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# Postharvest Losses in Ethiopia and Opportunities for Reduction: A Review

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**Abstract**

Agriculture is important for addressing food security problems in Ethiopia. Stimulating agricultural growth will therefore be the major instrument for increasing the income of the country in general and households in particular. Agriculture contributes to overcome the food security problem through growth that distributes its benefits as widely as possible and through food production increases by the rural poor. In order to help and to address the problem of small scale agriculture towards development into a modern production sector, strengthening the postharvest sector or system is essential. Estimates suggest that the magnitude of postharvest loss in Ethiopia was found tremendous for different cereal grains that can go as high as 30 to 50 percent. It is important to understand that postharvest losses in both quality and quantity since it is related to lost income and /or value of commodities produced and hence part of measure and primary concern to bring a food secured nations through modern agricultural production. Postharvest quantity and quality loss of cereal grains in developing countries appears to be initiated mostly at farm-level, so the potential remedies for the problem are needed at the same level. This review of postharvest cereal grains postharvest losses, contributing factors and possible mitigation remedies has been prepared focusing on Ethiopia situation that has cereal production potential and multiple suitable agro-climates. These are useful in quantifying the national magnitude of losses, the prevailing loss agents and relate the same to food security in the country. In a country where production is much lower than the national demand and is characterized by the level of post-harvest loss stated above, a great effort is needed in the area of generating technology that minimizes this loss.

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This could be in the form of technologies, which inhibit the growth of pests and provide proper storage facilities, appropriate packaging materials and transportation facilities required to minimize losses and increase the shelf life of the food grains. A remedial suggestion on suitable approaches to loss reduction in postharvest handling of cereal grains was reviewed.

***Keywords:*** Abiotic; Agents; Biotic; Factors; Losses; Postharvest; Remedies.

## 1. Introduction

Ethiopia is a country with a history of severe famine and remains dependent on food imports to feed its population. Thus, despite significant increases in the area of land under cultivation and the yield per acre over the last two decades, food security in the country remains fragile. An estimated 40% of the population still consumes less than the minimum daily requirement of calories. In a country like Ethiopia where production and productivity is low and post harvest loss is quite high, much effort shall be made to generate technologies that would boost production and minimizes loss. The post harvest aspect includes proper post harvest handling practices, proper storage facilities and management practices, appropriate packaging techniques and transportation systems [1; 2]. Postharvest losses therefore reduce the overall prosperity of the country and contribute to undernourishment among the large minority of the population that live in fragile eco-systems and/or have little access to affordable imported food-stuffs.

According to the African Postharvest Losses Information System, postharvest losses in 2012 for teff were estimated at 12.3%, for sorghum at 11.6%, for wheat at 9.9% and for maize at 16.8% [3]. All these figures represent a marginal decline from the year before. Other data sources put that postharvest losses for pulses at 19.6% due to insects and molds alone. Furthermore, a recent study conducted by Addis Ababa University and the Swiss Agency for Development and Cooperation (SDC) in two communities in the East Gojam zone of the Amhara National Regional State showed that, in at least some locations, postharvest losses can be as high as 30% to 50% [3]. The 2010 national grain balance estimated by United Nations Food and Agriculture Organization/World Food Program Crop and Food Security Assessment Mission estimates total postharvest losses at 2.04 million tons of grain whereas the cereal import requirement was roughly 1.16 million tons [3].

According to the SDC study, postharvest losses occur at different stages such as harvesting, threshing, winnowing, transporting and storage, with storage being the stage at which the biggest loss occurs. The causes of postharvest losses are multiple, however, the most significant losses are caused by pests (inspects and rodents), by lack of appropriate storage management and facilities, by inappropriate packaging and inadequate means of transportation [1; 4; 5]. Grain postharvest loss reduction invites pinpointing and working on loss agents which the present review focuses on along with forwarding its remedial measures.

## 2. Literature Review

### *2.1 Cereal grains postharvest losses*

Postharvest operations for cereal grains follow a chain of activities starting in farmers' fields and leading eventually to cereals being supplied to consumers in a form they prefer [6]. When determining the losses that may occur in this chain it is conventional to include harvesting, drying in the field and/or on platforms, threshing and winnowing, transport to store, farm storage, losses incurred in transport to market and market storage. In some contexts cereal processing losses may also be included but this is not usually the case [7]. Losses are normally expressed as loss in dry weight of the cereal crop but losses of grain quality may be of equal or even of greater significance [8].

