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Nutrition-Sensitive Agriculture and Appropriate Postharvest Handling of Crops: A Missing Link with Potential for Global Nutrition and Food Security

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Abstract
Currently, 822 million, and 2 billion suffer from hunger, and micronutrient deficiency, overweight and obesity, respectively. This is due to a variety of factors associated with pre-harvest and post-harvest activities in nutrition-sensitive agriculture. This paper is, therefore, aimed at reviewing nutrition-sensitive agriculture and appropriate postharvest handling of crops: a missing link with potential to global nutrition and food security. Agriculture provides food and nutrients through improved agricultural production systems such as biofortified and/or crop breeding, crop diversification, fish, poultry, and animal rearing, use of biodiversity, and urban and peri-urban agriculture. Appropriate postharvest handling such as right harvesting time, methods and maturity stage, field packing, transportation, storage, processing, packing, safety and distribution of the products help to safeguard the quality of the product and reduce postharvest food wastage. However, the agriculture and postharvest system of most crops in developing countries are constrained by lack of a complete package of agricultural inputs, income, facilities/technologies, tradition and religion, and lack of awareness on how to use technologies and protect the safety and or quality of the products. The interventions that make agriculture and the postharvest system of crops nutrition-sensitive should be appropriately applied to the crop and postharvest system of crops.
Keywords: Agriculture, Food security, Nutrition security, Nutrition-Sensitive, Postharvest handling.

1. Introduction

Studies indicate that about 822 million are food insecure and 2 billion people have micronutrient deficiency and are overweight or obese (FAO, 2022). The developing countries account for 91% of stunted children worldwide, with Sub-Saharan Africa accounting for more than one-third (UNICEF/WHO/WorldBank, 2021). To reduce the number of vulnerabilities, the United Nations modified the Millennium Development Goal in 2015 to the Sustainable Development Goal, which states that by 2030, 'end hunger, achieve food security, improve nutrition, and promote sustainable agriculture' will be achieved (SDG, 2016).

Food security exists when all people, at all times, have physical and economic access to sufficient, safe, nutritious food to meet their dietary needs and food preferences for an active and healthy life". It is most commonly defined as the four pillars: availability, access, utilization, and stability (Peng and Berry, 2019). In other words, nutrition security exists when food security is combined with a sanitary environment, adequate health services, and proper care and feeding practices to ensure a healthy life for all household members (FAO, 2012). Political insecurity, war, macroeconomic inconsistencies, trade displacement to ecological deprivation, poverty, population growth, gender disparity in food production, illiteracy, and inadequate health services are all factors that contribute to food insecurity (Birara et al., 2015).

Agriculture provides food and earnings for the human beings necessitated to survive.It is, however, only concerned with increasing output and productivity and cannot effectively contribute to nutrition (Chihambakwe et al., 2019).

Poor agricultural production and handling practices, on the other hand, result in postharvest loss and food insecurity. Consequently, food insecurity leads to malnutrition, which negatively affects agricultural productivity, socioeconomic development, educational performance, and community health (CWFC, 2012). Farmers with poor nutritional status have lower agricultural productivity, household income, and health. Thus, interventions that make agriculture more nutrition-sensitive are critical (de la Pena et al., 2018).

Nutrition-sensitive agriculture is a food-based approach to agricultural development that places nutritionally rich foods, dietary diversity, and food fortification at the heart of overcoming malnutrition. Making agriculture a nutrition-sensitive is an approach that seeks to ensure the continuous production of a variety of low-cost, adequate nutrient-dense, locally acceptable, and hazard-free foods in sufficient quantities and quality to meet the needs of consumers (Uccello et al., 2017). It also requires a good agricultural policy on food prices and consumption, women's employment in agriculture, and child feeding, nutritional status, and health conditions (Gillespie and van den Bold, 2017).

