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BRIEF SERIES | 14

Food Processing, Packaging and Storage

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SUMMARY

Demand for processed food is expected to account for approximately 75% of the demand for staple foods, due to lifestyle changes and increased human populations leading to increased demand for food in the 21st century (Conway et al. 2019; Badiane et al. 2023). Huge potential therefore exists for small-scale farmers and producers to process indigenous food to meet this demand. However, they experience challenges, which include: struggling to comply with food safety regulations due to limited resources and knowledge; limited access to adequate storage facilities; and poor storage conditions, which can lead to spoilage from microorganisms or other contaminants. Overreliance on traditional methods of storage may not be suitable for modern food safety standards. This is further worsened by limited resources for packaging and labelling, due to financial constraints which limit the processors' ability to invest in high-quality packaging and labelling materials. Lack of standardisation, inconsistent packaging and labelling undermine consumer confidence and trust. Recommendations to philanthropies include the need for direct funding for capacity building, technological support, financing research and innovation and local processors. This would realise the potential of indigenous food processing, storage and packaging, embracing circularity, and incorporating technology in these processes. There is also a need to identify local processing technologies that are working well, for them to be improved using modern scientific knowledge for credibility. The development of new markets for local processed food products and lobbying for a regional labelling approach for local processed products are needed. This brief provides a summary of the indigenous/local food products that can be processed, packaged and stored, the challenges faced, and recommendations to philanthropists.

INTRODUCTION

Urbanisation as a driver for food processing

By the year 2030, Africa's food market is projected to reach US$150 billion, giving a potential of small-scale farmers to earn up to US$30 billion in income (UC/NEPAD 2008; Conway et al. 2019). This available food market is growing due to urbanisation which is a major driver for demand in increased processed, ready-to-cook and ready-to-eat foods, and ultra-processed foods. Urbanisation and changes in dietary patterns are transforming domestic value chains, especially processing, storage and packaging. Demand for processed food is expected to account for approximately 75% of the demand for staple foods (Conway et al. 2019; Badiane et al. 2023). However, extreme processing may be a driver of obesity and several non-communicable diseases (NCDs), especially ultra-processed foods. Additionally, waste from food processing, if left unchecked, can have an impact on the environment, including pollution.

Reasons why the use of local foods is not common

Food and nutrition insecurity has been highlighted as a major chronic problem in Africa (FAO et al. 2022) and is partly because of the various 'green revolution' strategies and programmes that have been instituted in African countries. Unfortunately, most of those programmes tend to concentrate on the staple grain component and emphasise the production and processing of wheat, maize and rice to the detriment of indigenous, traditional and local foods, which are more nutrient dense (Pitso & Lebese 2014). The strategies and programmes have thus tended to worsen Africa's food and nutrition insecurity problem. Despite huge harvests of local foods worldwide (figures 1A and 1B), they have been replaced with lower-nutrient foods, resulting in an increase in health-related problems (Turner & Turner 2007). One of the key constraints of local foods is the demand for the products. Over time, in all parts of Africa and the world, there have been significant shifts away from local foods to 'industrialised' foods that are mass grown with synthetic inputs, and highly processed into easy-to-eat products made mostly from wheat, rice and maize (FAO 2015; Perrey 2017). To begin with these shifts were mostly in urban areas, but are now everywhere, thus reducing the demand for local food products. Promoting the consumption of agroecologically grown local foods thus faces challenges. One of the ways of reducing the constraints associated with locally grown food products is value addition: improved processing, storage and packaging of local foods will enhance their appeal and increase consumer demand.

FIGURE 1A: YAM BEING TRANSPORTED

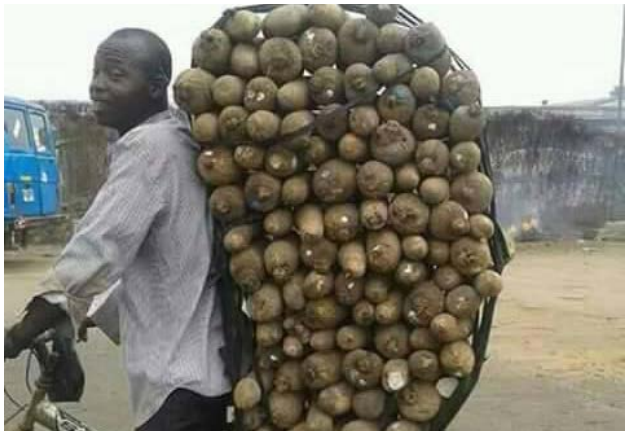
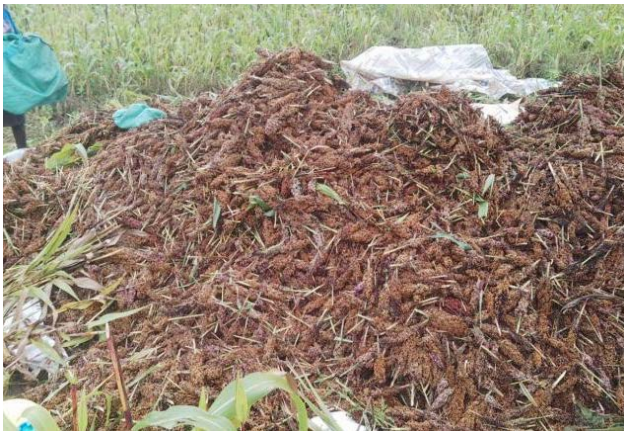


FIGURE 1B: HARVESTED SORGHUM



A&B: Bumper harvest of yam and sorghum indicating enough raw material for processing. B: Harvested sorghum left on the farm due lack of storage facilities

Local processing methods this brief will focus on

There are numerous traditional or indigenous processing, storage and packaging methods that present valuable opportunities for the development of sustainable methods. They are important because they must have been developed to meet specific needs of the people under the prevailing conditions and, by the very fact that they still exist, they most likely have elements of sustainability and resilience. The common methods of processing local foods this brief will focus on is drying and fermentation. Drying (figures 2A and 2B) is the process of reducing the moisture content of a food commodity to a point at which it is suitable for storage, processing or consumption. It is used to reduce food losses and improve the commercial value. Natural drying methods include sun drying, solar drying and fermentation. Solar drying eliminates the problem of poor quality and unsafe products associated with the traditional open air, shallow layer sun-drying. Fermentation is the process that helps break down large organic molecules via the action of microorganisms into simpler ones (Sharma et al. 2020). It often leads to changes in nutritional and biochemical quality relative to the starting ingredients. Sun-drying and fermentation are two of the most important and common African traditional food-processing techniques used in the production of a wide range of processed food products and for low-cost food preservation under non-refrigeration conditions (Aworh 2023). These techniques extend shelf life and infuse food with unique flavours and cultural significance.

