WTA amounts were higher for urban than peri-urban farmers. The results also showed that access to extension services and farmers' attitude negatively influenced the WTA amounts. Based on the aforementioned results, a variety of incentives can be geared towards reducing contamination such as input subsidies. There is also the need for access to extension services. This can be done by the involvement of more stakeholders in farmer trainings including private companies that manufacture and sell technologies that help reduce pesticide contamination. Manufactures of IPM technologies should also work on farmer centred marketing to improve farmers' attitudes towards these products.

Keywords: Post-harvest losses, pesticide residue, contingent valuation, willingness to accept

Consumers' perception and willingness to pay for processed fluted pumpkin in Northcentral Nigeria

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Although there are diverse kinds of leafy vegetables in Nigeria, fluted pumpkin has arguably the widest spread in the diets of Nigerians. However, the high perishability of its leaves has been a source of concern for which mild processing has been suggested in the literature as a way to preserve them. Several studies have been done on the production and profitability of fluted pumpkins. However, none exist on consumers' willingness to pay (WTP) for processed fluted pumpkins based on sensory/organoleptic attributes in Nigeria. This study fills this gap by investigating consumers' perception of processed fluted pumpkin leaves, their WTP for processed fluted pumpkin leaves, and the factors affecting their WTP. Data used in this study were obtained using a set of pretested structured questionnaires in an interview schedule, and it was administered to 120 consumers in Ilorin, Northcentral Nigeria. Descriptive statistics and logistic regression analysis were used to analyse the data. We found evidence that consumers have a high perception of the sensory/organoleptic attributes - general acceptability, texture, colour, general appearance, and aroma - of the processed fluted pumpkin leaves; with 92.3% of them willing to pay for the processed fluted pumpkin leaves while 64.0% of consumers were willing to pay a premium more significant than 100% of the conventional price of fresh fluted pumpkin leaves. The study also revealed that the perception of consumers about the sensory attributes of the processed pumpkins and their preferences for the processed leaves positively influence their willingness to pay. Based on the study's findings, it is recommended that further studies be carried out on processed fluted pumpkins to ascertain their suitability for scaling their production for the market.

Keywords: Willingness to pay, perception, sensory attributes, vegetables, logistics regression

SUBTHEME 6

ENABLING POLICIES, EFFECTIVE NATIONAL/REGIONAL STRATEGIES, EXPERIENCE SHARING, COLLABORATING, LEARNING AND ADAPTING (CLA)