Though agriculture's primary role in nutrition improvement is to improve access to sufficient, safe, and nutritious foods, the expected benefit is not realized due to inadequate agricultural inputs, biotic and abiotic stresses, a poor social and infrastructural situation, a weak extension service, poor governmental regulations and legislations, labor wastages, a chronic shortage of cash, and poor women empowerment (de la Pena et al., 2018). Even though it is advised that food and nutrition security be ensured through nutrition-sensitive agriculture and proper crop postharvest handling, it can be challenging to find reliable, organized information. Therefore, this paper aims to review nutrition-sensitive agriculture and appropriate postharvest handling of crops: a missing link with potential for global nutrition and food security.

2. Nutrition-sensitive agriculture

2.1. Agriculture as a source of income

Agriculture affects nutrition by influencing money spent on purchasing a variety of nutritious food; access to a consistent source of income; and the role of women in agriculture (Dennison, 2014). Ensuring consumers' regular and adequate income is necessary to attain nutritious food, access to health care and education services. This is accomplished by increasing the potential of agriculture and food systems to generate income and increasing the likelihood that the income is used on purchasing nutritious foods and accessing nutrition-enhancing services (Uccello et al., 2017).

2.2. Agriculture as a source of food

The principal purpose of agriculture is not to provide the food types required by families, as most rural low-income families are net purchasers of food (AFC, 2018). Food security for families with access to arable land is determined by the food produced for consumption, income, and local food availability and prices, while the type, quantity, and seasonality of food available in the household for consumption are affected by food production (Chihambakwe et al., 2019). The availability and diversity of food in local marketsare also influenced by food production (Herforth and Harris, 2014).

The role of agriculture as a source of nutritious food is indicated through several interventions reported by several researchers. For instance, the availability and consumption of microelement-rich foods reduced microelement malnutrition in Bangladesh, South Africa, and Ethiopia through home gardening connected to primary health care activity and nutrition (Talukder et al., 2000). Furthermore, own production improves family nutrition because they use their products at home (Chihambakwe et al., 2019). Similarly, the production of diversified farming by crop-livestock incorporation with market accessibility improved the nutrition of family members in Zimbabwe (Murendo et al., 2018). Crop diversification, cattle ownership, credit access, and education also improved Mali's food consumption score (Mango et al., 2018).

Livestock and animal-based foods are critical to long-term sustainability. They play an important role in improving nutrition, reducing poverty, promoting gender equity, enhancing livelihoods, increasing food security, and strengthening human health (Adesogan et al., 2020). Animal source food (ASF) is a good source of protein, as well as certain micronutrients (easily absorbable iron, zinc, calcium, vitamin A, vitamin B12, and various essential amino acids) (Neumann et al., 2014). The link between animal-source food consumption and stunting reduction is also reported, indicating that food supplementation with a small amount of milk and meat improves macro and micronutrients dramatically.Moreover, meat supplementation also improves cognitive skills, leadership behavior, physical activity, and initiative (Headey et al., 2018). Similarly, fish-based foods are high in omega-3 fatty acids and iodine, which are essential for children's brain development (Thilsted et al., 2016). However, consumption of animal-source foods is subjected to religious custom and practices, which excluded women and children from some foods. Because of this, most foodstuffs were not permitted for pregnant women. Pregnant women, for example, were not permitted to consume meat and fish products, potatoes, fruits, beans, eggs, butternut, or pumpkin (McNamara and Wood, 2019).

Biodiversity is also viewed as a means of achieving dietary diversity and ensuring nutrient sufficiency. For instance, an increase in species diversification resulted in a 12.7% improvement in micronutrient adequacy in Kenya (Oduor et al., 2019). Similarly, households with higher agricultural biodiversity scored higher on dietary diversity and had greater food security than those with lower agricultural biodiversity (M'Kaibi et al., 2017). Moreover, the use of underutilized food crops such as *Dolichos (*Minde et al., 2021), Amaranth (Aderibigbe et al., 2020), and Anchote (Mosissa et al., 2019), African native fruit plants (Omotayo and Aremu, 2020) as well as the fortification of neglected legume and oilseed crops with cereals (Desire et al., 2021), and use of local agro-forestry practices Jemal et al., 2018), have improved the nutrition. Some underutilized wild animals, such as rats,were also reported to be good protein sources (Broegaard et al., 2017).