FIGURE 2A: DRYING CASSAVA ON ROAD PAVEMENTS

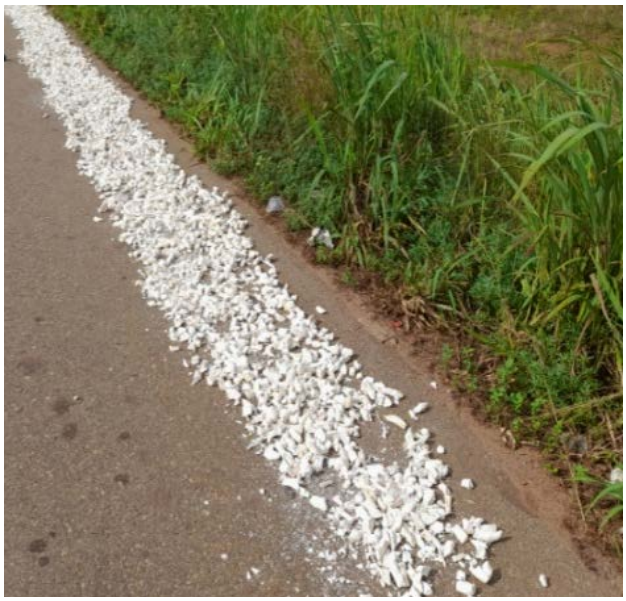


FIGURE 2B: SUN-DRYING MILLET AND SORGHUM

Examples of food products from processed local foods and benefits

There are several local food types that are economically beneficial. Cereals, and non-timber forest products (NTFPs) of two semi-domesticated (or semi-wild) trees, tubers and fruits are the examples that will be used in this brief. These are: the millets (mainly pearl and finger millets: *Pennisetum glaucum* and *Eleusine coracana)*; sorghum (*Sorghum bicolor*, which is sometimes classified as a millet); baobab (*Adansonia digitata L*); tamarind (*Tamarindus indica L.*); and cassava (*Manihot esculenta*). Sorghum grains are processed by dry milling, wet milling and by fermentation. Various actors (aggregators and processors) are engaged in sorghum processing from the harvesting stage of the value chain, shelling, storage and transportation. Sorghum can be processed into flour to substitute wheat and is used to develop nutritious and tasty food products. The sorghum grain is a good source of energy, carbohydrates, polyunsaturated fatty acids (PUFAs), minerals and vitamins, as well as some essential amino-acids and bioactive compounds including polyphenols. Some of the African sorghum-based fermented foods include porridge, alcoholic beverage, beverage, sourdough/bread, pancake and infant weaning food (Adebo 2020). These products have increased demand and opportunities for commercialisation. Mariera et al. (2017) partially substituted 8% sorghum flour with wheat flour to develop sorghum bread with improved nutritional and sensory quality. In Makueni, Kenya, sorghum flour is used to prepare stiff porridge (ugali), thin porridge (uji), fried dough (mandazi), flat bread (chapati), githeri (sorghum mixed with legumes), sorghum cake, beverage (sorghum tea) and animal feed (Beinah et al. 2020). Nutritious beverages are developed by employing different malting days and fermentation conditions to come up with products having varying levels of iron, vitamin C and phenolics, depending on the process or consumer needs (Kiptanui et al. 2022).

Millet-based fermented probiotic food products include finger millet-based beverages. The fermentation of finger millet increases the overall nutritional value of flour and physicochemical profiles (Mutshinyani et al. 2020). Hence, it has a promising potential for targeting international markets and different population groups, from children to the elderly. In Kenya, the Luhya people ferment millet to create Ujiro, a sour porridge. Spontaneous fermentation of millet-porridge could be an effective way of improving the bioactive compounds and antioxidant activity of finger millet flours (Mutshinyani et al. 2020). In fermented millet biscuits, grain fermentation and malting periods increased the proximate composition and mineral contents while decreasing the antinutrient content of the biscuits (Adugna et al. 2024). In general, the acceptance of biscuits was enhanced by fermentation and malting.

Millet-based fermented probiotic food products include finger millet-based beverages. The fermentation of finger millet increases the overall nutritional value of flour and physicochemical profiles

Certification of processed and packaged products

Certification is required for processed products in Kenya, Malawi and Ghana. In Malawi, for example, every processed food that is intended for established markets is expected to be certified by the Malawi Bureau of Standards (MBS). Due to inappropriate processing techniques and environment, most small-scale processors fail to meet expected standards, thereby failing to acquire certification of their products. The MBS certification has always been perceived as expensive and rigorous (Malawi Bureau of Standards 2021). As such, MBS and the Small and Medium Development Institute (SMEDI) signed a Memorandum of Understanding (MoU) in 2020 in order to build the capacity of SMEs by enhancing the knowledge and certification gap. Processing, packaging and storage for local food products by small scale farmers/processors experiences challenges which will be highlighted in this brief. Generally, reaching out to philanthropists to prioritising funding for processing, packaging and storage can significantly enhance the processing of indigenous food products, contribute to local economic development, and promote food security and cultural preservation among communities.

Key stakeholders in processing, packaging and storage

Despite the challenges in processing, there are a number of stakeholders and sectors interested/supporting processing, packaging and storage initiatives. Some include:

- **Governments and line authorities:** In Malawi, for example, from 2016, the Government launched a Buy Malawi Strategy to encourage consumption of locally processed foods. Malawi, through the Ministry of Agriculture, subscribes to the 2021 UN Food Systems Summit resolution to transform the food systems. Other line sectors like the African Union and the African Development Bank (AFDB) have promoted agendas in agro-processing.
- **Non-governmental organisations (NGOs):** There are a lot of advocacies through developmental partners working in Kenya, Malawi and Ghana for small-scale crop farmers to access agro-processing training to improve food processing techniques and enhance packaging and storage practices. For example, TechnoServe, an NGO, has been working with Malawi local and traditional food processing companies to help them to improve operations, access financing and tap into new markets. It actively supports small and medium-sized food processors in Malawi, contributing to the industry's growth.
- **Farmers and community-based organisations:**
  - Small-scale food processors like Nsanama Women Cooperative, an all-women cooperative in the Southern region of Malawi which focuses in production of cassava flour, and Kwithu Kitchen, a first women-owned food processing cooperative in the Northern Malawi that started with honey processing but now includes other food products such as fruit jam and others.
  - Community Innovative Programs Outreach (CIPO) based in Kenya, a community-based organisation dealing with economic and technological advancement with preservation of nature could support some areas.
  - **International organisations:** Various global entities, such as the United Nations Development Programme (UNDP), United Nations World Food Programme (WFP), World Bank, Food and Agriculture Organization (FAO) among others work on projects aimed at reducing food waste in developing countries through technical assistance
- **Foundations and foreign missions:**
  - Foundations such as the Rockefeller Foundation and the Bill & Melinda Gates Foundation have projects aimed at reducing food waste globally.
  - The UK's Foreign, Commonwealth and Development Office (FCDO) have supported initiatives that aim to increase farmer incomes by reducing post-harvest losses in Sub-Saharan Africa.
  - The Green Climate Fund (GCF), for example through RE-GAIN, aims to strengthen smallholder farmers' climate resilience and adaptive capacity by promoting the wide-scale adoption of food loss reduction solutions (FL-RS) in Burkina Faso, Ethiopia, Kenya, Malawi, Tanzania, Uganda and Zambia.
  - The Alliance for a Green Revolution in Africa (AGRA) is dedicated to transforming Africa's agricultural landscape by promoting sustainable farming practices and improving access to markets for smallholder farmers.
  - The Global Agriculture and Food Security Program (GAFSP) aims to improve food security and nutrition in developing countries through emphasising on collaboration between governments, civil society organisations and the private sector to create sustainable solutions to food insecurity.
  - Researchers and innovators are interested in research and working with communities in creating and evaluating sustainable solutions in processing, packaging and storage.

MOTIVATION

Why this issue matters and why philanthropies should be interested

To reduce food waste/losses and contribute food security: Processing and storage allows seasonal products to be available all year round and reduces the chance of food spoilage and losses from pest and disease infection. There is a need to reduce intentional and unintentional food losses during post-harvest handling, processing and storage. Value addition to raw products of small-scale (agroecological) farmers has been a problem mainly because of quantity, quality, aggregation and safety.

Processing may be a driver of obesity: Despite modern food processing having benefits for food preservation and safety, it is increasingly recognised as a driver of obesity and several non-communicable diseases (NCDs), especially ultra-processed foods.

Need to handle waste from processing: The diverse nature of the food industry generates a variety of wastes from processing, handling and packaging operations. If left untreated, these wastes can exacerbate disposal challenges and cause severe environmental pollution. Moreover, the failure to recover and utilise these wastes results in the loss of valuable biomass and nutrients that could otherwise be upgraded, bio converted, or reused through appropriate technologies (Kroyer 1995). Supporting this view, Chukwu (2009) highlights that unchecked activities within the food processing sector have led to environmental degradation, negatively impacting land use, aquatic ecosystems, and biodiversity, including flora and fauna.