During postharvest operations there may be losses of both quantity and quality of cereals [9]. Grain postharvest losses may be both the physical losses i.e weight and quality suffered during postharvest handling operations and also the loss of opportunity as a result of producers being unable to access markets or only lower value markets due to for instance sub-standard quality grain or inadequate market information [8].

### *2.2 Magnitude Post-harvest losses in Ethiopia*

Post-harvest losses have been broadly categorized into two groups as qualitative and quantitative loss. Qualitative loss is loss in the nutritional and caloric value, loss of acceptability by consumers and loss of edibility of the commodity while quantitative loss is loss of actual commodity causing a reduction in the amount available [10]. Post-harvest losses occur between the completion of harvest and the moment of human consumption [11]. Magnitudes of this loss along value chain of selected crops in Ethiopia Production of the selected crops in Ethiopia have been above 5,000 metric tons per annum for all crops and their post-harvest losses have been estimated between 10 to 50 percent [12].

**Table 1:** Production, hectare, yield levels and post-harvest losses selected for crops in Ethiopia

| Cereal crops | Maize, Rice, Sorghum. Millet | | | |
|---|---|---|---|---|
| | Average Production 2002-2010(Mt) | Average area harvested (2000-2010) Hectares | Average Yield 2000-2010) Mt/hectares | Post-harvest loss (%) |
| Maize | 3,394,676 | 1,738,765 | 19,599 | 17.4 |
| Rice | 16,230 | 8,742 | 18,485 | 11.9 |
| Sorghum | 2,051,251 | 1,396,569 | 14,475 | 12.5 |
| Millet | 403,965 | 353,150 | 11,345 | 11.0 |

**Source**: [13]

**Maize**

Stored maize damage and losses in Ethiopia ranged between 11% and 100% and weight loss between 2.9% and 20% for storage periods of 2-12 months [14; 10].

**Rice**

Rice Traditional and inefficient methods of harvest, threshing, drying, storing and processing caused about 13% post-harvest loss of the rice grain which is about 3.51 million metric tons per year [10].

**Sorghum/Millet**

The marketed quantity of sorghum is about 516,000 metric tons, of which some 8% comes from the commercial farms that are mostly located in northwest Ethiopia. The overall marketed quantity represents roughly 13% of national sorghum production and 16% of total cereals marketed in Ethiopia. Almost 87% of the total national sorghum produced is retained on-farm for seed and home consumption. Sorghum and millet postharvest losses in Ethiopia are estimated as 11% and 100% respectively [13; 10].

### *2.3 Major factors influencing grains postharvest losses*

Grain losses arise either from poor post-harvest handling or from production over and above the capacity of the available stores, or both. In case production exceeds total storage capacity, two options are deployed to solve the problem which is the instant disposal of the excess produce or increase storage capacity. There are several causes for the observed post-harvest losses experienced by peasant households. Attacks from weevils and rodents, and moisture or growth of molds are among the key factors and agents contributing to the losses. Among these, weevils' attack was reported as the biggest and most common cause. Rodents and moisture and/or growth of molds are also important loss factors [15]. Major factors that influence post-harvest losses of rice in Ethiopia are lack of access to post and pre-harvest equipment and facilities, inadequate knowledge of pest and disease control and management techniques, lack of knowledge and unavailability of threshing, de-hulling or milling equipment and limited markets and buyers [10]. Grain postharvest loss agents can generally be summarized as Abiotic and biotic factors.

#### *2.3.1 Abiotic deterioration factors*

These loss factors include grain being scattered or spilt during postharvest handling as in harvesting, threshing and transport. Grain quality decline may result from are poor handling that allows contamination with foreign matter, mechanical damage during handling, insufficient drying and protection during storage [8].

**Contamination with foreign matter**

Foreign matter includes organic matter (e.g. chaff, other types of grain) and inorganic matters (stores, soil). Some organic matter may be classified as filth like rodent droppings and hair and bodies of dead insects. Contamination with foreign matter accumulates during the early stages of postharvest handling when there is insufficient care during harvesting, drying and threshing and then the accumulation of filth may continue due to the activities of insects and rodents [8]. Grain may be contaminated with foreign matter that is either organic like maize cob cores, tassels or inorganic like stones. Careful sieving can reduce much of the foreign matter content [16].