In Sub-Saharan African countries, breeding programs have also improved nutrient density, for example, maize is made suitable for local processing of bread and snacks, the yield has increased, a loss is reduced, and anti-nutritional factors are reduced (Ekpa et al., 2018). The urban and peri-urban agriculture (UPA) program also enabled residents to grow crops, medicinal herbs, fruits, raise small animals, and participate in an integrated farming system, which improves their food and nutrition security.This UPA enables low-income urban residents to obtain fresh, diverse, and nutritious food near the market(Nisbett et al., 2017). The food producers in urban areas benefit in two ways: their food requirement is fulfilled, and the expenses incurred for food are reduced (Chihambakwe et al., 2019). Since there are no more agricultural lands in urban and peri-urban areas, intensification of farming is very critical to encourage agricultural production to promote food and nutrition security (Smith, 2013).

3. The appropriate postharvest handling of crops in nutrition-sensitive agriculture

3.1.Appropriate postharvest handling practices of perishable crops

3.1.1.Harvesting

Postharvest handling begins at harvest. Nonetheless, the product's postharvest quality is determined by pre-harvest factors such as environmental (relative humidity, temperature, light, rains, and winds) and cultural factors (nutrient management, cultivar, disease management, irrigation, agronomic practices, and economy) (Weber, 2020).Improper harvest, maturity stage, harvesting time, and methods are causing losses on crops after harvest (Kumar and Kalita, 2017). The majority of the losses of fruits at the farmer’s level occur during storage due to the harvesting of immature fruits or the fruit being overripe (Omotayoand Aremu, 2020). Therefore, during harvesting, mechanical damage (cuts, scratches, and abrasions) should be minimized because it affects the appearance of the perishable crops and is a pathway for microorganisms that deteriorate at transportation and storage (Kuiper et al., 2020). Harvesting at the propermaturity stage also helps attain fruit quality and reducesthe chance of spoilage (Mutungi et al., 2020).

3.1.2.Packing or Field handling

Packing is one of the activities performed to place detached produce into containers used for transportation. Before packing the produces, remove extraneous materials, wash to remove soil and microbial load, pre-cool to reduce heat physiological activities, sort based on required size categories, inspect the quality of the produces, and pack into the appropriate containers during the transportation is very important to reduce the postharvest loss (Alistair, 2005). To reduce the loss in the packing house, careful transfer of produce from containers used to pick to field crates is necessary as it reduces mechanical damage. Similarly, soil-borne microorganisms should be protected by avoiding direct soil contact withthe crop. It is also critical to place containers in a shaded area and fill them to the recommended filling weight (Behera et al., 2020).

3.1.3.Transportation

The primary transportation step is to hold the crop from the productionarea to the selling place by truck, rail, ship, plane, pickup truck, and human back, animals (donkey, horse, or mule). Unlike developed countries, the transportation system is constrained by the lack of a cold transportation system and does not haveventilation facilities to transport perishables in developing countries (Arah et al., 2016). In Ethiopia, for instance, all transportation methods predispose perishable produce to heat buildup and mechanical damages due to impact force, vibration, and damage due to humans loading over the crop and improper and inadequate roads (Kuyu and Tola, 2018). Furthermore, delays in transportation without the use of cushioning materials, uncovering the vehicle, transporting during the hot time of day, mixing the products, overfilling, loading with other harmful chemicals, and a lack of refrigerated transport were reported as constraints in developing countries (Emana et al., 2017; Kuyu and Tola, 2018).