To create demand for more traditional/local foods due to its benefits: There is a need to promote uptake of agroecological practices to create demand for the consumption of more traditional/local foods that are nutrient dense and healthy for the planet and people. For instance, microbes and other beneficial organisms involved in the process of fermentation of indigenous foods have the potential to transform food in the gut, which increases its value and alleviates several diseases. Further funding for participatory action research is required on technologies used for processing of fermented foods, nutritional quality of the fermented foods, and the influence of fermented foods on gut microbiome and health (Fasogbon et al. 2023; Sudarsini et al. 2023). Fermented foods are of prominent significance to the economy, health and nutrition of Africa. It is an age-old process, known to improve nutritional qualities, palatability and consumer appeal, aroma, structural modification and shelf-life. It is also important to exploit fermentation to improve and enhance food safety in Africa. Mycotoxins (e.g. aflatoxins) pose a significant threat to economies, trade and health and compromises food safety, and fermentation of sorghum has been shown to reduce mycotoxin levels.

To exploit multiple uses of local foods: Most local foods have multiple uses, and value addition in the form of processing is what gives prominence to their importance and the great value of their multiple uses. Well-informed value addition also increases the nutritive value of the produce and removes anti-nutrient compounds that some of them have. Several local foods are more nutrient-dense than others, are medicinal and are more suitable in terms of climate resilience and mitigation in the areas in which they are produced (Cloete & Isardie 2013). They are also more socially and culturally acceptable to the people (Lara et al. 2019).

Alignment with the United Nations Sustainable Development Goals (SDGs): This brief aligns with Goal 12 on Responsible Consumption and Production since it prioritises the need for supporting smallholder farmers/processors in sustainable agricultural practices while also implementing a local food recovery.

Potential of social impact and economic empowerment: Food processing, packaging and storage can be used for impact investing and social enterprise models, and hence generate social or environmental benefits alongside financial returns. Examples are development of social enterprises that process surplus food into value-added products while also providing job training for local residents. Such an approach will not only address food waste but also creates economic opportunities within the community for the local producers/processors.

CONTEXT

State of knowledge, cross-cutting issues and key levers to transition

This brief relates the link of food processing to rapid urbanisation which has seen increased demand for processed ready-to-cook and ready-to-eat foods, and shows how processing generates waste that, if left unattended, can cause pollution. Food processing not only affects human health but may also have significant environmental consequences, including pollution.

At farm/enterprise level, there are numerous indigenous or local processing, storage and packaging methods which may appear crude but are opportunities for the development of sustainable methods. Their development to sustainable methods can start with the identification of indigenous foods and existing processing methods and community participation in the selection of processing methods.

For the relevance to food systems transitions in Africa, it will be important for governments and policy-makers to develop a road map of potential solutions to inform philanthropies/venture capitalists and further design support mechanisms and environments that will strengthen links between processors, storage and package enterprises to markets and consumers to assure and expand their markets. Attracting funders and business investors to support the development of the roadmap and funding potential solutions to strengthen linkage of the value chain actors will be key. This can be done through public private fora which will bring the funders to realise the potential of the indigenous food systems and will help in accelerating the shifts to ensure our food systems are more equitable, sustainable, resilient and healthy for both people and planet.

This brief relates to many cross-cutting issues. For instance:

(i) Processing, storage and packaging can positively impact livelihoods of farmers and women. In particular, food processing in Africa is primarily done by women and, if the processed products are taken up by markets, it assures women reliable income and strengthens their position within the family and society. Also, farmers can form community-based cooperatives that undertake processing, storage and packaging of traditional foods. This will strengthen marketing of the value-added products and generate more income.

(ii) Small indigenous food processors undertake sustainable and socially responsible food systems. This brief will vouch for the need to strengthen women and farmers' capacity efforts to diversify the range of traditional processed and packaged products they offer in the market for competitiveness, sustainability and resilience of value chain.

Some of the key levers of the food system transition include the regional need to begin characterising processed and packaged foods in markets for consumer education. Food labelling guidelines on traditional food that have been processed could increase demand for indigenous foods. What is more, a lot of processed foods are exported/imported, justifying the need to explore the possibility and potential of a regional labelling approach. This wider approach of a regional labelling will need lobbying from regional governments and potential institutions. Promoting nutritious and traditional foods through targeted advertising on billboards and digital platforms, including campaigns, is also an effective strategy to boost demand across diverse populations in a sustainable manner. Other aspects that are key levers are mentioned as recommendations in this brief, including research and innovation, capacity building, collaborations, and creating new markets.

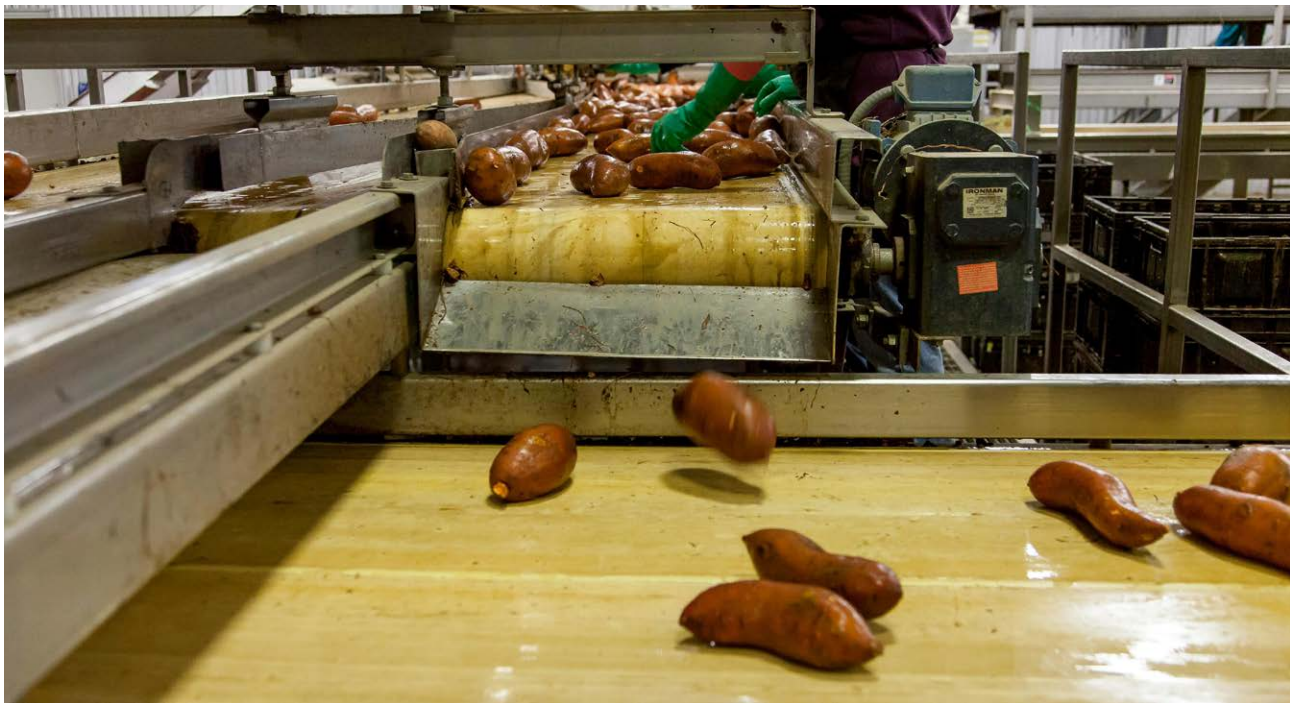
CASE STUDIES

Methodology of country case studies

The documentary survey was carried out in Ghana, Malawi and Kenya in West, Southern and East Africa respectively. Our experiences however go beyond these countries. In Kenya, information was collected from Uasin Gishu and Elgeyo Marakwet. Eldoret in Uasin Gishu was selected because it is a city strategically located to most counties, thus receiving farm produce from many counties. Arror Ward in Kerio valley, Elgeyo Marakwet is a semi-arid area producing large quantities of drought tolerant crops. Qualitative information/data was collected from primary food processing, packaging and storage actors as well as relevant personnel in government and non-governmental organisations and institutions. Methods used were focus group discussions (FGDs), key informant interviews (KIIs), single person discussions, and observations. The documentation was done on local food products of cereals, tubers, fruits and vegetables. The cereals were millet and sorghum, the fruits were mangoes and tangerines and non-timber forest products (NTFPs) from two semi-domesticated trees, baobab and tamarind, found in the northern part of Ghana. The vegetables were the African leafy vegetables, while the tubers were cassava and sweet potatoes. The processing techniques that were the focus of this brief are fermentation and drying.

