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Beyond the Farm Gate: Postharvest Loss and the Role of Agro-Processors in Sub-Saharan African Food Security

Lisa F. Clark and Jill E. Hobbs

Department of Agricultural and Resource Economics, University of Saskatchewan, Saskatchewan Canada
lisa.clark@usask.ca; jill.hobbs@usask.ca

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ABSTRACT

The paper examines the challenge of postharvest loss (PHL) in Sub-Saharan Africa. It focuses on strategies to address PHL at the agro-processing level through more coordinated approaches to nutrition-sensitive agriculture programmes. Looking beyond the traditional focus of on-farm storage facilities and smallholder behavioural change, the paper examines three interrelated issue areas that ought to be included in broad-based strategies to curb PHL: accurate measurement of losses; better coordination of agriculture and nutrition interventions; and addressing informational and infrastructural challenges. The paper argues that improvements made in any or all downstream components have the potential to reduce rates of PHL. It emphasizes the value of a systems approach when developing multi-stakeholder strategies to combat PHL.

Keywords: postharvest loss; sub-Saharan Africa; food security; supply chains; agro-processors

JEL Classification: Codes: O13, Q13, Q18

1 Introduction

In 1997, the Food and Agriculture Organization (FAO) recognized the importance of local agro-processing to curb food losses and to address food insecurity across sub-Saharan Africa (SSA). It stated: "increased food processing through the establishment and strengthening of small-scale agro-industries can contribute to the year round availability and variety of micronutrient foods in rural and urban markets. Agro-processing industries will not only even out seasonal price fluctuations, but will also create jobs and incomes from such activities as processing, storage, distribution and marketing. Agro-processing will also stimulate demand for farmers' crops and products and give consumers additional choice" (FAO, 1997). Twenty years later, the FAO, and a global community of stakeholders, continue to strive to address food loss and its contribution to food insecurity across SSA. Some have argued that reducing food loss is an important way to increase the availability of food, alleviate poverty and improve nutrition. Reducing food loss can also have positive impacts on the environment by improving agricultural productivity, which could help restrict agricultural expansion into fragile ecosystems to produce food that will never reach the consumer (See GIZ, 2013; Hodges et al., 2011). Retaining more of the food that is already grown could make a significant contribution to nutrition and food security goals across SSA by making locally grown agri-foods more widely available and accessible to local markets. An increase in retained food can be especially important in places where the prices of storable staples commonly increase sharply several months after the harvest period (Sheehan and Barrett, 2016).

Nutrition-sensitive agriculture programmes and projects have included various interventions along the supply chain to reduce unintentional food loss.* Efforts to curb food loss, or Postharvest Loss (PHL), tend to focus on modifying the behaviour of smallholder farmers through the introduction of innovative storage facilities or practices. These solutions have been met with limited degrees of success (World Bank, 2011). Some estimates value total food weight loss across SSA at approximately $4 billion (USD) annually. This exceeds the value of total food aid received by SSA between 1998 and 2008 (Hodges et al., 2013:16). Part of the reason why rates of PHL have remained so high across SSA could be factors beyond the farm gate, which are not typically addressed in nutrition-sensitive agriculture programmes and projects focusing on PHL. As Kiaya (2014:5) states, "food losses are mainly due to poor infrastructure and logistics, lack of technology, insufficient skills, knowledge and management capacity of supply chain actors and lack to [*sic.*] markets" (see also Prusky, 2011). The causes of PHL thus span far beyond ineffective storage facilities on the farm and likely are present throughout the supply chain.

By evaluating findings from research organization and donor reports, stakeholder interviews, and scholarly studies on postharvest loss and related nutrition-sensitive agriculture frameworks, this paper identifies three issue areas beyond on-farm storage facilities and smallholder behavioural change that are in need of further attention in order to effectively address PHL across SSA. First, the challenges of accurately measuring PHL and how this affects agro-processors' ability to scale-up are discussed in section 2. How to better coordinate top-down nutrition sensitive agriculture intervention frameworks to improve supply chain management and reduce PHL is discussed in section 3. Section 4 examines how informational and infrastructural challenges pertaining to price discovery, quality measurement and food safety within agricultural marketing channels contribute to the magnitude of PHL, and present challenges to agro-processors' abilities to scale up. Overall, the paper argues that improvements made in any or all of the components of the food system have the potential to positively impact rates of PHL across SSA. It also emphasizes the value of a systems approach when developing multi-stakeholder strategies to combat PHL.

