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POSTHARVEST PRACTICES ALONG SUPPLY CHAINS OF *SOLANUM AETHIOPICUM* (Shum) AND *AMARANTHUS LIVIDUS* (Linn) LEAFY VEGETABLES IN WAKISO AND KAMPALA DISTRICTS, UGANDA

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ABSTRACT

A cross-sectional study design was employed for the purpose of understanding the postharvest practices and entry point for losses along the supply chains of *Solanum aethiopicum* and *Amaranthus lividus* leafy vegetables. This is important so that interventions along the supply chain may not be misplaced. The target population included chain actors: farmers (n=10), traders (n=30) and key informants (n=7) who were selected purposively for interviews. A total of 10 farms and 7 market visits were made along the two supply routes: Kabubbu-Kalerwe and Kabubbu-Kireka. Data were collected using a semi-structured questionnaire and key informant checklist. Two supply chains were observed in this study: short supply chain where the farmer doubled as a trader. Farmers in this category were the majority (90%). In the long type, farmers (10%) supplied middlemen/transporters who then delivered to the markets. Furthermore, there were no exports or value addition in either of the supply chains. A good hygiene practice observed on the farm was that of trimming off the roots of vegetables to reduce contamination from the soil and also the amount of garbage generated in the market. Packing of vegetables on hired trucks was a common practice where roots/leaves faced each other to prevent soiling of the leaves by the roots. The main transport means used was truck (100%) with alternative transportation means being motorcycle and bicycles. The cool evening hours (20:00 to 00:00hrs) were the most preferred transportation times. The packaging method observed in the market was use of either black or white polythene bags at the point of sale with only 53.3% of the traders packaging for their customers. There was no proper packaging and storage both on the farms and in the markets. Traders in the markets either sprinkled water on the leftover vegetables or covered them with a wet sack as a preservation method. Moreover, only 16.6% sorted and graded their vegetables whereas 83.4% did not. There was inappropriate handling, storage and packaging practices along the two supply chains.

Key words: handling, transport, packaging, storage, leafy vegetables, supply chain, chain actors

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INTRODUCTION

Horticultural crops are an important source of vitamins and minerals that are essential for human health and well-being, and micronutrient deficiencies are of particular concern for children and women of reproductive age [1]. Leafy vegetables contain reasonable amounts of protein, carbohydrates, iron and zinc [2, 3]. They are also a rich source of calcium, beta- carotene and vitamin C. The quality and nutritional value of leafy vegetables cannot be overlooked as it can help curb micronutrient deficiency especially vitamin A deficiency. In Uganda, vitamin A deficiency is a common problem in both children and pregnant women [4].

Vegetables such as the leafy vegetables *Solanum aethiopicum*, and red and green amaranth leaves (*Amaranth spp*), are food sources of provitamin A carotenoids as well as lots of minerals that can contribute effectively to improve vitamin A and mineral intakes. Raw *S. aethiopicum* leaves contain 4.78 g protein, 2.52 mg iron and 0.81 mg zinc [5] while amaranth leaves alone contain 17.3% crude protein, 310 ppm of iron [6] and 4.92 mg beta-carotene [7].

S. aethiopicum (Nakati) and *Amaranthus lividus* (Bugga) are some of the most important vegetables grown in Central Uganda predominantly for cash [8]. Their commercial production is restricted mainly to peri-urban areas [9] and widely grown for its ready market, palatability and high nutritive value [8].

Despite the high content of nutrients, leafy vegetables are highly perishable, which causes postharvest losses both in quantity and quality. Poor handling, premature harvesting, inadequate market facilities, lack of processing facilities, inappropriate packaging, poor storage, timing of harvest not being optimal, high postharvest handling temperatures, delays in marketing and poor infrastructure [10, 11, 12, 13] are some of the causes of postharvest losses in vegetables. Poor postharvest handling practices induce damage to fresh produce, which include splitting and tearing. These deteriorating physical conditions of the leaves result in development of entry points for mold and bacteria, increased water loss and an increased respiration rate [14]. Furthermore, the high moisture content of the vegetables encourages increased rate of metabolic activities, which are accelerated by higher temperatures especially when the produce is harvested during hot periods without pre-cooling [11]. The high moisture content and active metabolism result in senescence, desiccation and microbial spoilage, which can occur at any point from harvest through the food value chain [15]. Proper handling practices that minimize injury and water loss are therefore important in reducing rate of deterioration in vegetables.