The information captured for processing, packaging and storage was on:

- the indigenous food products being processed, packaged and stored and from which foods/crops/fruits/vegetable
- reasons for undertaking the processes
- challenges faced during the processing, and proposed solutions to them
- documenting knowledge on laws and regulations, standards, safety issues that govern/guide processing
- issues to be prioritised to improve the process
- information on knowledge of IoT/AI technology in supporting the processes
- recycling of processing waste for circularity through energy and other processes.



Ghana

Processing, packaging and storage of local food products

(i) Millet and sorghum

Millet and sorghum are the most important indigenous cereals of the people in Ghana. Their main products from sorghum and millet can be categorised as follows:

- Stiff porridge (*tuo zaafi* or *TZ*): This product is eaten with different types of soups. Also, it is usually prepared with indigenous vegetables, while in the Sahel countries and the northern parts of several other West African countries it is eaten as a staple food.
- Thin porridge (*koko*): It may be eaten alone or with bean cakes (*kose*) or millet cakes (*massa*). The porridge can be enriched with baobab or tamarind pulp during preparation.
- Local non-alcoholic and alcoholic drinks (*zomkom* and *pito*, respectively). *Zomkom* is largely millet-based while *pito* is mainly sorghum-based. All the products are made from fermented millet and/or sorghum. There are several different varieties of millet and sorghum, and the products described above can vary in appearance, texture, taste and shelf life. The characteristics also vary with respect to what ingredients are added to the preparations. Baobab (see figure 3A), tamarind and other pulps can be added to the preparations. Additionally, sorghum is also being used in breweries.

Challenges of millet and sorghum processing in Ghana

The main challenge with millet and sorghum processing is competition from maize. According to a farmer respondent, 'Maize TZ (stiff porridge) is watery and does not satisfy no matter how much you eat it, unlike millet or sorghum TZ'. A key informant also said, 'Millet and sorghum products prepared for sale are poorly packaged and do not attract consumers'.

(ii) Baobab

In the case of baobab, many products are produced from various parts of the tree for food and medicines. The most common parts for food are the leaves and 'baobab powder' (the pulp). According to focus group discussants, 'because the fruits usually mature in the time of the year referred to as the *hunger period*, the products (and products of similar trees – shea, dawadawa and others) serve a major purpose in closing a hunger gap'.

The most important food products of the baobab are:

- Leaves: The majority of respondents ranked the leaves as the most important food product of the baobab. The leaves are used as a vegetable in fresh and dried forms. People believe the leaves are nutrient-rich because 'they form delicious soups'. Both the fresh leaves and dry/grounded versions are commonly sold in markets and some shops across the country (see figure 3A). However, none of the respondents were aware of the produce being sold in supermarkets.
- Baobab powder (the pulp): The pulp is removed from the pod and separated from the seeds for use. It can be added to the main cereal-based preparations as described above. It can also be dissolved in water and fermented into a milk-like preparation and eaten by adding millet or sorghum flour to it. The pulp is

FIGURE 3A: DRIED AND GROUND BAOBAB LEAVES

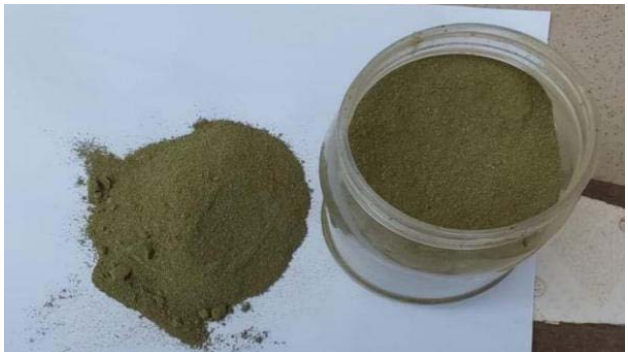
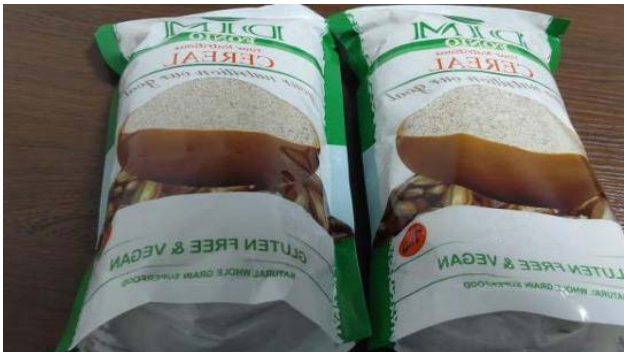


FIGURE 3B: FONIO FLOUR, ANOTHER LOCAL PROCESSED PRODUCT, WHICH IS GLUTEN FREE



used by local and other entrepreneurs to produce baobab drinks, yoghurt and ice cream among others.

- The seed: At the local level, the seeds of baobab are ground and used to make soup/sauce. People were not aware of oil being produced from the seeds.

According to the discussants, no baobab tree is like another, so the taste of the leaves, pulp, seed among other parts differ from one tree to another. At the village level, they know which baobab tree produces better leaves and pulp, but at the commercial level everything is mixed together. They believe all the baobab products are medicinal and it is part of the reason many people cherish them.

Packaging of baobab products is either very poor or non-existent. There are also hardly any storage facilities for the baobab fruit. According to the women focus group discussants, nobody thinks about storage facilities for baobab products. They are stored in any available containers.

Challenges of processing baobab

The major challenge people face with baobab products processing is the breaking of the pods. The outside of the pods has itchy substances, and protective materials are needed when breaking them. Another major challenge identified during the FGDs is that 'recently some people are harvesting the baobab in large quantities, and it is a threat to their source of livelihood'.

(iii) Tamarind

The pulp is the only important part of the tamarind, and is used in a similar way to that of the baobab. The pulp is added to millet/sorghum food preparations, and also to produce local drinks. It is now being used to produce drinks for sale as done with the baobab pulp. Tamarind is not much used by the discussants, as it is not readily available. There were some respondents who did not know it was produced in Ghana.

There is a need for thorough investigations and documentation of the importance of these valuable indigenous products to better understand their processing and uses and including those of other available local processing methods like cassava (gari) and palm (Figures 4A and 4B). More information is also needed on how to leverage knowledge to improve the processing, packaging and storage of the products. By doing so, the products will gain domestic and foreign demand and propel increase at the production level. Many industries in Europe and North America are increasing use of natural products in their food, pharmaceutical and cosmetic industries, and improvements in the availability of indigenous products can take advantage of that.

FIGURE 4A: GARI PROCESSING

FIGURE 4B: PALM OIL PROCESSING

Malawi

Local processed products and procedure used

Market and supermarkets in the surveyed areas show that the common local food products that are traditionally/locally processed and packaged included: sweet potato flour, groundnut flour from groundnuts, maize flour, plantain crisps, dried mangoes, chickpea (chana) flour, chopped tomatoes, potato chips, dried blanched blackjack vegetables (*mfutso wa chisoso*) and fermented cassava flour (*kondoole*). The most common processing techniques used for the products were: salting, washing, cutting, peeling, milling then drying for sweet potato flour; peeling, slicing and frying for plantain crisps; peeling, cutting, addition of preservative ascorbic, and solar drying for the dried mangoes; sorting, dehulling and milling/grinding for chickpea (*chana*) flour; and cutting and heating for tomatoes. Additionally, the potato chips are sorted, peeled, sliced and fried, while the blackjack vegetables are sorted, chopped, blanched and sundried. For fermented cassava flour, the cassava tubers are sorted, peeled, washed, cut, soaked in water, dried and milled.