2 Measuring Postharvest Loss

Developing effective and contextually appropriate approaches to curbing PHL requires accurate measurements of the scale and magnitude of the problem. Accurate measurement stems from defining the problem in a clear, concise way. One way food loss is defined is what Kiaya (2014:5) describes as "the decrease in edible food mass (dry matter) or nutritional value (quality) of food that was originally intended for human consumption." *Postharvest* loss specifically, can be defined as 'degradation in both quantity and quality of food from harvest to consumption'. This includes quantitative loss, which refers to decreased weight or volume. Loss can also be qualitative in terms of reduced nutrient value, and unwanted changes to organoleptic qualities, including compromising the safety of food (Buzby and Hyman, 2012). These types of qualitative loss can make food unfit for human consumption, which contributes to quantitative loss.

Challenges facing accurate measurement of PHL

The FAO (2011) estimates that globally, 32 percent of food is either wasted or lost along the supply chain. In SSA, this figure is estimated to be around 37 percent. Yet, as stated by Affognon et al., (2015:50), PHL figures vary widely – anywhere between 10 and 70 percent. Many international organizations and scholars routinely cite such wide-ranging figures in discussions of food losses in SSA (FAO-World Bank, 2010; Kader, 2005; Prusky, 2011), which obscures the scope of the problem and how to address it. PHL is difficult to aggregate, since figures largely depend on the country, region and crop. According to Kaminski and Christiaensen (2014:149), estimates vary substantially depending on the metric, crop and stages in the supply chain. The wide range of estimates makes it difficult for policy makers and donors to determine where to focus resources and interventions along the supply chain to help curb losses across SSA.

More accurately measuring 'unintended food loss' (food loss) has been aided by breaking down estimates based on where loss is occurring in the supply chain. A 2011 FAO document defines where and why PHL occurs: during harvesting (namely due to mechanical damage, or spillage, postharvest handling like drying or winnowing), processing, distribution and marketing, and consumption. Food loss can occur because of spoilage from insects, rodents, and birds, or from handling, physical changes or chemical changes in fat, carbohydrates and protein or by contamination from mycotoxins, pesticide residues, etc. (Aulakh and Regmi, 2013:3). Qualitative losses are more common in developing countries, as opposed to the post-consumer quantitative losses experienced in developed countries. Both qualitative and quantitative losses vary considerably by commodity and country. In SSA, most PHL happens during harvesting, postharvest

* Some degree of loss in food weight or volume is to be expected, since some loss occurs through normal harvesting activities such as drying or processing.

handling and storage, but it takes place at all stages of the supply chain including processing (Parfitt et al., 2010). According to available statistics, the World Resources Institute reports that only five percent of food loss happens at the consumption stage in SSA, compared to 61 percent in North America. For a commodity specific example, current estimates put PHL of cereals in SSA at around 19-21 percent, with more than two-thirds of that percentage of loss occurring at harvesting. Losses during handling and storage represent the remaining third (Kaminski and Christiaensen, 2014:149). Comparatively, losses at the processing stage across SSA for other agri-foods are significant: 20 percent of fruits and vegetables; 11 percent of roots and tubers; 6 percent of oilseeds; and 3 percent of cereals and grains (Deloitte, 2015:6). In the case of Ethiopia, as much as 15 to 20 percent of pulses are lost due to poor quality storage (Shahidur et al.,2010:29). Though these statistics are useful in drawing attention to the magnitude of the problem across SSA, they capture only part of the picture.

Affognon et al. (2015) state that often PHL data are incomplete and of poor quality. Most data on PHL do not contain related qualitative information like socioeconomic drivers or agro-ecological specificities (topographical-related precipitation patterns, soil quality, etc.). Self-reporting of crop information is common practice for collected data on PHL in Uganda, Tanzania and Malawi, for example, which can be problematic when aggregating across a region. These state-level collection methods are somewhat different from the way the Africa Post Harvest Loss Information System (APHLIS) calculates loss.