Reducing postharvest losses for fresh produce including leafy vegetables is an important part of sustainable agricultural development efforts meant to increase food availability worldwide [11]. The need for food security, quality nutritious foods and food diversity has stimulated research in the area of postharvest losses in leafy vegetables in Uganda. Despite the findings by other researchers on the postharvest practices on horticultural crops [16,17], little is known about postharvest handling, storage and packaging practices of leafy vegetables along supply chains in Uganda. The aims of the study were twofold,

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firstly, establishing the nature of supply chains for *S. aethiopicum* (Nakati) and *A. lividus* (Bugga) leafy vegetables in Central Uganda and secondly, documenting the postharvest practices along these supply chains.

MATERIALS AND METHODS

This study was a cross-sectional study along vegetable supply chains between Wakiso and Kampala Districts. These areas were purposively selected for their high leafy vegetable production and trading routes for *S. aethiopicum* (Nakati) and *A. lividus* (Bugga) [8], respectively. Both qualitative and quantitative approaches to data collection were used. Key informants were purposely selected based on their experience, availability and interest to participate in the interview. These included farmers who doubled as transporters (n=3), transporters (n=2) and traders (n=2), and data were collected using a checklist that included questions on handling, means of transport used, use of packaging materials and storage of vegetables. Field notes and audio recordings were also adopted to collect data and later transcribed. Field visits were conducted and observations made along the supply chains at different stages (on-farm, during harvesting, during transportation and in the markets). Stakeholders (farmers, transporters and traders) were selected to participate in the study. This was because the study targeted only those stakeholders handling *S. aethiopicum* and *A. lividus* leafy vegetables. A total of 40 selected stakeholders were interviewed on handling, packaging, means of transport used and storage of vegetables. Farmers (n=10) were selected from Wakiso District and traders (n=30) from Kampala District, based on location of farms and main markets, respectively. Data were collected using a semi-structured questionnaire. The quantitative approach (survey) was used to validate the qualitative approach and data. The postharvest practices were observed at different levels of handling the vegetables after harvest including, handling, storage, packaging and marketing. Qualitative data were analyzed through content analysis, which involved identification and categorizing into themes. Data from personal interviews (quantitative data) were coded and imported into Statistical Package of Social Scientists (SPSS, Version 16.0) software for analysis and results described as frequencies and percentages.

RESULTS AND DISCUSSION

Respondent characteristics

This study involved participation of 40 respondents (10 farmers and 30 traders) for interviews. Of the respondents who participated in the personal interview, 67.5% were women and 32.5% were men. The respondents' age ranged between 21 and 68 years and 97.5% had an experience of 1-15 years in handling leafy vegetables. Moreover, 62% of the respondents had attained formal education (primary and secondary). More details are provided in Table 1.

Supply chains for leafy vegetables in Central Uganda

Three main actors were observed before the final consumer is reached in the market including farmer, wholesaler and retailer (Figures 1a and 1b). Because of lack of processing culture, there was neither export nor value addition done for the respective vegetables. It was further observed that 90% of the farmers sold directly to the traders in the

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market, while 10% sold to middlemen leading to the two types of vegetable supply chains, including short/simple and long/complex supply chains (Figures 1a and 1b). In the short supply chain, characteristically the farmer doubled as a trader and transporter and supplied directly to the wet market and also to other traders (wholesalers) or vegetable agents who then supplied the vegetable retail vendors.