**Mechanical damage during handling**

Rough handling of grain results in grain breakage that may happen at any point during postharvest handling and storage but is especially a problem during threshing. The presence of broken grain by itself is a reduction in quality for all types of cereals and an important reason for this is that broken grains are much more susceptible to other types of losses such as those mediated by moulds and by insects [8]. Most broken grain comes from poor postharvest handling especially shelling/ threshing, but may also be a consequence of pest attack [16].

**Insufficient drying**

Grain that is not dried to safe moisture content very soon after harvest will start suffering quality decline due to attack by moulds. Moulds may develop on the surface of grain that is above the safe moisture content, which under hot tropical conditions is around 14%. High moisture content is also favorable for the development of insect infestation and for grain discoloration [8]. Grain may be discolored due to grain heating [16].

**Insufficient protection during storage**

Poor storage arrangements can allow the entry of water, access of insects and rodents, and chemical browning reactions that lead to grain discoloration [8].

***2.3.2 Biotic deterioration factors***

Grain subject to bio-deterioration can lead to losses of both weight and quality. The organisms involved are mainly

- Arthropods (mostly insects such as beetles and moths but also sometimes mites)
- Moulds, and
- Vertebrates (mostly rodents such as rats and mice but also sometimes birds)
- Natural changes to the chemicals within grain itself that results in loss of grain quality due to increases in rancidity (milled rice), number of discolored grain (maize), number of yellow grains (milled rice) and number of non-viable seed grain [8].

Pest problems and these natural chemical changes generally proceed more rapidly under higher temperatures and greater relative humidity. For every 10ºC rise in temperature the speed of a chemical change is doubled. Besides happening more rapidly at higher temperatures and humidity, these changes can also happen more quickly due to pest attack. Good postharvest handling and storage can slow down all these loss making changes [8].

**Insects, moulds and rodents**

Postharvest losses due to biodeterioration may start as the crop reaches physiological maturity, i.e. when grain moisture contents reach 20-30% and the crop is close to harvest [8]. It is at this stage, while the crop is still standing in the field, that storage pests may make their first attack and when unseasonal rains can dampen the crop resulting in some mould growth. A key issue is the weather conditions at the time of harvest. If weather conditions are too cloudy, humid or even wet then the crop will not be dried sufficiently and losses will be high. Climatic conditions during crop drying are key to understanding the potential losses of grains. However, successful drying alone is not a remedy against all postharvest losses since insects, rodents and birds may attack well dried grain in the field before harvest and/or invade drying cribs or stores after harvest [17; 18].

**Insects**

About thirty species of insects commonly infest grain. Most of the insect pests are either beetles or moths although there are some other types. Insects have six legs and are usually easily visible since they are in the range of 1 mm to 15 mm long. Insects make holes in grains and hollow them out [16]. Besides attacking grain, several insect pests create other types of damage and all contribute filth to the grain through dead bodies and their droppings which include uric acid. Some species that bore into grain may also burrow into wooden or plastic structures so weakening them. The larvae of many moths produce large quantities of silken threads when moving over surfaces. This builds up into webbing that can bind flour and grain together into a solid mass so blocking machinery or causing additional machine wear and breakdowns. Insects that attack cereals are usually divided into two groups: primary pests and secondary pests. It is useful to distinguish between them as primary pests are usually more destructive than secondary pests, especially during short-term storage [8].

Primary insect pests are insects that can attack and breed in previously undamaged cereal grains. Such pests can also feed on other solid but non-granular commodities, but they are rarely successful on milled or ground foodstuffs. Primary pests include the beetles such as the weevils (*Sitophilus* spp.), the Lesser Grain Borer (*Rhyzopertha dominica)*, Larger Grain Borer (*Prostephanu struncatus)*, and the Angoumois Grain Moth (*Sitotroga cerealella)*. Many primary pests attack the commodity in the field prior to harvest. Some species spend their pre-adult life concealed within a grain, making them difficult to detect visually. Secondary insect pests are not capable of successfully attacking undamaged grains. They are, however, able to attack materials that have been previously damaged either by other pests (especially primary pests) or by poor threshing, drying and handling. They are also able to attack processed commodities such as flour and milled rice where they may form the majority of insects present. Secondary pest species appear to attack a much wider range of commodities than primary pests [8].

Maize weevils (*Sitophilus zeamais*) and Angoumois Grain Moth (*Sitotroga cereallella*) were the two major insects known to be primary pests of stored grains were identified in stores around Jimma zone of south western Ethiopia [19; 20].