The role of APHLIS in measuring PHL

APHLIS consists of a network of experts across SSA who are responsible for submitting information to the APHLIS database. Its purpose is to facilitate a network of members to establish country-specific web pages offering in-depth information about PHL, and offering advice to help curb it (Hodges et al., 2013:18). APHLIS bases its data on state-level extrapolations from purposively sampled case studies in addition to FAO estimates. FAO estimates are based on state level food balances and losses as defined by experts (Kaminski and Christiaensen, 2014:149). Though the populating of APHLIS databases is important to getting closer to understanding the magnitude of the problem of PHL and where it occurs along the supply chain, this method of measurement has its limitations. APHLIS currently calculates loss estimates based on a small pool of loss data and grain quantity. Grain *quality* losses are not part of the estimates. The fact that APHLIS does not collate data on quality loss presents a challenge to those attempting to calculate the socioeconomic impacts of PHL on food insecurity in SSA. Some scholars argue that food quality loss can have a greater economic impact than quantity loss (Hodges and Maritime, 2012). As Cook and Maier (2014:586) explain, low quality grain may receive a higher price during times of scarcity than high quality grain during times of plenty. This can make some foods even more unattainable for those living in conditions of poverty. Low quality grain may also force stakeholders into lower value markets (animal feed) contributing to the economic insecurity of smallholder and rural communities.

The uncoordinated methods for measuring PHL have presented challenges to those trying to understand how to mitigate it. There are no standard protocols for documenting PHL and published studies on the topic use a wide range of methodologies for data collection (interviews, surveys, etc.) and base conclusions on a wide set of variables. Sheahan and Barrett (2016) argue that there is little evidence of efforts to better establish the magnitude of quality loss in SSA and see little action on finding innovative ways to curtail the pervasiveness of substandard food quality across the region. Without accurate measurements of the problem it is almost impossible to determine whether real progress is being made through on-farm interventions and elsewhere along the supply chain. As stated by Cook and Maier (2014:582), "accurate grain postharvest loss assessments are critical in prioritizing and evaluating PHL reduction project goals. PHL estimates can be utilized as a tool for assessing such projects, targeting improvement in a country's cereal grain supply chain, can help inform the creation of food balance sheets that help predict future food shortages, and inform policy decisions about grain imports and exports." Many estimates also do not disaggregate where in the supply chain the PHL is occurring, which is problematic in terms of understanding how food loss affects the quality and quantity of agri-foods utilized by agro-processors. The capacity for agro-processors to effectively scale up and add value to agricultural raw materials is key in improving the availability, affordability, accessibly and awareness of micronutrient-dense foods in SSA (Hawkes and Ruel, 2011). The ability for SSA agro-processors to fully participate in scaling up and value addition is significantly constrained by a lack of consistent measurement of the quantity and quality losses experienced by other stakeholders along the supply chain.

The differences between commodities and countries largely limits a 'one size fits all' approach to addressing PHL, making more nuanced and available data an important part of effective strategies to addressing food insecurity as argued by Sheahan and Barrett (2016:3). As stated by Kitinoja et al., (2011:599), accumulating data on the causes and magnitude of PHL can help identify priority areas for research and extension services across SSA. Including details about socioeconomic constraints can help to tailor responses in a way that will maximize the benefits of interventions.

3 Coordination of Nutrition-Sensitive Agriculture Frameworks

Research suggests that a lack of coordination between agriculture and nutrition policies is contributing to stalled advancements towards food security goals and the integration of a nutrition sensitive policy agenda into existing frameworks (Pingali, 2015:1; FAO/CGIAR, 2015:40). Specific to PHL, the international community has struggled to find a coordinated way to address the challenge in a holistic manner. Before 2000, there were several attempts at global coordination to help address PHL. The first was the establishment of the Group for Assistance on Systems Relating to Grain After Harvest. This was replaced and rebranded as PhAction (The Global Post-harvest Forum). But as Hodges et al., (2013:18) note, this forum fell into disuse as commodity prices fell to historic lows as donors and research shifted focus away from agriculture. Since the global recession of 2007-2008 however, interest in addressing PHL has increased as food prices rose rapidly contributing to political and economic instability across SSA and beyond.

Coordinating policy across jurisdictions to address crosscutting issues of food and nutrition security like PHL becomes more difficult to achieve and maintain as diverse networks of stakeholders (governments, UN agencies, donors, NGOs, research institutions, farmer unions, etc.) engage within multilevel governance systems (see Resnick et al., 2015). This makes it problematic to pinpoint where one stakeholder's engagement in, or influence on, the decision-making process begins and another's ends. It also further complicates how to address PHL along the supply chain through coordinated policy interventions.