2021

3RD ALL AFRICA POSTHARVEST CONGRESS & EXHIBITION, BOOK OF ABSTRACTS

Theme: Postharvest Loss Reduction for Sustainable Food Systems



Status of Postharvest Management Policies in sub-Saharan Africa

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Postharvest losses in sub-Saharan Africa (SSA) are unacceptably high resulting in \$4.17 billion worth of food grain being lost per annum. Improved postharvest management (PHM) to reduce food loss has the potential to avoid food losses equivalent to the food and nutrition requirements of 48 million people in SSA. Providing an enabling environment can help curb this loss and make more food available and reduce food aid needs. However, the PHM policy landscape in SSA is poorly understood. The current study sought to analyse the PHM policy status on the subcontinent and identify gaps. The study covered 27 countries and 53 respondents across East, Central, West and Southern Africa. The respondent interviews were conducted virtually using a semi-structured questionnaire. The study collected primary data from experienced respondents who are involved in the food and agriculture sector. The data were analysed using thematic analysis, a qualitative data analysis approach that is used to identify, analyse, describe, and report themes found in a dataset. Of the countries surveyed, none have clear policies specific to PHM. The PHM aspects are embedded in general agricultural policies, and respondents were strongly against this approach as these created constraints in resource allocation for the implementation of PHM activities. Respondents reported that PHM interventions are often crippled by a lack of specific budgetary allocation, making it difficult for countries to meet their AU Malabo Declaration reporting requirements. Ten countries in SSA have submitted the required AU data according to the specifications. Most respondents were not familiar with the AU data submission processes and where they were, the data was not available to feed into the data template. From the surveyed countries, only seven have developed PHM strategies. In most of the instances, the strategies are still awaiting government approval and therefore have not yet been implemented. There is a general awareness of the African Postharvest Losses Information System (APHLIS) as a tool for estimating postharvest losses in SSA, but it is mainly used by researchers, who understand its application. The study revealed major policy gaps as evidenced by lack of specific policies on PHM in SSA countries. This study also revealed a lack of national and continental harmonisation in PHL reduction activities. Where there has been some PHM action, it is crippled by political agendas, bureaucratic arrangements, and lack of financial and human resources. The private sector plays a key role in PHM technology generation and dissemination, yet its engagement is still at infancy in SSA countries. Key recommendations include the need: to develop PHM Policies and/or strategies where they do not exist, with clear M&E frameworks to determine delivery against set indicators and overall impact; the AU needs to operationalise the recently launched continental Postharvest Loss Management Strategy; to have clear methodologies for estimating PHLs to feed into the AU PHL framework, e.g. APHLIS but requires expansion of APHLIS user-base; for governments to provide incentives for the private sector to invest in PHM; and for governments to spearhead the formation of national PHM innovation platforms for better coordination and prioritisation of PHM interventions and guide strategic policy direction.

Keywords: Postharvest management policy analysis, Policy incentives, AU Malabo Reporting, African Postharvest Loss Information System (APHLIS), continental Postharvest Loss Management Strategy

Role of Policy on Minimizing Post-Harvest and Food losses

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Reforms in food and agricultural policies to enable more effective, efficient and inclusive policy frameworks are necessary in emerging economies. The major challenge is that post-harvest and food loss issues are not included in policy development in many government blueprints, resulting in research organizations and other partners not investing more on post – harvest value chains. Creating sustainable policy monitoring systems and carrying out a consistent set of policy and public expenditure analyses across a wide range of agricultural value chains is paramount. Research and monitoring and evaluation data are used to analyse and inform agrarian policy reforms that will result in a more conducive environment for agricultural investment and productivity growth, especially for smallholder farmers. As countries need support in collecting information, most governments are not providing enough budgetary contribution for these important exercises that informs policy development. Collaboration with other partners and national stakeholders, is important in implementing a series of activities to support governments in driving private investment towards the most cost-effective food loss reduction actions. Overall, the study aims to create an enabling environment to reduce post-harvest losses and increase food availability, raise farmer's incomes, and improve food quality by reducing food losses in selected value chains in the face of COVID 19 where food systems are disrupted. The study assesses the regulatory framework and gathers information on policies affecting food losses in Zimbabwe. The study was done under the Hand in Hand initiative under FAO. Key informant interviews and desk review of different policy documents was done to ascertain the recommendations. The study recommended that governments should provide incentives to reduce post-harvest losses and encourage private sector investments in storage, logistics, handling and processing technologies. The private sector, through value chain development can be the most cost-effective food loss driver with the support of sound policies. There is need to look at the fiscal incentives that can be proposed and adopted by governments.

Keywords: Policy, government, post-harvest losses

Postharvest Loss, ICT, New Technologies and Alternative Practices: a Bibliometric and Network Analysis