Reasons for processing local food products

Most of the processors have been undertaking processing as a lifetime activity after learning from their parents. Processing is done in order to extend shelf life, to allow the incorporation of the food with other foods – for example in seasoning vegetables, making futali (dish from sweet potato and groundnut flour). Processing is also done to make products more palatable, for example by processing *kondoole* (cassava flour) by fermentation from bitter cassava (Figures 5A and 5B).

Challenges related to processing flour

In Malawi, the major challenges in processing include poor processing equipment, since most use the traditional mortar and pestle in processing most food items like *kondoole* (figure 6A). The main challenge in groundnuts flour processing arises from bad weather – a rainy season contributes to low-quality products for *kondoole* flour from cassava. The colour and taste of processed products changes if poorly handled, while lake flies reduce the quality of *kondoole*. The peeling of cassava takes a lot of time since it is done manually using knives. Additionally, since the processing environment is open, animals like chicken and goats, if not monitored, eat and destroy the cassava on the drying racks.

One proposed solution to the challenges highlighted by the interviewees is the adoption of solar dryers during the rainy season to reduce drying times and lake flies. Most processors have taken proactive steps to solve the challenges experienced. They prepare large quantities of cassava flour during dry seasons and cover the cassava on the drying mats to protect it from dust and lake flies. Although there are no regulations or laws followed during processing, fermented cassava is cleaned with clean water before it is spread on drying racks as a measure to ensure food safety and hygiene. Prioritising safety and hygiene would improve processing of these local food products. However, along the lakeshore areas there is a tendency to dry cassava on the racks which are also used to dry and preserve fish (Figure 5B). If fish is mishandled on these shared racks, the *kondoole* absorbs the fish flavours making it less acceptable at market.

FIGURE 5A: SOAKING FERMENTATION OF CASSAVA

FIGURE 5B: DRYING CASSAVA ON OPEN RACKS

FIGURE 6A: KONDOOLE (CASSAVA) FLOUR BEING SOLD AT THE MARKET

FIGURE 6B: COOKED AND SERVED NSIMA (FERMENTED CASSAVA UGALI)

Packaging

Packaged products and related challenges

Packaging is mainly done to reduce storage spaces and for future use of products when the food item is not in surplus. In Malawi, the common packaging materials in use include plastic pails and containers, sacks, *zikwatu* (balls with tree leaves) and banana leaves. The reasons for using the types of packaging are that plastics and sacks are cheap, while banana and tree leaves are locally available and also maintain the flavour of products.

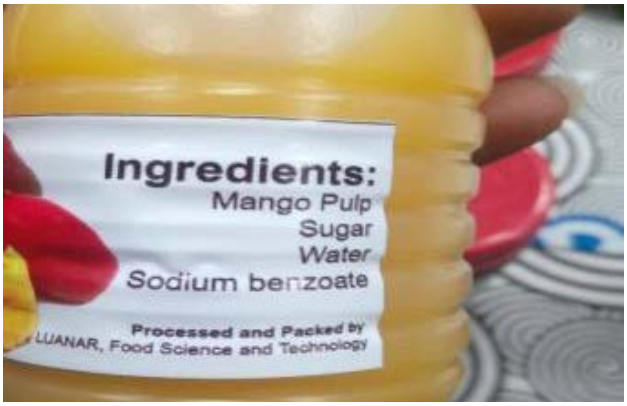
Challenges related to packaging by the processors include the ease with which leaves tear, discoloration of cassava, loss of flavour when stored in plastics and sack bags, and the labour-intensive process of packaging fermented dried cassava into bags. Additionally, bags and plastics are expensive, and plastic pails take up a lot of space in the stores. To try and overcome the challenges, processors often sell flour without pre-packaging. Also, the leaves are heated partially before packaging vegetables in them, to keep them flexible.

Other challenges faced concerning processed, packaged and stored local food products in markets and supermarkets in Malawi are: expensive cost of packaging materials for sweet potato flour; softening of crispy products due to air entry which reduces the shelf-life of plantain crisps; and high sugar content in dried mangoes and juice (see figures 7A and 7B). The polythene sachet bursting when packaging chopped tomatoes is a common problem, while for potato chips processing, potatoes are expensive when off-season. For blackjack dried vegetables, bad weather during drying and expensive packaging materials are a major challenge, while for fermented cassava flour, customers complain about high prices due to the materials used. The possible solutions proposed by the sellers in the market for the challenges include the use of readily available materials, proper handling of the polythene bags and sachets, and change of packaging materials to cheaper ones.

There are no regulations, standards or safety measures that govern or guide packaging activities. However, packaging of products is done when they are fully dried to prevent the products from going bad. The processors also prioritise the use of packaging items and methods that occupy less