Issues facing multi-level policy coordination

The artificial policy divisions between nutrition, agriculture and industry create obstacles in dealing with complex, crosscutting problems like food insecurity, which requires coordinated, multi-stakeholder governance (Rota, Zanasi and Reynolds, 2014). The divisions lend themselves to siloed governmental ministries focusing attention on specific stages of agri-food supply chains (see Clark, 2017). This generates problem-solving strategies that primarily target one specific stage of the supply chain over others, without considering how interventions targeted at one stage may underemphasize the importance of addressing issues at other stages. For example, some agriculture ministry's food security programmes tend to focus on agronomic interventions and crop yields on the farm, while agro-processing is part of the industrial ministry portfolio, despite the importance of effective management of both stages to meet food security goals. Even the FAO considers agro-processing a subset of manufacturing that processes raw materials and intermediate products derived from the agricultural sector between harvesting and final use (FAO 1998). But as noted by a report on PHL in SSA penned by Deloitte (2015:4), "while increasing crop production has, and continues to, receive great attention, disproportionately fewer resources have been employed to address the related and equally challenging issue of PHL". The Hodge et al. (2015) study relaying stakeholder perspectives on food security efforts across SSA shows most stakeholders felt that increased market access and improving postharvest processing needed more attention in nutrition-sensitive agriculture programmes, in such places as Kenya and Uganda. Marketing and investing in agro-processing appear to be often overlooked in nutrition-sensitive agriculture programmes and projects (Hodge et al., 2015:516-517).

Traditionally, development projects tend to focus on agricultural modernization, whereas processing is often delegated to the industrial sector. The conventional approach in most African countries is that the government focuses on agriculture first, in terms of policy, programmes and resources. A focus on industry, which typically includes agro-processing, comes only after agricultural issues are addressed (Ohiokpehai et al., 2009). But these policy cleavages impact the ability to implement coordinated food security frameworks that often involve multiple, overlapping issue areas like nutrition and agriculture. The divisions extend to research as well. There appears to be little coordination among PHL researchers focused on SSA, and limited multidisciplinary collaborations within projects and programmes addressing PHL. Coordination of data and research agendas is vitally important to properly assess how socioeconomic dimensions contribute to, and are affected by, PHL. While some research findings on PHL acknowledges the importance of coordinated policy interventions that consider the entire supply chain and a number of socioeconomic dynamics, as Vallema (2008) notes, 'there is little connectivity between this literature and the scholarly work on technological innovation found in the social sciences and development studies' (cited in Kitinoja et al., 2011:599). This presents a challenge to researchers hoping to find appropriate, effective and sustainable solutions to PHL at various stages in the supply chain. As noted by Kaminski and Christiaensen (2014:150), "past interventions too often prove to be financially unsustainable, ill-aligned with farmer's economic incentives to store and better protect food, or their duration too short to pay off." Further, the way research funding is structured often undermines efforts that require long-term, coordinated commitments with a time horizon extending beyond the typical five-year lifespan of most research and development projects (see Resnick et al., 2015).

The lack of coordination between the goals of nutrition-sensitive agriculture and the way donors and other funding agents allocate resources also applies to research on PHL. As a report from the Rockefeller Foundation (2015:2-3) estimates, "only 5% of investments in agricultural research over the past 30 years has been directed towards preventing postharvest losses…Now, many in the food security world are waking up to the fact that not only are significant losses occurring, but these losses compromise both the profitability and the long-term sustainability of value chains." A significant proportion of funding for agronomic research and extension has focused on increasing production, and not on other stages in the supply chain (Kitinoja et al., 2011:598). The lack of investment in ways to accurately measure the magnitude of the problem at various stages of the supply chain and a lack of coordinated investment in methods to curb PHL along the supply chain has stalled overall progress on this issue across SSA.

Because processing is often not covered in domestic agricultural policies and international intervention programmes, there is a lack of facilities across SSA to process locally or regionally grown agri-foods. Without processing facilities, PHL increases, especially in terms of quality loss. Harvested products may be wasted, especially fruits and vegetables because there are no processing facilities available to process fresh foods that store poorly over the long term. Filou (2011) states that 70 percent of fruits and vegetables and 30 of cereals are lost every year due to poor handling and storage, but also because of a lack of processing facilities across SSA.