3.1.4. Storage

Food storage preserves the quality of the products for an extended period until consumption. Good storage facilities help to extend the shelf life of produce and ensure a sustainable supply of the product throughout the value chain (Arahet al., 2016). As a result, the produce season of availability is prolonged, and the product can be kept till prices rise, creating a uniform retail distribution. It has been demonstrated that products stored in refrigerated storage, controlled atmosphere, modified atmosphere packaging, and hypobaric storage has a longer shelf life (Kaur et al., 2021).The commodities stored together should be checked for their initial quality, stability, environmental and handling practices, compatibility, optimum temperature, relative humidity, and other environmental factors (Lee and Kader, 2000). Before storage, produce should be sorted into healthy and unhealthy categories, and the maturity stage of the product should be considered, with high-quality products stored together (Arah et al., 2016). If different crops are to be stored together, the compatibility of the produces should also be checked first (Table 1). Grain products should also be dried to reduce their high moisture content before being stored to prevent a microbial attacks and insect infestation(Asemu et al., 2020). The storage facilities, warehouse, and environment must be protected from all kinds of environmental hazards. Grain storage in steel bins and plastic silos is preferable because it provides the necessary protection (Manandhar et al., 2018). Good ventilation with low humidity and propertemperatures must be maintained at the storage sites of grains (Uniyal, 2014). Generally, storage temperature below 41^{o}C is recommended to minimize bacteria, fungal, and mold growth, whereas a temperature above 70^{o}C increases their outbreak(Arahet al., 2016).

Table 1 Storage compatibility of agricultural crops

Group 1. Temperature 32-36 ºF, Relative Humidity 90-95%				
Apples*	Berries	Grapes	Pears*	Rutabagas
Asian pears*	Cantaloupe*	Parsnips	Plums*	Turnips
Beets, topped	Cherries	Peaches*	Radishes	
***These items can produce high levels of ethylene that can be detrimental to items in Group 2.**				
Group 2. Temperature 32-36 ºF, Relative Humidity 90-95%				
Beets, topped	Cabbage	Cherries	Greens	Radishes
Berries	Carrots	Corn	Lettuce	Rhubarb
Broccoli	Cauliflower	Grapes	Parsnips	Rutabagas
Brussels sprouts	Celery	Onions, Green	Peas	Turnips
Group 3. Temperature 32-36 ºF, Relative Humidity 65-75%				
Garlic	Onions	Shallots		
Group 4. Temperature 50 ºF, Relative Humidity 90-95%				
Beans†	Eggplant	Peppers	Squash, Summer	Tomatoes, Ripe
Cucumbers	Okra	Potatoes†	Squash, Winter	Watermelon
†Fifty degrees is slightly above ideal conditions for these commodities.				

Source: Boyhanet al. (2009).

3.1.5. Processing

Processing includes postharvest activities such as freezing, drying, milling, canning, mixing/fortifying, fermenting, sprouting, dehulling, and adding salt, sugar, fat, or additives after harvest (Greenberg, 2017). According to Greenberg (2017), it is used to produce food that is safe, diverse, abundant, and accessible in supply. Mainly, processing methods such as fortification and fermentation add nutritional value. However, consuming an excessive amount of highly processed food results in lower-quality food (Mozaffarian et al., 2011). During processing and packaging, intentional losses, inefficiencies in techniques and malfunctioning, deviations during processing lines, restriction because of legislation, extra production and the packaging system should be minimized (Ishangulyyev et al., 2019).

Biofortification also increases the concentration of specific microelements, lowers the concentration of phytate, or increases the activity of compounds that improve the digestibility of essential elements and compounds by adding zinc, iodine vitamins, and iron either at the time of processing or processing at the household level (Kruger et al., 2020). Amino acids in biofortified plant foods, for example, improved zinc digestibility or availability (Gharibzahedi et al., 2017). A molecule Nicotianamine is a metal chelator in transgenic plants manipulated by biofortification, which improves intestinal Fe and Zn absorption by enhancing the filling of Fe and Zn into certain foods such as grains (Borrill et al., 2014). It also improves conventional fortification because it provides nutrients to the rural poor who do not have access to fortified foods (jBouis and Saltzman, 2017). The use of biofortified staples reduced the prevalence and duration of diarrhea in children aged above 5 and 3 years by 11.4% and 18.9%, respectively (Jones and de Brauw, 2015). Some countries use vitamin and microelement fortification of foods. Some of the biofortified crops and foods are indicated in Table 2.