**Molds**

Molds, also called fungi, that are found on stored grain initially grow on the surfaces of grain and then slowly penetrate and destroy them. These molds have tube like filaments called hyphae that form the main part of their body. They reproduce by forming spores that are usually released in enormous numbers. Although many types of mould are very important as agents of natural decay, they also cause decay where it is not wanted such as on cereal grains. Mold growth on grain is only possible when the relative humidity at the grain surface layer is at more than 70% [8]. The humidity at the grain surface layer is determined by the grain moisture content and for most cereals the corresponding moisture content in equilibrium with 70% relative humidity is about 14%. Elevated moisture content of stored foods is the primary cause of storage mold growth. To be more exact, it is the thermodynamic water activity ($a_w$) that actually limits biological metabolic activity [21]. Keeping grain at or below this safe storage moisture content is essential if mold growth is to be avoided. The moisture content below which micro-organisms cannot grow is referred to as the safe moisture content [22]. Table 2 lists the safe moisture content levels for cereals and pulses, valid for temperatures up to 27ºC.

**Table 2:** Safe moisture content levels for cereals and pulses stored below 27ºC.

| Product | Safe moisture content (%) |
|---|---|
| Cereals: maize flour | 11.5 |
| Maize shelled | 13.5 |
| Millet | 16.0 |
| Rice (milled) | 13.0 |
| Rice | 15.0 |
| Sorghum | 13.5 |
| Wheat | 13.5 |
| Wheat flour | 12.0 |
| Pulses: broad bean, cow pea | 15.0 |
| Lentil, pea | 14.0 |

**Source:** [22].

Physiologically mature grain may become mould infected because when physiologically mature the plant's own defenses against mould attack are lowered. However, the growing crop in the field can also become infected if subject to drought stress as this also reduces the plants defenses against mould growth. Mould may also grow on moist grain that has been left exposed by the attack of field pests [8]. Mould growth can cause heating and caking of the grain, and subsequent discoloration due to either production of pigments or browning reactions occurring at the elevated temperatures. Caking and heat damage of grain are typical signs that mould growth has already occurred. Moldy grains have been dried too slowly or allowed to become wet. They have patches of mould growth on them and may also be discolored. Some moulds also produce mycotoxin that is dangerous poisons like aflatoxin [16]. Mycotoxins are mould metabolites that, when ingested, inhaled or absorbed through the skin, cause lowered performance, sickness or death in man or animals [8]. There are many different mycotoxins that could contaminate grain. The most well-known is aflatoxin which is produced by some strains of the mould *Aspergillus flavus* and is regarded as the most important mycotoxin in developing countries. It is a liver toxin that can induce cancer in susceptible animals, and is the most potent liver carcinogen known. Much circumstantial evidence suggests that it may be a factor in the high incidence of human liver cancer in some parts of the tropics and subtropics including Ethiopia. The growth of *A. flavus* can be very rapid under tropical or subtropical conditions, and aflatoxin has been found in cereals, pulses, and oilseeds especially groundnuts. For growth *A. flavus* requires a minimum relative humidity of 82%. For cereals at typical tropical temperatures (20 ºC-30 ºC) this would be equivalent to a moisture content of about 18%. It is therefore; clear that if cereal grain is maintained at about 14% it is safe from aflatoxin formation. However, during postharvest handling if moist grain is not dried quickly and thoroughly it is in danger of *A. flavus* infection and toxin formation. For this to happen the grain must be contaminated with the spores of *A. flavus* and the likelihood of this is greatly increased if the grain is allowed to come into contact with soil or other moldy grain during postharvest handling. Good hygiene is thus important in avoiding contamination [23]. However, it should be remembered that grain may become contaminated while on the plant in the field due to drought stress.

If mould damage and toxin formation has been avoided during postharvest handling and the stored grain remains at the safe moisture content then it should remain free of aflatoxin. The main danger then is water coming into contact with the grain, due to leakage or condensation. In large scale storage there is also a danger of hot spots occurring in the grain due to insect infestation, this results in high temperature and moisture which presents a danger, but these conditions have not been reported from small bulks of grain stored by smallholders or in sack storage. The most common fungi isolated from grains stored in storage containers (*Gombisa* and Sacks) in selected districts of Jimma zone of south western Ethiopia were *A. flavus, A. niger, D. halodes* and *F. oxysporum* (Table 3). It is also evident from same study that fungal species *A. flavus, A. niger, D. halodes,* and *F. oxysporum* were the most frequent species recorded over the storage periods of six months [24].