Options for facilitating policy coordination

So what solutions are available to overcome the lack of coordination between programmes and projects designed to address nutrition sensitive agriculture policy and PHL simultaneously? A holistic approach considering interactive stages of the supply chain can help to design strategies that consider how interventions in one stage may impact activities in other stages, which may ultimately influence project outcomes. In Robinson and Humphrey's 2014 study of Nigeria, they suggest, at least in the short term, donor support could be directed to help companies or groups of companies to develop relationships with farmer clusters. In other words, they suggest investing in creating robust economic relationships among stakeholders involved in supply chains. They state, "without considerable support, government policies on import substitution are likely to make it more difficult for local food-processing companies to deliver foods that are safe, nutrient-rich and affordable" (Robinson and Humphrey, 2014:16). Companies facing procurement problems often lack the scale or market power to impose requirements on other stakeholders along the supply chain. Most small or mid-size agro-processors do not have the resources or networks to scale up or develop markets on their own. Yet, both of these issues are vital to getting closer to meeting nutrition-sensitive agriculture goals across SSA. Prioritizing information exchange among stakeholders could be an important way to address PHL beyond the farm gate in a way that could make positive contributions towards meeting food security goals throughout the supply chain.

4 Marketing Systems, Food Safety and Quality Standards

In addition to a lack of accurate measurement of the magnitude of PHL, and uncoordinated top-down nutrition-sensitive agriculture frameworks, Kitinoja et al. (2011:598) claims that several, overlapping socioeconomic factors contribute to the lack of progress on the PHL issue in SSA: inadequate marketing systems, inefficient modes of transportation, inadequate storage facilities, poor handling practices, the absence of supportive governmental regulation and integrated policy frameworks. The lack of coordinated efforts to address quality and standards for agri-foods directly contributes to the magnitude of PHL experienced in Ethiopia and other neighbouring countries. How PHL affects the processing sector, and how this presents a challenge to achieving broader food security goals, is often overlooked. However, PHL contributes to stalled advancements of agro-processors towards scaling up and marketing locally processed products because of loss in food quality (see van der Vorst, van Kooten and Luning, 2011).

Improving the efficiency and effectiveness of agri-food supply chains in SSA that may help curb PHL requires addressing a series of informational barriers that frequently plague these supply chains. Specifically, challenges with respect to price discovery, quality measurement, food safety and traceability contribute to PHL need further discussion. The need for institutional adaptations attempting to address these informational barriers, including the establishment of commodity exchanges, commodity grading systems, private food standards and closer vertical coordination is addressed in this section.

Improving price and market efficiencies

Pricing efficiency refers to the ability of the market system to efficiently allocate resources and coordinate food production and marketing in response to market needs. Pricing efficiency within a supply chain is weakened when prices fail to fully represent end-user needs, fail to direct resources between lower and higher-valuing uses, or fail to effectively coordinate transactions between farmers, processors and endusers (Kohls and Uhl, 2002). These problems may arise due to lack of competition, informational barriers, or inadequate spatial integration of markets. In the context of developing country agricultural markets, institutional adaptations to improve pricing efficiency have included the introduction (by governments) of formal commodity exchanges to reduce transaction costs and facilitate transactions. As Andersson et al. (2017:1) note, commodity exchanges were introduced in a number of SSA countries (e.g., Uganda, Kenya, Zimbabwe, South Africa, and most recently, Ethiopia) with a specific focus on addressing fundamental shortcomings in market infrastructure, including lack of physical and information infrastructure, lack of storage facilities and inadequate access to credit. These initiatives aim to create well-functioning agricultural exchange platforms that are capable of disseminating timely information to decision-makers and typically provide for the establishment and operation of storage facilities in local and regional markets, a legal framework for negotiating and enforcing contracts, and the means to bring buyers and sellers together to reduce search costs (Andersson et al., 2017).