Table 2. Some biofortified crops with their improved characteristics

Biofortified crop	Biofortified by	Reference
Orange fleshed sweet potato	Vitamin A	De Brauwet al. (2018)
Maize and wheat	Zn and Se	De Valençaet al. (2017)
Bean and pearl millet	Iron	Haaset al. (2017)
Pearl millet flatbread	Iron	Finkelsteinet al. (2015)
Provitamin A maize	Vitamin A	Palmeret al. (2016)
Yellow cassava	Vitamin A	Talsmaet al. (2016)
Wheat	Zink	Kinget al.(2015)
Biscuits	Iron	Parasar and Bhavani (2018)

Fermentation is the mechanism by which food loss and waste are minimized. It also helps in reducing the amount of time and fuel required for cooking, which increases food production and sales (Waqas et al., 2018). During fermentation, the development of lactic acid bacteria enhances intestinal tract health, the immune system, synthesis, and bioavailability of nutrients; decreases lactose intolerance, susceptibility to allergy, and cancer risks (Parvez et al., 2006). Furthermore, fermentation increases prebiotic availability, extends shelf life, prevents pathogenic contamination, reduces anti-nutrients (Knockaert et al., 2014), reduces lactose, and increases lactase enzyme for improved digestibility in dairy products (Savaiano, 2014).

Germination is the other ordinary bioprocessing technique used to develop modified grain and legume flours with improved nutrient qualities and solubility (Xu et al., 2020). Malting amaranth, for example, increased in-vitro protein digestibility, protein composition, oxalate and tannin content while decreasing phytic content (Hejazi et al., 2016). Similarly, phenolic bioactive compounds were increased during quinoa sprouting, with antioxidant capacity, phenolics, and flavonoids increasing by 40, 49, and 62%, respectively. Phenolic bioactive compounds found in sprouted cereals can control chronic hyperglycemia and oxidative stresses in people with type 2 diabetics. Sprouting also improved the functionality of wheat-based bread flour (Aguilar et al., 2019).

Pickling has been used to preserve fruits, vegetables, fish, and meat. Moreover, probiotics improve the safety of preserved foods and reduce pH through produced acids and detoxification during pickling (Behera et al., 2020). Drying is also used to remove the water content of foods through the use of evaporation, yielding solid products for long-term storage. For instance, drying to less than 10% water content inhibits microbial growth, and is used to extend shelf life. It is also used to reduce the water content and increase the concentration of the components contained in food products. It also saves storage space and shipping costs (Djaeni and Perdanianti, 2019).

3.1.6. Packaging and packing of processed products

Food packaging helps to prevent the products and ensure a good distribution of food products without physical damage, chemical contamination, or biological and environmental hazards that can threaten life (Wyrwa and Barska, 2017). It also plays a major role in improving nutrition by extending shelf life and facilitating the wider distribution of processed foods, during packaging and packing, caring is necessary to reduce loss at storage sites (Arah et al., 2016). Therefore, packaging material should fulfill the fundamental roles of packaging, such as protecting/preserving food, providing convenience, and informing the consumer to reduce food waste and protect the consumer's health (Wyrwa and Barska,2017).

3.1.7 Food labeling

CODEX(1991)defined food labelling as any written, printed, or graphic information expressing the food or presented near the food together to promote the sale of the food or why the food is disposed of. Words, letters, logos, images, and symbols refer to the shelf life, method of preparation, consumption, nutrient quality, and commercial characteristics of a product (Wyrwa and Barska, 2017). Any information on the label should be accurate, standardized, appealing, and simple for consumers of all literacy levels to understand (Darkwa, 2014). Furthermore, the supervisory authority must verify the label in order to reduce declarations that mislead consumers (Wyrwa and Barska, 2017).

3.1.8.Retail distribution

The retail market is the ultimate destination for agricultural products and visible crop handling practices.Consumers can choose to buy or reject food in packaging materials or unpackaged products. The design of the commodity display should allow for quick and impulsive purchases (de la Pena et al., 2018). The quality of commodities at the retail distribution stage is determined by factors such as incompatible commodities displayed close together, period of exposure, temperature, relative humidity, lighting, and how to store personnel and consumers handle the produce (Kumarand Kalita, 2017). Inadequate conveyance conditions, poor transportation and market facilities, insufficient roads, business rules, consumer perceptions, and packaging preferences are also causes of loss and waste during retail distribution. Therefore, rapid turnover is recommended as a food and loss reduction mechanism at this stage (Ishangulyyev et al., 2019).