FIGURE 7A:: PACKAGED CASSAVA FLOUR

FIGURE 7B: PACKED PROCESSED MANGO

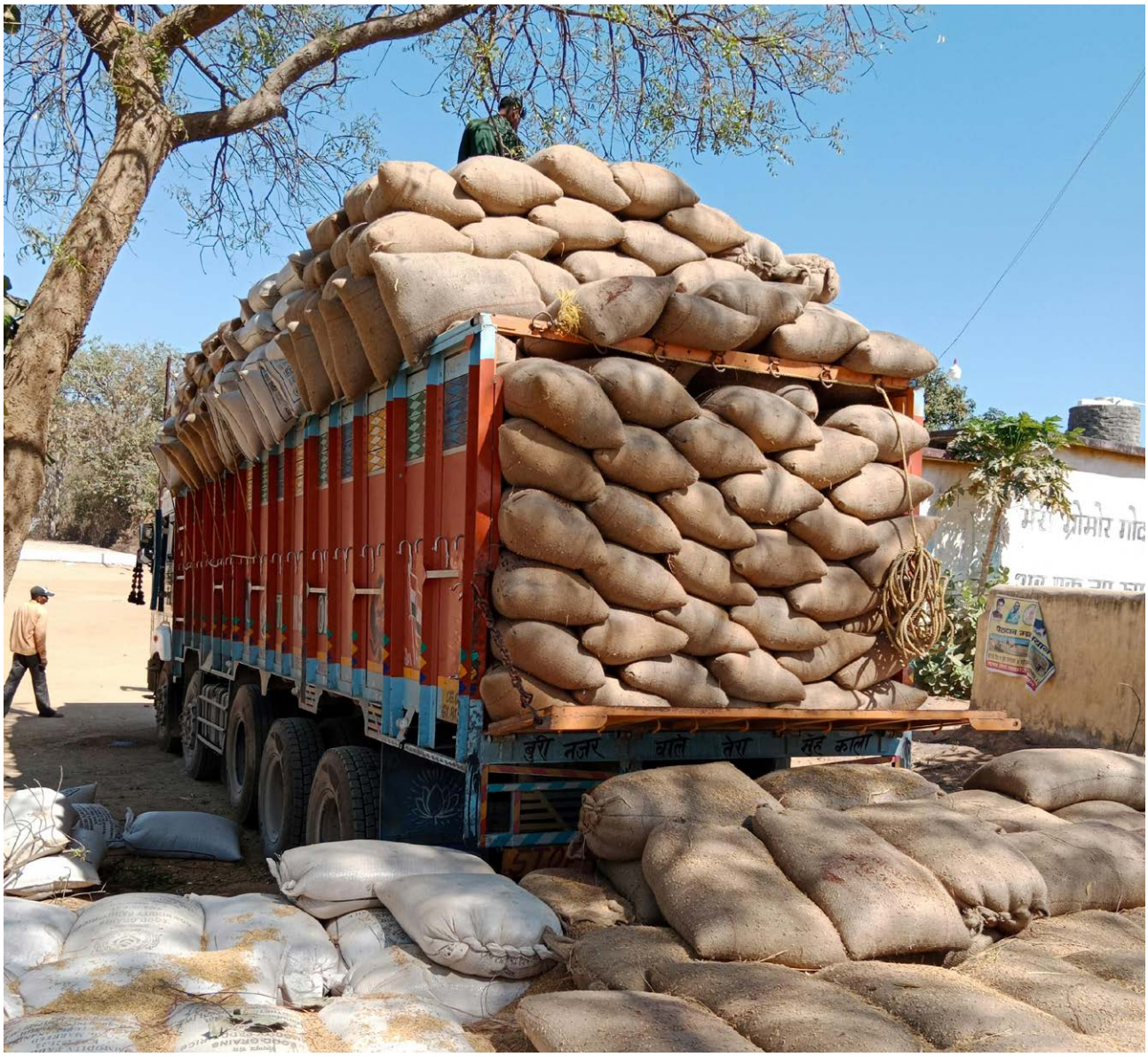


space and that are convenient. The intention is to avoid discoloration of processed products or loss of flavour when packaged – which customers dislike. This affects selling, acceptability or marketability of products as currently there is lack of information on the processed products due to limited knowledge of proper labelling.

For the processed and packaged products in the market, the information that was available on packaging labels of some products included: nutrition information on packaged sweet potato flour and blanched blackjack vegetables; expiry dates for the plantain crisps, dried mangoes and chopped tomato; batch number and expiry dates for the chickpea flour and potato crisps (*chana*). The fermented cassava flour had no information provided concerning the product. Local certification standards, or pre-certification were available for the products except for the fermented cassava flour. The common packaging material used for the products were aluminium foil for orange sweet potato flour, plantain crisps and blackjack vegetables, and cardboard/ laminated carton for dried mangoes. Polythene bags were used for *chana* flour, potato chips and fermented cassava flour while polythene sachets were used for chopped tomatoes.

Storage and related challenges

The processed local foods that were common under storage included cassava flour, vegetables, maize flour and millet flour. The most common storage structures were stores (warehouses). The challenge that small-scale local food processors face in the storage of their products include discoloration of the products and loss of flavour and taste during storage. These challenges have been mitigated by improving ventilation and exposing the products to the sun after some months of storage.



Kenya

Processing

In Uasin Gishu county, an urban area like Eldoret, processing of sorghum and millet is done on a small scale in the Posho Mills. The sorghum or millet is dried in the sun for daily consumption while others are packaged and sold in cereal and legume stores, and those processed in the factories can be found in the supermarkets and shops in residential areas. In Elgeyo Marakwet county, in rural areas like Arror ward, sorghum, mango, millet and cassava value chains are traditional and local. For several decades farmers have wanted to own a processing plant, but none is operational due to overdependence on selling unprocessed food products locally and to external markets.

Challenges that hinder small-scale farmers to undertake processing of local food products in Kenya

For small scale processors, some of the challenges include lack of adequate funds to run the operation on a large scale, the small number of customers who consume their products, and the high cost of buying the sorghum and millet. The few acquired machines lack equipped personnel to run them. With this, there is no operational processing unit in the entire Arror ward. The community wishes to own portable processing plants to process products and add value to them for higher profits, and also to use during the off season. Therefore, there is a need to mobilise resources through stakeholders for technical advice and support to purchase portable processor plant units. Aside from concerns regarding cassava, there are other concerns on the other crops like mango, sorghum and millet. To improve processing of these crops, farmers need training to enhance production quality, and processing staff require skills development on processing, quality and safety measures. Advanced processors can benefit from product exposure and support for benchmarking. For example, the machines for processing in Kabanon/Kapkamak irrigation scheme and cooperative society were bought in 2013, and have not been used due to lack of trained personnel to operate and repair them (figures 8A and 8B). Additionally, modern machines, equipment and technologies are needed for adequate and hygienic processing (figure 9A). Training of youth-led teams in adopting modern techniques in processing and storage through artificial intelligence (AI) can increase processing plant adoption and value addition of products, which would drive a market-driven demand of products, leading to robust economic growth for increased household income and changed livelihoods.

Additionally, fermentation and germination of millet is a common processing method common in Arror for making porridge and local brew (Fig 9B & 10).

FIGURE 8A AGRO PROCESSING MACHINES INCLUDING DESTONER FOR REMOVING ALL STONE AND METALLIC PARTICLES AND A GRADER FOR GRADING FOOD PRODUCTS SUCH AS COW PEAS, MILLET, GREEN GRAMS AND SORGHUM CEREAL

FIGURE 8B MANUAL THRESHING OF SORGHUM DUE TO LACK OF MECHANICAL THRESHERS

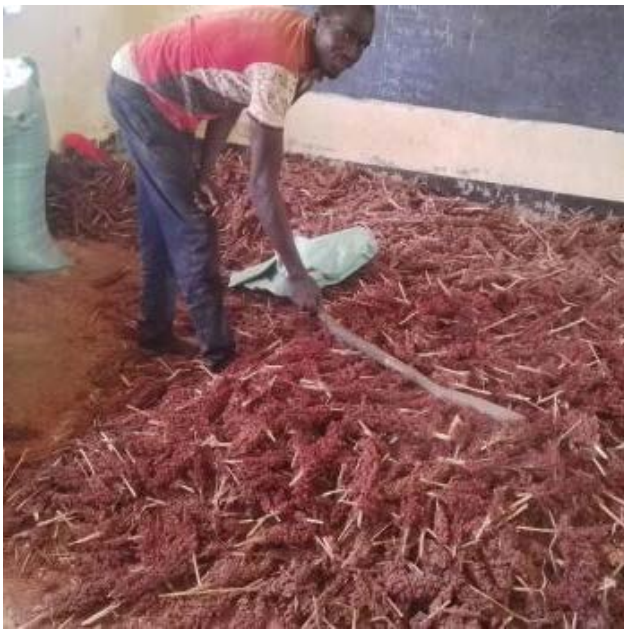


FIGURE 9A: TRADITIONAL EQUIPMENT FOR THRESHING SORGHUM AND MILLET, WHICH IS SLOW AND THRESHES SMALL QUANTITIES AT A TIME.

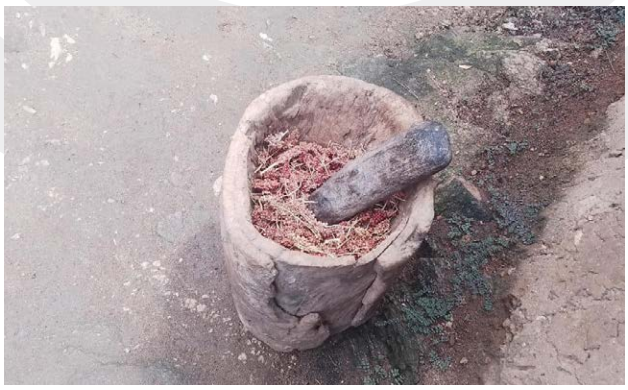


FIGURE 9B: A PROCESSOR FERMENTING MILLET FLOUR FOR PREPARING PORRIDGE, WITH CONTAINERS USED FOR FERMENTATION.