The literature on the effectiveness of commodity exchange systems in improving price discovery and market efficiency in the agricultural markets of developing countries paints a mixed picture. For example, Katengeza (2012) finds that the Malawi Agricultural Commodity Exchange (MACE) had a positive effect on spatial integration, wherein the Exchange facilitated the tendency of prices for the same commodity to move together across spatially separated markets (Andersson et al., 2017). Taking a slightly different perspective, other research finds that the introduction of the Ethiopian Commodity Exchange (ECX) failed to facilitate higher levels of participation in commercial markets by smallholder farmers, or that traders were still able to earn excess profits using the predictability in price series. This suggests that market prices established through the ECX failed to capture all relevant market information (Andersson et al., 2017). Clearly, commodity exchanges are successful in facilitating efficiently functioning markets to differing degrees in different countries and across different contexts. In markets suffering from under-developed storage and informational infrastructure, however, there is evidence that commodity exchanges can improve spatial price integration. Indeed, in an analysis of coffee trading on the ECX, Andersson et al. (2017) find that the provision of regional warehouses connected to a commodity exchange improves the link between local, national and international markets and reduces the price dispersion between export prices and local retail prices, thereby improving market efficiency. For agro-processors this translates into more reliable local and regional commodity markets as an ongoing source of raw material supply.

Product quality

Informational barriers also arise with respect to product quality. In his seminal article, “Measurement costs and the organization of markets”, Barzel (1982) draws attention to the effects of quality measurement and sorting costs on the organization of transactions and the incentives that subsequently arise for the development of institutions or the restructuring of supply chains to reduce measurement costs. He notes, “the problems and costs of measurement pervade and significantly affect all economic transactions. Errors of measurement are too costly to eliminate entirely. The value of equally priced items will differ, then, and people will spend resources to acquire the difference. Such resource expenditures is wasteful, and it is hypothesized that exchange parties will form such contracts and engage in such activities that reduce this kind of resource use” (Barzel, 1982:48). The nature of the measurement error explored by Barzel is the existence of information asymmetries within supply relationships, wherein the seller of a good or service has more information about true product quality than the buyer. As noted by Akerlof (1970), in the presence of information asymmetry, uncertainty over quality is reflected in the (lower) price buyers are willing to pay, reducing the incentive for producers of high quality goods to supply the market and thereby inducing low quality products to force high quality goods from the market (Akerlof’s classic “market for lemons” argument). Thus, sellers of high quality goods have an incentive to develop credible quality signals, particularly if net measurement and sorting costs are lower when quality is signalled by the seller rather than requiring repeated sorting activities by multiple buyers. As Barzel (1982:30) observes, “under the assumptions here, sellers will sort the commodity to that break-even point in variability…just finely enough to dissuade buyers from any sorting. When the seller effects such sorting, each item is measured *exactly* once. On the other hand, when buyers effect the measurement, each item will be measured *at least* once; some will be measured twice or more. Thus the net price…of the cost of measuring – at which the commodity can be offered is lowest when the seller conducts the measurement. Competition will force sellers to effect the measurement”. Product warranties, share contracts, brand names and collective reputation are explored as strategies to reduce the incentives for buyers to engage in costly measurement activities.

In agricultural commodity markets, grading systems perform this role. When quality can be measured by a set of observable or easily measurable characteristics (such as kernel size, colour, weight, absence of pest damage, etc.), and is vertical differentiable (i.e. there is general agreement on what constitutes high versus low quality), the establishment of a set of commodity grades identifying gradients of quality facilitates price discovery between markets both spatially (between regions) and vertically (within supply chains). Commodity grades contribute to reductions in PHL by more effectively allocating different qualities among different uses, and through reducing sorting costs for buyers. As Barzel (1982:36) notes: "A canner known to change the quality of peas (e.g. size, tenderness, sweetness) from one season to another will induce buyers to conduct a fresh, costly test every season. If, on the other hand, the canner is known to maintain tight quality control, much less testing is required." Thus, in the present context, if commodity grading systems provide a credible quality signal, buyers' need for further sorting, and potentially discarding sub-standard commodities, is reduced. The presence of a third party, such as an independent grading agency, to establish and oversee the commodity grading system is an important component of credibility. If buyers do not trust commodity grades the system will be ineffective in reducing sorting and measurement costs. Discussions with agro-processors in the Ethiopian chickpea market indicate that the absence of an effective quality grading system creates significant sorting costs for buyers, for example, mixing of the Desi chickpea variety in shipments of Kabuli chickpea. The absence of an effective quality grading system also hampers efforts to scale up existing value chains, reducing the market opportunities for cooperatives focused on targeting higher quality markets.