3.1.9. Safety and quality of food products

Food safety is the assurance that food will not cause harm to the consumer when prepared and consumed as intended.Biological contaminants such as bacteria, viruses, parasites, and prions, as well as chemical hazards such as heavy metals, environmental pollutants, mycotoxins, and allergens, can contaminate foods (WHO, 2019). According to FAO (2019), food-borne spoilage causes six million illnesses, four hundred and twenty million deaths, and thirty-three million disabilities. The food-borne disease affects 40% of children under the age of five. Detection and abolishing the risks of food borne illness are difficult because of interconnected global markets, the length of supply chains, and the growing number of stakeholders in the food system. Food quality, hygiene, and safety standards are required in such cases to protect consumers and improve access to safe and nutritious foods (Khairuzzaman et al., 2014).

3.2. Appropriate postharvest handling practices of durable crops

Several factors, including biological and environmental factors, limitations in mechanization accessibility and cost, a poor marketing system and farmer organizations, lack of information, insufficient irrigation water and infrastructure, a lack of credit, inadequate improved varieties, and an inadequate policy framework and governmental regulation, all pose challenges to nutrition-sensitive postharvest handling practices (Bolarin and Bosa, 2015). Postharvest losses in cereal grains were primarily caused by inefficient harvesting, drying, threshing, winnowing, storage, transportation, packaging, and marketing (Mutungi et al., 2020). In Uganda, for example, estimated maize postharvest losses accounted for 6.4 16.4%, 4.0%, 1.3%, 2.4%, and 1.2-5.9% at the harvesting, drying, shelling, transport to farm, and storage stages, respectively. Gender disparity in the value chain is another factor of postharvest crop loss, and findings also confirmed that female-headed farmers experienced lower crop loss (Shee et al., 2019). Similarly, the degree of loss is determined by the level of education and training received by the farmers. In Ethiopia, Tanzania, and Uganda, for example, postharvest losses are reported to be lower for more educated and trained farmers than for less educated and untrained farmers (Shee et al., 2019). Generally, appropriate postharvest handling reduces loss, increases producer income, lowers consumer prices, increases food availability, creates job opportunities, and improves the livelihoods, food and nutrition security of rural and urban consumers (Mezgebe et al., 2016). The following topics explain some of the appropriate handling practices at each postharvest value chain stage.

3.2.1. Pre-harvest drying

The cereals or legumes should be dried during pre-harvest drying to prevent moisture content. Furthermore, avoiding prolonged pre-harvest field drying may increase the risk of loss due to birds, rodents, insects, moulds, and theft. The crop should also be harvested at the proper maturity stage to reduce seed decay due to mould development (Njoroge et al., 2019).

3.2.2. Harvesting and transporting

Harvesting is the point at which the grain's maximum quality should be achieved. Harvesting time is determined by the degree of maturity of the grain. However, the lack of a proven maturity index for some crops and native export markets, lower adoption of established indices due to price and distance to market, poor weather conditions at harvesting time, and moisture content of harvested products cause grain loss during harvesting (Bolarinand Bosa, 2015). A large number of losses occur before or during harvesting operations if they are not performed at optimum crop maturity and moisture content because too early crop harvesting increases crop drying costs and grain susceptibility to mould, insect, and breakage during milling (Emana et al., 2017). Shattering, birds, rodents, animals, thefts, rain, and storms, on the other hand, cause losses if the crop is left on the pitch past its optimal maturity (Kuyuand Tola, 2018). Furthermore, a lack of sufficient labourers during peak harvesting delays harvesting, resulting in significant losses (Coker and Ninalowo, 2016). Therefore, an appropriate harvesting stage, method, and time, as well as well-designed harvesting tools, equipment, and harvesting containers, are suitable for reducing qualitative and quantitative loss during subsequent postharvest handling practices (AFC, 2018). It is also necessary to prevent grain from falling on the road when transporting harvested crops from field to threshing or storage location (Kumarand Kalita, 2017).