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Concerns about feeding the world population in the future are deeply related to food loss reduction policies. Based on a bibliometric and network analysis, this paper aims to identify how academics have explored the relation between postharvest losses, information/communication technologies (ICT), and alternative management practices. We analyzed a total of 482 articles based on a group of keywords. The number of papers published per year has increased since the '90s, reaching 68 articles in 2018. From 1990 to 1999, the average number of papers published per year is 2.8. We observed a significant increase in the 2000-2009 and 2010-2019 periods - 10.5 and 34.9 articles per year, respectively. The ten most cited papers are mostly related to technologies and alternative practices to reduce postharvest food losses. Three of them focused on estimating and monitoring the amount of loss. The network analysis found that the average clustering coefficient is 0.166, which indicates that the papers included in the study have poorly in-between interactions. The diversity of subjects studied by the articles seem to be one of the causes of this weak interaction between the authors. We also have to mention the high complexity and dimension related to postharvest loss issues, and all the different (but complementary) approaches developed in fostering this problem. An effort to increase the PHL research agenda between institutions, universities, and countries seems to be relevant. The development of the new postharvest tools and technologies has been the focus of a significant part of the work, and a great effort has been made to deal with African countries' postharvest problems. Differences in infrastructure and technology between countries and regions are central problems for PHL reduction and increased food shelf life. The advance of new technologies and management practices (like cold storage, solar drying, and packaging techniques) is considered one of the pillars of this research field. Studies focusing on PHL quantification in different regions are also the basis of this academic literature, as the willingness to adopt new findings, especially smallholder farmers, is a significant research agenda. Farmer's past experiences, production scale, access to extension services, acquisition costs, and potential economic benefits seem to be the leading causes that affect how farms adopt new improvements on PHL. How farmers could better access markets and have information for assertive decision-making remains a central question. ICT could be more focused on PHL issues, contributing to the reduction of food loss among different value chains. Due to the advance of the digitalization of agriculture, a data-driven approach could promote food loss and waste reduction by improvements on existing commercial tools/channels.

Keywords: postharvest loss, ICT, bibliometric, network analysis

A call for women inclusiveness in fish value chain in Malawi

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Gender disparities have a long history in most parts of the world. The United Nations (UN), African Union (AU), African Development Bank (AfDB) and Southern African Development Community (SADC) among others are striving to eliminate gender disparities in Africa. Malawi is a signatory to both international and regional conventions, treaties, declarations and protocols enforcing the rights of women and children. At the national level, Malawi has a strong legal and policy framework for human rights which includes gender-related rights. However, due to poor implementation, monitoring and policing of these legal and policy frameworks, this has resulted into gender disparities remaining a challenge to date even in fisheries sector. Women have low participation in the fish value chain thereby weakening the economic and nutritional value of fish at household, community, and regional levels. At the moment there is a severe decline in fish consumption per capita from 14 kg per person per year in the late 1990s to about 5.4 kg per person per year in 2017 hence posing a severe national nutrition problem as fish contributes about 40% of total meat consumed in Malawi. Women are involved throughout the fish value chain; however, more participation is done in fish processing and marketing though into as much as men. Limited women participation is observed on the actual fishing although at the moment only 2% of women are gear owners. Several interventions are being made to increase women's participation in the fish value chain in Malawi. Dispersed cases of child labour were as well observed across the fish value chain but require proper quantification. Both Nsomba Mchuma Project and World Fish Centre advocate for a climate-smart technology designed to trap warm air inside and dry the fish faster, even during rainy weather in a clean environment without any dust and houseflies. The technology is reducing deforestation as there is now no needs to cut down trees carelessly which were formerly used to smoke the fish. The technology will greatly enhance fish value chain in Malawi. Women benefit from this technology even more as it tackles the fishing processing and trading nodes where more women participation is in the fish value chain. There is a need to develop a Fisheries Gender Strategy that should be in unison with the National Gender Policy and the current fisheries regulations. At the same time, the said strategy should be well monitored and policed to ensure its implementation adherence by stakeholders.

Keywords: Gender, policy, fish value chain, Malawi, climate-smart technology

Understanding awareness and policy context for reducing mycotoxin contamination and food and feed losses in African