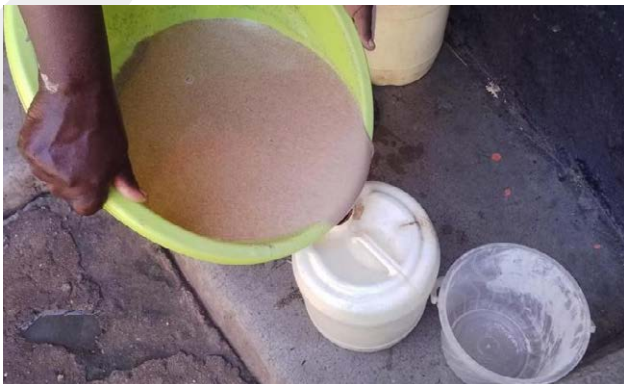
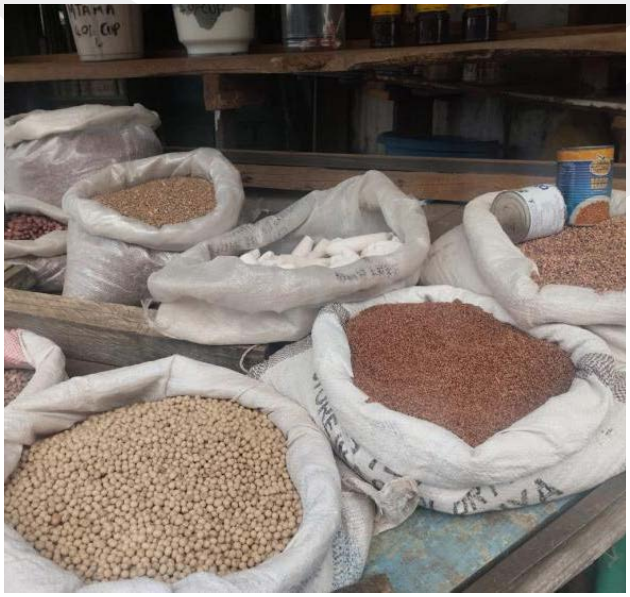


FIGURE 10: GERMINATED FINGER MILLET FOR PREPARING LOCAL BREW, BUSAA. THIS ACTS AS TRADITIONAL YEAST.

FIGURE 11: INDIGENOUS FOOD STORED IN WOVEN POLYPROPYLENE SACKS AND PLASTIC CONTAINERS IN A CEREAL AND LEGUME SHOP



Storage of indigenous foods

Local foods that include millet, sorghum and green gram are stored mostly in plastic containers and woven sacks (figure 11). Plastic containers are used for storage because they are easily available and affordable. They vary in size from large to small and have lids to ensure the hygiene of the food stored. Woven sacks are also used as they accommodate large quantities and therefore make good use of the available confined spaces.

Storage challenges for small-scale farmers in Kenya

Challenges faced in storage include lack of enough spaces as the sale room acts as the storage facility or even classrooms when not in use are used as makeshift storage facilities (figure 12A). A lack of modern storage facilities affects the humidity content of the millet and sorghum, therefore affecting its quality when processed. Figure 12B shows a charcoal unit for storing fresh horticultural crops such as melons, tomatoes, French beans, pawpaws and bananas. A modern cold room is needed, that would enable controlled room temperatures to keep the crops fresh for longer periods. To reduce post-harvest losses and wastage, there is also a need for small processing equipment to make fruit purees and juices.

From one respondent, 'Storage is very essential in the agriculture industry, poor storage results in losses in our produce. Storage allows seasonal products to be available all year round, which in effect secures the cash flow of an agricultural business'. Proper storage prevents chances of food spoilage and pest and disease infection. Mango fruit, for instance, if not well stored (figure 12 C) can develop fungal, bacterial and mold, which is dangerous for human consumption and other food value chains.

The Ward Agriculture Officer reported that 'A study by Lesuuda et al. (2021) in this ward suggested the need for sensitisation campaigns and social behavior change to improve knowledge about mycotoxin contamination and suboptimal postharvest handling and storage practices of sorghum'. The Ward Agriculture Officer additionally said, 'for proper storage capacity, we wish to mobilise resources through stakeholder interventions on capacity building for the construction of modern storage facilities such as cold rooms, ventilated warehouses and other modern storage facilities to curb the losses incurred on post-harvest handling. However, packaging materials will be paramount for storing the food products to preserve quality (Figure 13) and to ease transportation handling, branding the product and storing'. Additionally, farmers struggle with post-harvest handling of the food products due to a lack of storage facilities. Apart from locally made granaries, farmers use makeshift structures and their own living rooms to store foodstuff. Modern technologies such as the Internet of Things (IoT) and AI technology have a great potential to be used and implemented through trained personnel for effective proper food storage handling to prolong shelf life and quality of the products for continuous market supply flow.

FIGURE 12A & FIGURE 12B: TRADITIONAL GRANARY FOR STORING SORGHUM AND MILLET FROM KENYA AND GHANA. THERE IS AN INCREASED RISK FOR FUNGAL GROWTH.

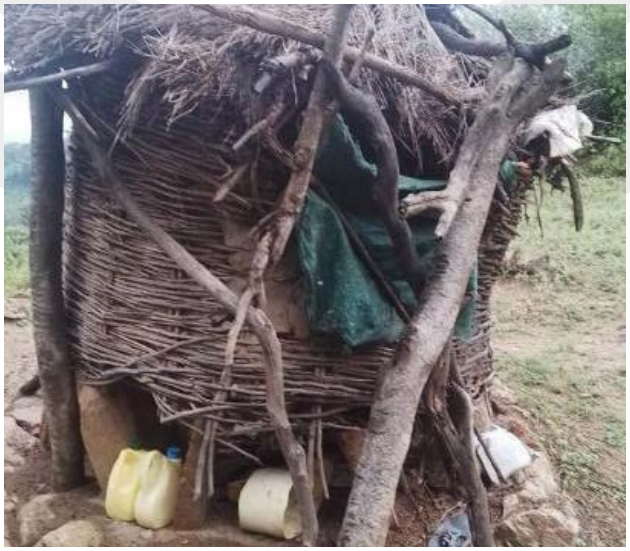


FIGURE 12C: MANGO STORAGE IN ONE OF THE STORES. POOR HANDLING, STORAGE AND PACKAGING RESULT IN LOSSES DUE TO ROTTING. THERE ARE NO COLD ROOMS AND PROCESSING OF MANGOES DESPITE THE HIGH PRODUCTION IN ARROR. THE MANGOES ARE TRANSPORTED TO FAR MARKETS IN ELDORET CITY AND BEYOND. THERE IS A NEED TO INVEST IN MANGO COLD STORAGE AND BUILD CAPACITY OF FARMERS AND PROCESSORS.

FIGURE 12A: MAKESHIFT STORAGE OF MILLET

FIGURE 12B: CHARCOAL COOLING UNIT

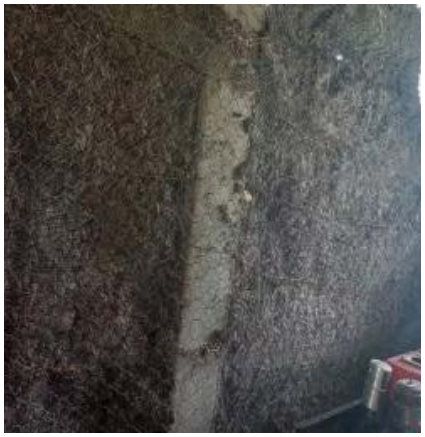


FIGURE 12C: A FOOD SOLAR DRYER

FIGURE 13: POOR HANDLING OF PROCESSED MILLET FLOUR DUE TO LACK OF KNOWLEDGE, PACKAGING AND STORAGE EQUIPMENT

In rural Arror ward, one respondent indicated that packaging is one of the advanced processes for storage and marketing food products. Well organised and packaged products attract market inflow, promote product recognition, allow customers to identify, describe and differentiate items from similar commodities based on the brands. Packaging protects products from damage during storage or transportation. It plays an important role in marketing, as it determines and shapes the consumer's first impression and desire to purchase the product. Currently, food products in the Arror Kerio ward are not specially packaged. People repurpose commonly available materials such as crates, ventilated nets, gunny bags and plastic containers. Standardised and branded packaging innovations should be developed with stakeholders to ensure portability.