3.2.4. Postharvest drying

The time required for complete drying is determined by atmospheric and weather conditions. Unprotected drying and threshing places make grains vulnerable to livestock, birds, rodents, and small ruminants at this stage. Contamination of the grains by the droppings of these animals results in higher losses and is a nutrition-sensitive postharvest handling problem (Asemu et al., 2020). Brittleness and cracking of grains after threshing, hulling, and milling also result in significant postharvest losses. Consequently, the broken grain will be separated from the husks, resulting in weight loss and a decrease in the price paid for the grain when it is sold. Therefore, during postharvest drying, the surface should be covered or raised in drying areas with accurate techniques for assessing the grain moisture content (Shee et al., 2019).

3.2.5. Threshing

Before threshing, the crop should be sufficiently dried because threshing will be futile if the crop is not completely dried. Therefore, proper management of grain moisture content is vital before threshing. Lack of proper threshing equipment isalso the causes of losses in grains (Coker and Ninalowo, 2016). Grains should also be thoroughly cleaned to prevent insect infestation and mould growth during storage. Furthermore, proper grain cleaning during threshing helps to reduce the development of unwanted taste and colour as well as damage to processing equipment during processing. The area for threshing or grain storage should also be large enough to hold the grains and be clean (Kumarand Kalita,2017).

3.2.6. Storage

In developing countries, cereal storage accounts for the majority of postharvest losses (Kumar and Kalita, 2017). Traditional storage structures are used to store grains in these countries. Traditional storage structures, however, are incapable of completely preventing insect infestation and mould growth in storage, resulting in significant losses. Ethiopian farmers, for example, mechanically remove insects, infested grains or cobs, shake, and restack the grains to disturb and reduce the activity of the insects. Farmers also heat the grains by exposing them to the sun, treating them with cow urine, and admixing salt during storage to control sorghum infestationduring storage (Mendesil et al., 2007).

Appropriate, low-cost and simple loss reduction mechanisms are reported for low-income countries. For instance, Mohapatra et al. (2015)suggested using low-cost, low-risk, locally available materials such as inert dust and hermetic storage materials to control insects in storage. Proper use of these mechanisms prevents insect infestation, ensures effective resource utilization, increases production and use, family income and standards, and improves food and nutrition security in households (Kembabazi, 2019). When compared to traditional storage materials, hermetic storage such as metal silos and grain bags reduces aflatoxin B1 contamination, kills insect adults, and reduces insect infestation during maize storage. For example, Kumar and Kalita (2017) reported that proper hermetic storage materials can reduce infestation by up to 98%.

In general, adequate storage facilities, personnel hygiene, and effective and sufficient monitoring are required during grain storage to control an infestation of insects and mould, rodent and bird entry, temperature, moisture, and humidity (Kumarand Kalita, 2017). For example, storing grain at a temperature of less than 15^0C and a moisture content of 9% to control mould and insect infestation in grain storage is highly recommended (Befikadu, 2014). Moreover, good agricultural practices and appropriate storage technologies can significantly reduce losses and contribute to food security, increased farmer income, and poverty alleviation (Kumar and Kalita, 2017). Using recommended storage pesticides at their recommended levels is also beneficial in limiting insect and mould infestation of grains during storage.

3.2.7. Food losses and wastes prevention

Food waste refers to food materials and beverages that are intended to feed humans but were not ultimately consumed by humans(Gustavsson et al., 2011). It also refers to food that suffers unintentional deterioration in quality or quantity as a result of food spills, spoils, bruising, wilting, or other damage caused by infrastructure limitations (Papargyropoulou et al., 2014). It reduces food volume, quality, and nutrient losses, resulting in lower nutritional content (Timmermans et al. 2014). It also raises the cost of unnecessary transportation, energy, water, fertiliser, machinery and equipment, packaging, labour, and capital (FAO, 2014). Therefore, interventions that reduce food loss and waste must be implemented throughout the food chain.