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The three major scientific networks addressing mycotoxins contamination in Africa* joined forces for launching an online survey exploring the level of awareness of the main food systems stakeholders towards mycotoxin contamination and its impact on human and animal health and on food and feed losses. The survey was designed with the aim of testing awareness of the presence of mycotoxins in foodstuffs and actions taken to counter their presence and reduce losses. The survey, launched in April 2021, consisted of five different modules targeting farmers, food processors, food scientists, food traders and food policy makers. The questionnaires consisted of a common section completed by target class specific questions. One of the objectives of the survey was also to test the ability to communicate with the target groups. Among the fields of investigation common to each class we considered: geographical location, gender, knowledge of issues related to the presence of mycotoxins in food or food raw materials, knowledge of food safety laws and presence of mycotoxins, knowledge of a food safety authority recognised in the territory at national or regional level, knowledge of rules in force on controls and control methods/plans to ensure the healthiness of foodstuffs, interest in receiving information and/or updates on mycotoxins and food safety issues. In addition to this information, we asked farmers for more specific information about their fields, type of cultivation, actual technologies or methods applied to limit mycotoxin contamination and the costs and benefits of implementing contamination control plans. Food and feed producers and sellers were also asked about the possible costs of safety controls, the type of tests used and the market response to mycotoxin-tested food and feed. Researchers and scientists in the field responded to specific questions about whether they feel they have sufficient means to progress in food safety research and whether they have the opportunity and/or opportunity to interact with each other and with the other classes of actors identified for the survey. Food policy makers about the possibility of better dissemination, standardisation or transposition of food safety regulations on mycotoxins, whether there is a specific interest in this area, what are the preferred channels of communication. It is worth noting the good response from the researchers, who readily adhered to the initiative, enabling us to collect a number of responses corresponding to the expectations (n=62). It was much more difficult than expected to reach the representatives of the other four classes of respondents. Despite the small number of responses from food traders and producers (n<10), some points of reflection were nevertheless drawn. While for the class of farmers and policy makers, the responses allowed a scenario to be drawn, the starting point for any possible future decision and action (n>10). The preliminary results and analysis of this survey are the subject of this presentation. Further and different approaches will be implemented in order to obtain a broader and more targeted response from the subjects considered in the survey.

* African Society of Mycotoxicology (ASM), Mycokey and Mytox-South Networks

Keywords: mycotoxin, Africa, food losses, food safety, survey.

Food security efficiency metrics: a cross country comparison

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The four dimensions of food security are availability, access, utilization, and stability. A country's economic, social and environmental conditions affect, in a different way, the performance and the sustainability of its food system. Knowing how the food systems perform in different places might be helpful to give insights for policymakers and other institutions that are fostering food security. This paper investigates the food security performances in 107 countries using Data Envelopment Analysis (DEA) approach. Using data from Food and Agriculture Organization (FAO) and World Bank (WB), the result consolidates a relative efficiency metric for food security and makes the countries around the globe comparables. We used the DEA CCR model - which assumes constant returns to scale. The relation between the total loss and total production (for maize, rice, wheat, and soybean), the prevalence of undernourishment (%), and the consumer prices food indices are the input variables of the DEA model. The lower the value of these variables, the greater the countries' food security efficiency metric. The output variables are food supply (kcal/capita/day), the relation between the grains production and domestic supply quantity, and the countries road density (m/km²). Two DEA models are analyzed: (i) an efficiency analysis comparing all the 107 countries; (ii) an efficiency analysis comparing only African countries (a total of 25 cases). Given the set of countries considered, Romania, France, Lithuania, Latvia, and Italy are the top five countries regarding food security efficiency - a minimum of 99,4% of efficiency. The five last countries in the efficiency ranking are Mozambique, Chad, Sudan, Angola, and Venezuela - 18,0 to 3,6% of efficiency. In this list, Morocco and South Africa are the most well-ranked African countries - 25th and 30th positions, respectively. South Africa and Morocco are the most well-ranked countries in the African countries model, followed by Mali, Burkina Faso, and Ethiopia - 100,0 to 83,9% of food security efficiency. Those countries serve as benchmarks for the other African countries when analyzing food security indicators and general strategies. At the end of the list are Algeria (52,0% of relative efficiency), Sierra Leone (51,1%), Mozambique (24,1%), Angola (18,0%), and Sudan (10,1%). The results also show that the food security efficiency metric, in both DEA models, has a positive correlation with other transportation and infrastructure World Bank indexes and other metrics related to the economic and institutional environment of the countries, reinforcing the need to improve all four pillars to effectively improve food security.