**Table 3:** Percentage occurrence of fungi isolated from stored maize in selected districts of Jimma zone, Ethiopia.

| Mycoflora | Storage periods (days) | | | | Occurrence (%) |
|---|---|---|---|---|---|
| | ID | 60 | 120 | 180 | |
| *Aspergillus flavus* | 41 | 46 | 46 | 39 | 90 |
| *A.fumigatus* | 5 | 2 | 0 | 0 | 3.6 |
| *A.niger* | 25 | 29 | 25 | 18 | 51 |
| *A.tereus* | 0 | 1 | 0 | 0 | 0.5 |
| *Cladosporium cladosporioides* | 2 | 3 | 2 | 7 | 15 |
| *Drechslera halodes* | 33 | 41 | 37 | 27 | 72 |
| *Fusarium oxysporum* | 16 | 20 | 24 | 24 | 44 |
| *Penicillium chrysogenum* | 0 | 0 | 1 | 0 | 0.5 |
| *Sterile mycelium* (white) | 3 | 11 | 3 | 3 | 10 |

‘0‘indicates the absence of fungi; ID (Initial loading day), 60, 120 and 180 represent storage periods in days.

**Source**: [24].

**Rodents**

Rodents chew into grain and remove the germ [16]. Rodent problems may vary from just the occasional damaged grain sack to severe damage that result in the collapse of bag stacks. Grain may be eaten in the field or in store by rodents. Apart from the food eaten, spoiled or contaminated, there are additional 'invisible' losses such as the replacement or repair of packaging materials and the cost of re-bagging spilled grains. Much of the spillage arises when rodents attack food packaging to obtain nesting material; stacks of heavily infested bagged foodstuffs may ultimately collapse. Finally, rodents are capable of transmitting diseases to people either directly by bites, through the air or the handling of rodent carcasses; or indirectly through contact with food and water contaminated with rodent hair, droppings and urine [25].

**Metabolic activities**

Cereal grains are living materials and their normal chemical reactions produce heat and chemical reactions by products [25]. Heat is also generated by insects, mites and micro organisms, which if presented in large number may lead to a significant rise in temperature of stored products. There are two types of losses during metabolic processes: The loss due to grain being converted by micro organism to carbon dioxide and water and when the grains are rejected for quality deterioration [15]. Under aerobic condition the complete combustion of a typical carbohydrate can be represented by the following equation:

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + 677.2\text{Kcal}$$

### *2.4 Post-harvest management practice in Ethiopia*

Farmers in Africa predominantly use traditional methods in the management of stored product. Some farmers are also attracted to the use of synthetic insecticides. Nonetheless, many farmers apply no protection measures in their storage structures. Farmers in Northern Ethiopia apply one or more management practice to stored maize, whereas 23% in the South of the country applied none [14]. Some of them are mud cribs, Woven basket, Open Platform, Pots, Maize Crib, Bamboo and straw roofs, Community stores, Mud Rhombu etc. The use of traditional stored product protection methods is very popular among small-scale farmers in Africa.

Reference [14] Reported that in Ethiopia traditional management practices for stored maize. In some parts of Ethiopia 70% of farmers treated their grains with synthetic chemicals [26]. They use chemicals to reduce grain losses that would result from pest attack because storage losses without chemical treatment can be substantial. Chemicals are usually used to treat maize and wheat since these crops are among the most susceptible to weevils' attack. Rice losses could be reduced by control of the two most important variables, such as moisture and temperature. Not much has been done to establish post-harvest loss management in sorghum and millet [10].

### *2.5 Remedies for tackling postharvest grain losses*

As losses of quality and quantity of cereal grains in developing countries appear to be initiated mostly at farm level, the potential remedies to the problem need to be applied at the same level [9; 27; 21). As suggestion to tackle postharvest grain losses, there has to be an incentive before smallholder farmers will adopt improved postharvest practices and they also require access to technical know-how and appropriate agricultural equipments to their circumstances through training and technology demonstrations at farm level. As an aid to those involved in helping smallholder farmers limit grain losses both in quantity and quality, recommended approaches include working in the areas on how to prepare for the new harvest, harvest on time, harvest carefully and dry the crop sufficiently, thresh/shell the crop carefully, clean the grain, store the grain using an appropriate method, using insecticides and other ways of killing insect pests in stored grain to maintain its initial quality and minimize quantitative physical loss [16].