4. Women empowerment in Nutrition-sensitive agriculture

Women are the distinct central point in nutrition and agriculture because they play economic, production, processing, marketing, vending, selecting, consumption, and preparation roles in their households (de la Pena et al., 2018). Therefore, empowering women is critical for proper time allocation for child feeding and care, farming, and working in the home to improve food and nutrition security for their families. Furthermore, giving women equal access to productive resources as men, the production yield increased by 20-30%, and a decline in 100-150million was recorded for malnourished (Quisumbing et al., 2014). Women control income and resources in families and have market access; therefore, they influence household food, nutrition security, children's dietary intake, and child education. Furthermore, involving women in income-generating activities improved their economic, social, and nutritional status while decreasing gender inequality (Shafiq et al., 2019). Likewise, child stunting is lower in families where women are empowered and educated (Jones et al., 2019). Overburdening women in food production and postharvest activities, on the other hand, may affect the time they devote to caring for their babies and food preparation (McNamara and Wood, 2019; Shafiq et al., 2019). Therefore, careful consideration of their allocation of time and management over resources, societal rank, and responsibilities in and outside their home is vital to confirm that developing nutrition-sensitive value chains that encourage women’s empowerment is beneficial to achieve positive nutrition outcomes (de la Peña et al., 2018).

5. The overall potentials and missing links in food and nutrition security

Achieving the Sustainable Development Goals (SDGs),mainlyGoal number two in developing countries by 2030, is highly challenging. Thus, the efforts of researchers and policymakers in identifying many potentially valuabletechnologies are paramount. Various postharvest loss and waste reduction mechanisms are being developed, and in some cases, public awareness is being raised (Ishangulyyev and Lee, 2019). Good agricultural and manufacturing practices are well-identified and understood measures. Likewise, the contribution of underutilized food types (Aderibigbe et al., 2020; Minde et al., 2021), indigenous local foods (Kimani et al., 2020), agro-forestry (Jemal et al., 2018), and mixed and integrated crop production (Gideon et al., 2021) was confirmed in food and nutrition security. However, stakeholders in the food system must be aware of the factors that can impact food and nutrition security. The stakeholders must also discuss climate change's impact on food and nutrition security (Durst and Bayasgalanbat, 2014). Despite the fact that researchers and policymakers identify potential technologies for food and nutrition security, the cost and benefit of the technology are not well known. Besides, because there are no close relationships between laboratory work reports and its extension, the technologies developed are difficult to apply in most low-income countries because the researchers do not consider the local cost. When farmers are given training, stakeholders do not check and assist them when they want to apply the information (Uccello et al., 2017). Even the mechanisms for combating them are lacking, and the expected results are inadequate due to a lack of adequate market access, transportation, necessary tools, awareness, governmental regulations, and legislation (Beddington et al., 2012).

Though agroforestry provides vital benefits in food and nutritional security, increases agricultural productivity, mitigates the effects of climate change, and increases environmental flexibility, and failure to extend advanced agricultural methods hinders smallholder farmers in developing countries from reaping the full benefits of agroforestry (Jemal et al., 2018). Furthermore, the lack of legislation and certification makes it difficult to promote and use underutilized indigenous foods and technologies (Rampa et al., 2020). The attention given to wild fruits and vegetables is also not as good as that of agricultural products. In areas where water is scarce, solar-powered irrigation technologies are not practiced.Researchers and policymakers ignored changes in the level of indigenous knowledge and contribution of human labor, which are critical in food security and require the same attention as agricultural sectors (Kuiper et al., 2020). In the areas where some politicians can use food as a weapon, people can starve as violations lead to food insecurity and food insecurity, which worsens the conflict (FAO/WFP, 2022).

Conclusion

Nutrition-sensitive agriculture and appropriate crop postharvest handling are widely recommended interventions in addressing food security, particularly in low-income countries. The management system used during production affects crop quality and/ or safety. The postharvest actions conducted on the crop also influence its quality and/or safety. Therefore, if implemented correctly for agricultural products throughout the value chain, these two interventions have the potential to control all types of malnutrition. Nonetheless, these interventions are hampered by a lack of complete agricultural input packages, facilities, awareness, and income. Therefore, coordinated and effective management of handling, storage, transportation, and methods and tools appropriate to gain maximum benefits from agro-forestry in various human and ecological settings is critical. To get the most out of agriculture, it is also important to raise awareness about nutrition outcomes, empower women, and promote mixed farming systems.

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