Keywords: food security, data envelopment analysis, African countries, efficiency analysis

Heavy metal concentrations in small pelagic fish from Lake Victoria, Kenya: The case of Dagaa fishery

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The toxicity of heavy metals is in part because they bioaccumulate in biological tissues. The objective of this study was to assess the concentrations of heavy metals in dagaa and compare the levels of these metals in samples from open and gulf waters. The study was carried out in December 2020 (dry season) and samples (dry and wet) were collected from six landing sites along Lake Victoria, Kenya with four landing sites (Marenga, Uhanya, Sori & Litare) in the open waters and two (Asat & Bao) in the Winam Gulf for heavy metal analysis. Lead and cadmium were analysed by use of AAS at wavelengths 217.0 nm and 228.8 nm, respectively while mercury was analysed by ICP-MS at mass 201 due to its high volatility. Lead concentrations were highest ($p < 0.05$) at Uhanya (0.498 ppm) and lowest at Litare (0.158 ppm) for both dry and wet samples. Cadmium was highest at Litare and lowest at Litare & Marenga with 0.028 ppm and 0.002 ppm, respectively for both dry and wet samples. Mercury was highest at Sori (0.580 ppm) and lowest at Uhanya (0.091 ppm) for dry and wet samples. Lead, the most abundant heavy metal in most sites, had levels beyond the Kenya Bureau of Standards (KEBS) and European Union (E.U.) Maximum Permissible Limits (MPL) of 0.40 ppm and 0.30 ppm, respectively. To minimize the health effects of heavy metals bioaccumulation in humans, strong management measures are necessary to mitigate both the industrial and agricultural impacts of heavy metal deposition and bioaccumulation in fish.

Keywords: Heavy metals, bioaccumulation, toxicity, concentrations

Socio-economic Impact of the Postharvest Loss project on Smallholder Farmers Welfare, Food Security and Awareness in Sub-Saharan Africa

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Recently, the issue of post-harvest losses, particularly in Sub-Saharan Africa has attracted much attention from scientists, policy makers and NGOs, because the level of produced food has decreased dramatically, over the last two decades, resulting in general deterioration in food security impacting the standard of living of the citizen. The recent pandemic of Covid19 is expected to further negatively affect the production of food. In Sudan, the available information reveals that about 30% of agricultural production is lost during post-harvest. Since 2016, WFP implemented a PHL project of modern storage technology and capacity building for improving small farmer's welfare, food security and awareness. The project covered all rural areas where people depend on their livelihood on rain-fed agriculture. The research aims at investigating the socio-economic impact on small farmers living standards in Sub-Saharan Africa, a case of Sudan. The research used secondary data, were collected from a base-line studies and the reports of WFP and primary data, were collected through the means of a questionnaire, which was distributed to a random sample from 382 small farmers in the project areas. The research adopted a before and after approach for assessing the socio-economic change of the project among the small farmers based on socio-economic variables. The research used descriptive analytical methods and adopted the inferential statistical tools including t test, Chi square and logistic regression model for measuring the socio-economic impact of the project under research on small farmers welfare. The research findings showed that the PHL reduction had improved the food security, income, expenditure, savings, durable goods, investment and seeds for a coming season among the small farmers after implementation of the project. The results revealed improvement in the social indicators, including health, sanitation, education, housing, and market accessibility. Furthermore, the results suggested that capacity building and development have changed the behavior of small farmers in favor of new technology adoption in the research area and ensuring the sustainability of such technology in the future. The research recommended that all African countries adopt similar projects to reduce post-harvest loss of agricultural production, improving food.