From the review it can be found that significant reductions in the loss caused by insects can be achieved through use of insecticides and that farmer will be able to store treated grain for longer periods to benefit from seasonal price rises provided that access of genuine pesticides is guaranteed at farmers' levels locally. The use of proven traditional grain protecting materials to control insect infestation need to be encouraged besides use of modern chemical pesticides. Mould damage is an important problem in grain stored especially in underground pits and even in above ground grain storage structures and containers currently being used in the country. Reduction of losses caused by mould growth on grain stored in underground pits and mentioned containers can be achieved by the use of storage structures with well designed aeration system, use of improved small scale hermetic storage containers like Pics bags (Perdue improved cowpea storage) and metal silos and the use of pit linings that restrict moisture and the subsequent development of mould to reduce not only postharvest quality and quantity losses but to reduce the health risks associated with consumption of mould damaged grain that may contain mycotoxin which is a potent carcinogen for human and animals upon ingestion of moldy grains.

Provision of basic postharvest training to extension workers is compulsory linking it to the development and promotion of improved grain storage containers with management of stored grains in them can minimize postharvest loss that occurs as a result of moisture, temperature and humidity rise inside containers; insect, rodent and mold attacks. It is clear that there are opportunities through the Bureau of Agriculture and natural resources, research and higher learning institutions to establish farm-level storage research and development projects to identify options for addressing various storage problems, extension of basic messages of good storage practice and improved storage facilities and short term and long term training provision to strengthen the post-harvest capability of extension personnel in the topic and act accordingly. An advancement of priorities inside the postharvest handling situation of developing nations from a predominantly technical emphasis geared towards the reduction of losses to a more all-inclusive method intended to tie on-farm activities to processing, marketing and distribution is also essential [28].

The major contributing problems for high postharvest losses relates with poor postharvest infrastructure and marketing systems, poor research and improvement capability, and insufficiencies in guidelines, and information sharing [29]. Consistent analysis of every commodity's production and handling practices would be focal point in creating effective management strategies for reducing postharvest loss and also a cost-benefit examinations to understand the return on investment in the suggested postharvest technologies is indispensable [30]. Reference [31] mentioned the most appropriate concerns for developing countries as the necessity for a regulatory basis that stimulates growth while safe-guarding well-being, provision of sufficient market information, additional investments in postharvest research and involvement in international bargains which endorse trade and food security. Evidently reducing postharvest losses of previously produced food is more sustainable than boosting production to pay off for these losses [32]. The developing countries drivers for change include more widespread education of farmers in the causes of postharvest losses, better infrastructure to connect smallholders to markets, more effective value chains that provide sufficient, financial incentives at the producer level, opportunities to adopt collective marketing and better technologies supported by access to microcredit, and the public and private sectors sharing the investment costs and risks in market-orientated interventions [33].

## 3. Conclusions

The issues reviewed were limited to evidence of measures of magnitudes of losses at different points along the commodity value chain, factors influencing losses and loss management practices. High moisture content, insect infestation and damage during postharvest handling (packaging, storage and transportation) are the major causes of grains postharvest losses. Appropriate packaging materials, proper storage facilities and transportation are required to minimize these losses. Efficient production and utilization of food crops are needed to increase food self-sufficiency and export earnings. Modern food processing techniques and post-harvest technologies are the main tools to reduce food losses and maintain their quality. Since deterioration of stored grains results from the interactions among the physical, chemical and biological variables existing in the system, it is important to understand the inter-relations and interactions of these variables in order to design an effective control and management of these factors postharvest loss reduction. In order to attain a high nutritional status, improved postharvest management, reduced post-harvest losses, production of value added products, effective and efficient research programs on the post-harvest sector must be strengthened and promoted.

## 4. Recommendation

- Recent information on magnitude of losses, influencing postharvest loss factors and exemplary management practices in the country is still needed specifically covering value chain points agreed by the entire concerned stakeholders on target staple grains of Ethiopia.
- Promotion of proven grain postharvest loss mitigating technologies at hand need to continue to reach individual and grouped farmers.
- Although the main causes of post-harvest losses are known and documented, it is important to further explore peculiar factors that cause postharvest losses at each production levels that will require special attention focusing the same in relation to physical, bio-chemical and socio-economic aspects.

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