Food safety and traceability

Food safety represents another challenge to agro-processors in reducing PHL. In developing countries, malnutrition is not only related to reduced caloric access, but also to food safety: food contaminants, including pathogens, mycotoxins, parasites, and antibiotic and pesticide residues, cause illnesses and increase the risk of chronic diseases among those with immune systems that are already compromised. Contaminated foods are a major cause of mortality and morbidity in the developing world, particularly among children, with recurring episodes of foodborne illnesses one of the most important underlying factors for malnutrition in developing countries (Unnevehr, 2003; Katerstein, 2003; Perez-Aleman, 2012).

Governments routinely regulate food safety, and the establishment of a stronger set of enforceable public food safety standards is an important prerequisite to improving food safety and reducing the scope of PHL due to spoilage, adulteration, and contamination. While developing country governments have moved to establish or strengthen food safety regulations to differing degrees, the effectiveness of these regulatory initiatives has been mixed, particularly where poor sanitation and inadequate access to clean drinking water remain challenges; thus, mycotoxins and foodborne parasites continue to be more common in developing country food systems (Unnevehr, 2003).

In the absence of rigorous public standards, uncertainty over food safety, for example the presence of mycotoxins, creates challenges for agro-processors in securing local supplies of raw materials. Strategic responses by agro-processors to this uncertainty take a number of forms, including: importing raw materials from international markets rather than sourcing locally, the establishment of private food safety standards, and a move away from spot market transactions to closer vertical coordination through implicit (relational) or explicit contracts which allow closer monitoring of suppliers. The implications of these strategies are examined below.

Efforts to scale-up local and regional supply chains may be thwarted by persistent problems with aflatoxins, which contributes to qualitative loss. Degradation of food quality and compromised food safety forces agro-processors to source key ingredients from more distant international markets. Discussions with stakeholders in the ready-to-use foods (RUFs) sector in Ethiopia suggest that this has been a problem in sourcing peanuts (a primary ingredient in some RUF formulations). Aflatoxin is a mycotoxin, which manifests as a mold on commodities such as corn and peanuts, and has recently been found in dairy products in Ethiopia. If consumed aflatoxins can be toxic to humans, particularly those suffering from malnutrition or with weakened immune systems. High levels of aflatoxin in domestic peanut supplies has forced some Ethiopian RUF agro-processors to seek alternative supplies from other countries, adding additional transportation costs, and limiting the potential to scale up domestic peanut supply chains (Hilina, 2015).

The development of private standards for food safety and quality represents a strategic response by downstream firms such as agro-processors and/or retailers, in response to missing or inadequate public standards or as a product differentiation strategy. A rich literature has emerged over the last two decades addressing the growth of private standards and the impact on producers, processors and supply chains in developing countries (see for example, Farina and Reardon, 2000; Hobbs, 2003; Henson and Reardon, 2005; Fulponi, 2006; Hobbs, 2010; Henson and Humphrey, 2010; Perez-Aleman, 2012; Ehrich and Manglesdorf, 2018). Complying with private standards generally involves investment by suppliers in, for example, technology upgrades, recordkeeping, and employee training, but can also result in capacity building and knowledge transfer. Perez-Aleman (2012) argues that private standards can spur institutional change to develop capabilities for product and process innovations at the local level, contributing to economic development and enhancing food security. Private standards are often process-based, requiring the adoption of specific production protocols that reduce the potential for bacterial or chemical contamination of foods that can result in qualitative loss. Third party verification to ensure that required production protocols are followed is a central component of most private standards. The potential for private standards to reduce transaction costs for agro-processors in sourcing raw materials has been examined at length in the literature. Reductions in PHL are made possible both by the reduction in quality uncertainty for agro-processors and the technological upgrades, knowledge flows and improved capacities for those suppliers able to adapt to private standards.

Another trend evident in agro-processors' adaptive strategies to deal with uncertainty over food safety and quality, reduce PHL, and enhance economic viability has been a move away from spot market transactions to closer vertical coordination in the form of either explicit contracts or implicit relational contracts. Spot market transactions, where products are aggregated across multiple suppliers, and often multiple regions, exacerbate quality uncertainty and pose problems with traceability. Agro-processors point out that products mixed between regions may result in a mix of two harvests from two different seasons, with different qualities or different varieties (e.g. different sizes of chick pea) thus increasing their sorting costs (GUTS Agro, 2015). In the presence of quality uncertainty, spot market transactions increase transaction costs for buyers creating an incentive to invest in closer vertical coordination.