Keyword: post-harvest, socio-economic, welfare, awareness, food security

Combating Aflatoxin in the maize value chain in Rwanda

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Agriculture is the economic mainstay of most households in Rwanda and makes a significant contribution to the Rwandan economy. The sector accounts for approximately 30% of the national Growth Domestic Product and employs about 69% of the labour. In 2007, the Crop Intensification Program (CIP) policy was launched in order to boost the agricultural production of high potential crops through improved productive input, irrigation coverage, and soil quality. Maize was one of the preliminary priority crops with success resulted in increased production of up to three-fold during the 2007 to 2013 period, from 350,000 to 930,000 metric tons, respectively according to the World Bank data. However, the CIP's success has been limited, resulting in unanticipated post-harvest losses due to a lack of appropriate and timely technology, which causes aflatoxins contamination in commodities which is a public health hazard and causes liver cancer and is associated with stunting of children. In this regard, a project on combating aflatoxin prevalence in the maize value chain in Rwanda has been designed and implemented by Eastern Africa Grain Council (EAGC) and funded by the Alliance for a Green Revolution in Africa (AGRA) with the overall objective to solve constraints related to quality maize production, especially aflatoxin contamination, associated market inefficiencies and strengthen extension services in the country. The project was conducted by developing teaching material for farmers training on post-harvest best practices to promote quality standards; also, a trial run of buying and selling unshelled maize on the cob was piloted in the eastern province of Rwanda. As a result, more than 40,000 farmers adopted the buying/selling maize on cob model, and more than 55,000 MT of aflatoxin free maize was sold through structured markets allowing big processing companies to source quality maize locally whereby they were struggling to import it from the neighboring countries and even from outside Africa at a very high cost. Therefore, buying and selling maize on the cob model would be deemed to be an effective way of mitigating aflatoxin contamination in the maize value chain.

Keywords: EAGC, cob model, post-harvest best practices, maize.

Household Level Food Security and Livelihood Diversification in Pastoral Districts of Guji, West Guji, and Borena Zones, Southern Ethiopia

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Ethiopian government and international donors are implementing different types of responses to food insecurity to attain food self-sufficiency and reduced food aid dependency and to sustain food security. Different food reduction scenario forces pastoral and agro-pastoral livelihood system weather by push or pull factors to diversify their livelihood to non-farm, on-farm and off-farm activities. Additionally, current information on the status of food insecurity and livelihood diversification strategy were in lack. Therefore, the main objective of the study was to assess household level food insecurity and the direction to where the pastoral household livelihoods has been diversifying in Borena, Guji and West Guji Zones pastoral communities, Southern Ethiopia. Out of 7 pastoral zones 3 zones were included namely Borena, Guji and West Guji. The study employed participant observation and a household survey. The survey was covered 270 randomly selected households. To examine the food security status of sampled households, calorie intake by households was taken as an indicator. Accordingly, results of food security status of the sampled households based on the minimum recommended calorie requirement of 2200 kcal/AE /day shows that among the total sampled households (270), 58.89 % were food insecure, while 41.11% were food secure. Food insecure and food secure households were getting the mean calorie of 1796.63 and 2317.22 kcal/AE/day, respectively. Moreover, the current study revealed that there was a diversification strategy like cultivation, broker, petty trade, forest wood and charcoal production, and labor work and livestock trade. Comparatively, the percentage of households who diversified their activities in to broker service in livestock trade (25.79%), Forest wood and charcoal production (27.67%) and Labor worker (27.04%) were more food insecure than households those who secured food, livestock trade (24.32%), Forest wood and charcoal production (15.32%) and Labor worker (5.41%). On the other hand, 90%, 27.03% and 33.33% were food secured households those who diversified their livelihood in to cultivation, petty trade and livestock trade, respectively than food insecure households. This indicates that household who diversify their livelihood in to cultivation, petty trade and livestock trade were more food secure than those who do not. Generally, people in the study area were food insecure. Therefore, different concerned agents should work on cultivation with minimum post-harvest loss, petty trade and livestock trade with minimum loss to boost food security of the pastoralist household to promote pastoralist transformation from food/feed aid to self-reliance and thereby ensure food security.

Keywords: Diversification, Food security, Livelihood, Pastoralism, Southern Ethiopia

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