Local food preservation using renewable technologies and biogas from bio waste

According to FAO (2013), one third of the food grown for human consumption goes to waste. This leads to food insecurity and adverse environmental effects. In developing countries, the wastage occurs due to poor food processing, storage and packaging (FAO 2013). This can be alleviated by adopting sustainable food systems (agroecology) which embraces circularity: the zero waste concept. There are several circular economy technologies or methods available that probably only need localisation and others need to be developed. Food system resource efficiency can be enhanced by closing resource loops.

Food systems produce organic wastes (figures 14A and 14B) which can be converted to useful resources. If left to rot, organic wastes release methane, causing global warming. Biogas from food wastes could instead power dryers, mills and refrigerators for traditional foods.

FIGURE 14A: TAMARIND SHELLS

FIGURE 14B: SHELLING SORGHUM AND GENERATED BIOMASS WASTE

HURDLES TO TRANSITION

Ghana

- **Lack of commitment by government and NGOs**: Government and most non-governmental institutions have not taken any particular interest in the processing, packaging, storage marketing and consumption of indigenous foods of almost all the local products considered in this brief.
- **Lack of documentation of the importance of the value of indigenous products**: This will help the local food products gain domestic and foreign demand and enhance local production, processing, packaging and storage.

Malawi

- **Lack of, or unclear regulations**, standards or safety measures that govern and guide packaging activities.
- **Poor quality of packaged products**: Customers dislike pre-packaged products because of the discoloration and loss of flavour.
- **Limited knowledge on proper labelling of products**: Lack of information on processed products affects their acceptability and marketability
- **Lack of available durable innovative local packaging materials.**

Kenya

- **Limited skills and knowledge on processing, packaging and storage**: There is a need for capacity building of farmers and processors on quality production for quality products, processing quality and safety measures.
- **Lack of processing and storage facilities for locally produced products** due to financial challenges that inhibit the farmers/processors to procure.

RECOMMENDATIONS TO PROMOTE TRANSITIONS

Addressing challenges encountered in local food processing, storage and packaging requires a combination of support, training and infrastructure development from key stakeholders including the government and the private sector. Providing access to affordable storage facilities, training small-scale processors on proper storage techniques, and promoting the use of high-quality packaging and labeling materials can help ensure that products meet market standards and are acceptable by consumers. Hence, to enhance local food product processing, the following areas should be prioritised for funding:

1. **Mobilising government and private sector for strong collaborations to improve facilities and infrastructure**

   Construction of modern processing facilities, upgrade of existing facilities, development of cold storage facilities, and improvement of transportation infrastructure are needed to facilitate the movement and distribution of processed products, especially from farmers to the markets. However, government support is also needed for high-cost infrastructure as well as involving the private sector to intervene on regional storage facilities. For instance, bringing onboard institutions like Community innovative Programs Outreach (CIPO) based in Kenya, a community-based organisation dealing with economic and technological advancement with preservation of nature, could support some areas. Establishing strong partnerships with organisations and stakeholders in the community, including farmers/processors, local businesses, government agencies and NGOs can enhance credibility and demonstrate a collective commitment to addressing food waste. Philanthropists could also be mobilised to assist in sharing learning - for example, in the storage of maize and cashew nuts in Tanzania. Maize is bought from farmers and stored to provide food security during drought by selling to regions without maize. Others could support a pilot programme that utilises their technology to track and redistribute surplus food from local farmers to other regions in need.

2. **Promoting research and development**

   Research and development is needed on product development of new and innovative approaches for local food products that cater to consumer preferences and meet market demands; effective preservation techniques to extend the shelf life of perishable local food products especially those which are perishable; packaging innovation of sustainable and attractive packaging solutions that protect the quality and freshness of local food products and pays key attention to environment conservation; and nutritional analysis to determine the nutritional composition and benefits of indigenous food products to boost consumer purchasing power.

3. **Supporting integration of traditional methods and modern methods**

   There is a need to integrate the traditional food processing, packaging and storage methods with the modern types in order to improve on the traditional methods for food shelf-life longevity and food safety. The traditional food processing, packaging and storage methods need to be improved to better them since they are the methods most widely available and affordable to rural farmers. It is important to identify initiatives that preserve food in their own way and improve on them. Hence it will be important to look for initiatives that can help their transition including IoT and use of solar.

4. Mobilisation of innovators in processing, packaging and storage

There is a need to bring together innovators providing affordable solutions to address a process of processing, packaging or storage available in a region. This can include certification bodies so that they can engage with farmers/processors, since very few of them have their products certified and being sold in markets. Also, there is a need to involve innovators who can provide alternative packaging materials that are affordable and available, for instance by developing local packaging material from recyclable bio waste (bio circularity). It could be for instance finding ways of improving local packaging material, for example *zikwatu* in Malawi (balls with tree leaves and banana leaves). These are locally available and also maintain the flavour of products.

5. Capacity building

There is a need for capacity building to upskill on use of technologies, technical assistance and training programmes for farmers, processors and food handlers on modern processing techniques, quality control and food safety, paying close attention to regulations by law on the same.

6. Mapping produce with high wastage

There is a need to identify products with high wastage in regions and identify the hot spots in the value chain for prioritised funding. However, it could also approach this by looking at an area/region which experiences huge wastage in products. In Kenya, for instance, this could be traditional green leafy vegetables, tomatoes, mangoes in Kerio valley and traditional cereals and tubers. In Malawi, tomatoes and pawpaw could be prioritised, while in Ghana tangerines and tubers merit attention.

7. Promotion of fair trade

There is a need to protect harvesters who get low prices for products sold for a premium in other places, for example baobab powder. The people to benefit are the stewards who keep the tree alive. Hence philanthropists can serve these indigenous groups/wild harvesters by supporting fair trade for those ingredients by paying suppliers value for their money.

8. Marketing

Support is needed for the development of new markets and distribution channels for processed local food products, both locally and internationally. A lot of processed foods are being traded between countries, justifying the need to explore the possibility and potential of a regional labelling approach. Also, this will need marketing and promotion campaigns to increase consumer awareness and demand for indigenous food products through civic education and live advertisement in the local media houses.

9. Identification of case studies and models that work

There is a need to conduct case studies of regulatory interventions, packaging innovations and standards that have successfully enabled small-scale processors to access export markets. Few women are involved in the export of processed products. Hence there is a need to get approval/understanding of philanthropists to support models that can work. Also, social enterprise models that have worked elsewhere can be explored, for instance supporting the processing of excess food into value-added products while at the same time providing job training/capacity building for local residents could address food loss while creating economic opportunities.

10. Supporting producers and processors organisations

It is important to support farmers to monitor and understand how and why wastage occurs. It is essential to enable development of preservation techniques for regionally popular products that allow innovations to scale out to other areas and markets. For instance, obtaining and presenting data on local food insecurity together with the amount of edible food wasted in their community can shed more light on the importance of preservation through processing, packaging and storage. It is important to organise the farmers and other small-scale people producing and processing for preservation for them to be supported to get maximum benefit. Very few farmers have their products certified. It will be good to know what is actually happening in the ground, good practices that exist in processing, packaging and storage and accessing their potential to deliver the transition to processing.

11. Labelling of processed and packaged products

To increase demand for nutritious processed and packaged traditional foods by consumers, there is a need to start a process to standardise, grade and label processed and packaged food to better inform consumers. Food labelling guidelines on traditional food that have been fermented could further increase demand for indigenous foods. Regional packaging and labelling standards could facilitate intracontinental and global trade of processed food based on traditional and indigenous crops. This wider approach of a regional labelling will need lobbying from regional governments and potential institutions, which will require funding.

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This network of researchers and food systems development experts collaborates to inform philanthropies, governments and development finance organisations on funding strategies to promote transitions to sustainable, equitable and resilient food systems across Africa.

To ensure a high standard of evidence-informed recommendations, briefs in this series were rigorously reviewed by peers within the AFSTC, including fellow researchers and members of the advisory committee.

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