Explicit, or formal contracts require a facilitating institutional environment for contract implementation and enforcement, while implicit (relational) contracts feature the establishment of long-term supply relationships with dedicated growers, the nature of which may evolve over time. For agro-processors, sourcing raw materials from known suppliers reduces sorting and transaction costs. The use of resource-providing contracts (wherein the buyer provides key inputs to the suppliers such as seed and fertilizer) can further reduce uncertainties over product quality. Contract enforcement, however, remains problematic particularly in low trust environments and in the absence of effective contract enforcement mechanisms. This has been a challenge for RUF agro-processors in Ethiopia, who struggle to develop long-term supply relationships with farmers since contracts cannot be enforced partially due to the absence of an effective commercial contract law (GUTS Agro, 2015). Farmers are often unwilling to enter into a supply agreement with an agro-processor in the absence of an assurance that the agro-processors will purchase the farmer's product at a specific price, while agro-processors are reluctant to provide advance payments or enter into resource-providing arrangements in the absence of contractual safeguards. The development of a facilitating institutional environment to foster closer vertical coordination through explicit and relational contracts is a key role for government and has been a common feature of successful agri-food industry transformation in developing (and transition) economies (Reardon et al., 2009; Swinnen and Maertens, 2007; Hobbs and Boyd, 2007).

In summary, marketing systems face a number of informational and infrastructural barriers, which contribute to PHL requiring a multi-level, multiple stakeholder approach. Efforts to improve price discovery and the efficient functioning of commodity markets have included investments in commodity exchanges and improvements to local storage infrastructure. Infrastructural investments also feature strongly in the response to uncertainty over food quality and food safety, along with the establishment or strengthening of public and private standards.

5 Conclusion

In early July 2016, FAO estimated that more than 60 million people, with two-thirds of them in eastern and southern Africa, faced food shortages because of El Niño-related droughts (FAO, 2017:25). In addition to climatic challenges faced by SSA, postharvest loss contributes to food shortages and ongoing food insecurity. Addressing it in a holistic and systemic way can work toward ensuring that the food produced in the region is not lost or wasted. This paper has demonstrated how PHL is a far-reaching problem that affects every stage in agro-food supply chains across SSA. Not only can interventions via technological innovations and behavioural change at the production stage help mitigate PHL, but accurate measurement, coordination of interventions, institutional adaptation and appropriate infrastructure are also key components to food security strategies. The OECD-FAO argue that "…the greatest challenge facing the agricultural sector in SSA is weak infrastructure including transportation networks, access to energy, irrigation systems and stockholding facilities. Poor transportation networks limit access to markets and often exacerbate high levels of postharvest losses, while also restricting efficient distribution of inputs such as seed and fertiliser" (OECD-FAO, 2016:92). Clearly, as this paper has demonstrated, looking beyond the farm gate is required to effectively combat PHL across SSA.

Enforcement capacity for food regulations across SSA is low (Robinson et al., 2014:19). This institutional issue could be resolved at the state-level, with stakeholder consultation and support. Policy frameworks designed to address institutional gaps can foster sustainable economic development, such as those covering business investment and growth. Facilitating an institutional environment designed to support the development of explicit and relational contracts, as well as grading and quality assurance systems is an important step towards addressing PHL beyond the farm gate. Implementing better methods and infrastructure for accurately measuring PHL supported by the international donor and research community would assist in targeting strategic responses. With better coordination of multiple stakeholders, nutrition sensitive agriculture intervention frameworks, improvements to agri-food supply chains across SSA would have a better chance at reducing PHL over the long-term.

Improving the ability for agro-processors (and their suppliers) to access machinery and equipment and technological knowhow is another way to nurture localized supply chains that can help to curb PHL and get more food from the farm and to markets. Facilitating the establishment of processing facilities and paying close attention to the policy and supply chain environment in which agro-processors operate are essential first steps towards stimulating both consumer demand for processed products, and assuring adequate supply of raw materials for the market. The investment in, and development of other infrastructural services such as transportation and reliable power sources, not only improves the ability for stakeholders across SSA to reduce PHL, but also has other long-term benefits to sustainable socioeconomic development and food security goals within the food system. Reducing PHL requires a holistic approach to examine and address the problem at multiple stages of the supply chain. Addressing PHL as part of long-term strategy requires the consideration of multiple perspectives, including increased consultation and participation of those who incur the consequences of PHL in their daily experiences, as they seek to stabilize their livelihoods.

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