SP4: Quality assurance and preservation of African vegetables during postharvest for reducing food losses and improving nutritional value, storability and food safety

Project partners

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I. Overall aim and objectives

African indigenous leafy vegetables (ALV) play a significant role in food security of smallholder farmers in rural and urban/peri-urban areas (Grivetti and Ogle 2000). Currently, the magnitude of postharvest losses of ALVs in Kenya can reach up to 50% (Aseno-Okyere 2012). Losses are attributed to inadequate conditions during production (Diwani and Janssens 2001, Abukutsa-Onyango and Karimi, 2007) and to rapid decay of products during transport, storage and marketing (Muchoki et al. 2007). Inadequate postharvest handling and facilities for storage and transport, inappropriate processing methods for product preservation, insufficient hygiene conditions in the markets and poor infrastructure aggravate these problems, causing massive losses along "the field to consumer" chain (Muchoki et al. 2007, HCDA 2008). Moreover, there is also a lack of quality control and food safety regulations (HCDA 2008), calling for regulatory policies and mechanisms.

In many parts in Africa, subsistence smallholder farmers cannot afford construction of expensive cold storage facilities and/or the use of refrigerated trucks, thus after harvesting ALVs, simple methods (shading products, charcoal cooler storage facilities) are applied (Lyatuu and Lebotse, 2010). However, alternative technologies such as on-farm evaporative coolers and modified atmosphere packaging (MAP) should be explored for adoption (Ambuko et al 2012). The commonly used, local preservation methods include blanching, air-drying, solar-drying (Nguni, 2007) and fermentation (Muchoki et al. 2007). However, despite their wide adoption, some of these result in significant loss of nutritional product quality and in microbiological contamination (Habwe et al. 2008, Owino et al., 2010). Thus, **the overall aim of intervention** is to identify and characterize quality losses during the entire food supply chain (from smallholder farmer to consumer) and to improve product quality, safety and storability. This will be done by adopting affordable harvest techniques, postharvest treatments and processing technologies, as well as by implementing emerging technologies for optimizing transport and storage conditions under unfavorable conditions in order to strengthen a product safety oriented food supply, which in turn will increase availability and access to high nutritive and safe food of indigenous ALVs in rural and urban/peri-urban areas along the entire food supply chain. Postharvest industries will also be affected by the availability of regulatory mechanisms related to food safety. **The relevance of intervention to the objectives of the project (output)** is implied by the overall assessment of small-farmer and consumer-oriented harvest, postharvest and processing technologies of ALVs, which aim to reduce food losses and to improve nutritional value, storability and food safety. **The research and/or technical goals of the intervention** will be the development of recommendations for food safety oriented harvest techniques, postharvest handling procedures and processing technologies for ALVs for utilization by all stakeholders of the food supply chain (smallholders, trader, consumer).

II. State of knowledge

The consumption of indigenous vegetables is increasingly gaining popularity in African rural and urban/peri-urban areas. These crops comprise predominantly the African nightshades (*Solanum* spp.), African kale (*Brassica oleracea*), cowpea leaves (*Vigna unguiculata*), spiderplant (*Gynandropsis gynandra*), leaf amaranth (*Amaranthus* spp.) and slender leaf (*Crotalaria brevidens*) (Abukutsa-Onyango 2008). ALVs are known to suffer from high quality losses during postharvest, e.g. for amaranth and nightshade comprising 11% loss at farm level, 17% at retail markets and 5% at wholesale markets, i.e. one third in total (Barry et al. 2009). The main constraints to increased production, marketing and consumption of ALVs are attributed to low storage capacity and transportability in their fresh state, which forces the farmers to sell soon after harvest (Maundu et al., 1999), or to insufficient application of processing methods such as fermentation, solar drying or blanching (Muchoki et al. 2007) for product preservation. Many small-scale farmers cannot afford storage cooling facilities or appropriate transportation (Irungu and Gotor 2010). Traditionally, storing of ALVs is frequently done also in times of scarcity. Hence, improving harvesting time and techniques are important to allow storage and transport of ALVs under unfavorable conditions (e.g. high temperatures, mechanical damage) with minimum loss in nutritional quality and quantity. ALVs should preferably be harvested during the early hours of the day (Masarirambi et al., 2010). There are four methods of harvesting ALVs, i.e. plucking leaves (African kale), picking branches containing leaves (cowpeas), cutting the plant near the ground level (night shade) or uprooting the whole plant (Onyango and Imungi, 2007). Many growers tend to rely on relatively imprecise indicators, e.g. leaf size and color or overall plant condition to determine the time of harvest (Barry et al., 2009). Although ALVs can be harvested at different stages of their development, optimization of harvest maturity is important to ensure yield, nutritive value and postharvest longevity (Diwani and Janssens 2001). Market preparation is mainly done traditionally and does not follow quality control regulations (HCDA 2008) and thus calls for regulatory policies and mechanisms.

Packaging of ALVs is currently used mainly for some dried products, but less for fresh ALV (Muchoki 2007, Lyatuu and Lebotse, 2010). The use of polyethylene- and polycarbonate bags with specific gas permeation could lead to a modified atmosphere inside the packages, which can reduce respiration and thus aid in keeping harvest quality. Such packages are locally available in the Kenyan market at affordable prices. An evaluation and commercialization of MAP for ALVs on the local market has not been conducted yet.

Storage at product-specific, low temperatures helps to maintain product quality and to prolong shelf-life by reducing the metabolism and ageing of ALVs. Cooling facilities at the stage of small-scale farmers generally comprise charcoal coolers without controlled temperature (Lyatuu et al. 2010). Therefore, alternative technologies, such as on-farm evaporative coolers and modified atmosphere packaging (MAP) have been recently implemented for adoption (Bloch 2009, Ambuko et al 2012). Controlled atmosphere (CA) storage are currently not utilized for storage of ALVs, however, these investigations could help to develop optimal modified atmosphere packaging (PE-bags) and thus, to prolong the shelf-life and supply of consumers with high quality ALVs.

Recently, there has been increasing interest in postharvest treatments (e.g. heat treatments) and new emerging postharvest technologies (e.g. UV-C irradiation, electrical impulses) also for African vegetables to meet food safety concerns. Numerous studies have shown the beneficial effects of postharvest treatments to control insect pests, prevent fungal rots, and inhibit undesired acceleration of ripening and senescence, or even to promote the synthesis of health-promoting compounds (e.g. carotenoids, flavonoids and dietary fibers) during storage and marketing (Lurie 1998, Nicolai et al. 2009, Dannehl et al. 2011, Huyskens-Keil et al. 2011). These easy-to-apply postharvest treatments can prevent quality losses effectively and can substitute chemical preservation with non-damaging physical treatments to prolong their shelf-life. Furthermore, there is the lack of available local preservation technology for ALVs. Processing technologies, e.g. fermentation or solar drying can increase the keeping quality, improve the safety and prevent nutrient loss. Studies have shown that the fermentation, blanching and drying of ALV, substantially preserves nutritive compounds (Muchoki et al., 2007). Emphasis will be placed on methods which ensure a high plant secondary metabolite profile and have a profound influence on food safety, especially growth and toxin biosynthesis by pathogens. Solar drying and fermentation are already practiced in Africa for various vegetable fermentations on a household scale, but methodologies differ widely and no standard or optimized procedures have been developed.

III. Utilization of results (Uptake)

- Increase knowledge of improved and affordable technologies under unfavorable conditions for harvest, postharvest and processing technologies of ALV in rural and urban/peri-urban areas at the **smallholder farmer-**level**.**
- Increase **food safety** and **food availability** for the poor, **increase income** from selling products with **longer shelf-life** and **increased nutritional quality**
- **Assist extension and advisory services** to better support farmers and consumers.
- Inform and work with **policy and decision makers** to support further development in the horticultural sector, to integrate findings into new rules and regulations in terms of quality standards and food safety (hygienic requirements)
- Provide markets **with a consumer-o**riented better quality and safer produce.
- For **research scientists** to build upon existing knowledge and to further develop and improve postharvest handling, treatment and processing technology.

IV. Internal cooperation and cooperation with other subprojects

- The postharvest project partners will support and complement each other in their respective activities. Project partners associated with optimizing harvesting (EGU, LUH, CUC) will supply material and data for those who apply controlled atmosphere storage, postharvest treatments and fermentation (MRI, UN, JKUAT, HUB, EGU, CUC), while the latter will feed back information on starting products on later postharvest behavior and product characteristics and help to define critical control points. The groups determining safety parameters (microbiological, mycotoxins; MRI) and product nutrient quality (JKUAT, HUB, MRI) can provide critical control point information to the groups involved in optimizing harvest and those optimizing postharvest treatment methods.

The postharvest group will further cooperate with partners of the following sub-projects:

- “Variety development and seed systems”. Results of this project will be a prerequisite for selection of varieties used for the investigation of the postharvest/processing sub-project.
- “Increasing water use efficiency in indigenous vegetable production systems”. Cooperation will determine the effect of water supply/availability on storability and shelf-life in terms of health-promoting compounds and food safety of ALVs.
- “Impact of fresh and processed African leafy vegetables on human health“. Cooperation will focus on the effect of optimized postharvest/processing technologies on bioavailability of health-related compounds of ALVs.
- “Knowledge creation for value chain promotion for prioritized Value Chains”. Cooperation will add information on food safety and consumer-oriented postharvest and processing technologies and will contribute to open new marketing possibilities.
- “Value chain effects on livelihoods and food security of vegetable producers and consumers”. Providing knowledge transfer about affordable postharvest methods for ALVs to assure high nutrient quality, food safety and storability, thus increasing income and food availability.