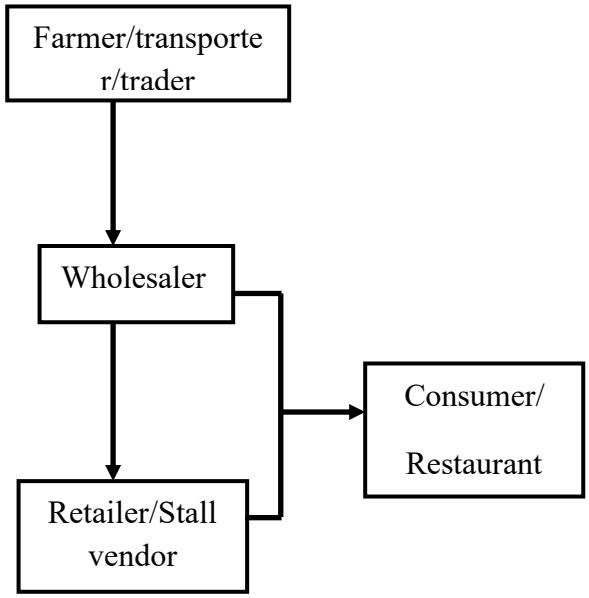

Figure 1a): Short/simple supply chain

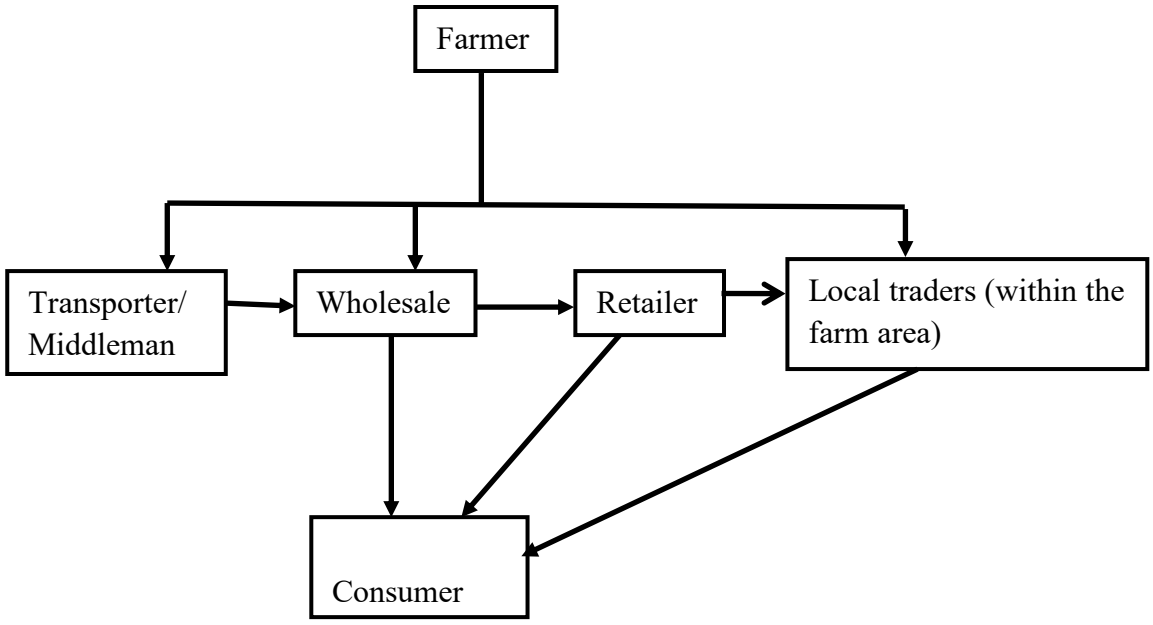

Figure 1b): Long/complex supply chain

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In the complex supply chain, farmers supplied middlemen/transporters who then delivered to the markets. Farmers identified in this kind of supply chain were not involved in direct market sales and they were the least in number (10%). In general, the number of actors participating in either supply chains was minimal. According to literature, Maestre *et al.* [18] described a food value chain in the same manner as in this study. Some authors describe food chains that supply wet markets like the ones in this study as traditional food value chains [19, 20]. This term best describes the short and long vegetable supply chain observed and identified in this study. They are characterized by small-scale farmers and poor postharvest practices, such as no proper packaging, storage and distribution facilities. These characteristics limit the ability of traditional food value chains to reduce micronutrient deficiencies and undernourishment [19]. Vegetables in these supply chains are easily accessed and affordable with prices ranging from 500-20,000 Ugandan shillings for a bundle of 0.2-80 kg, respectively. However, these prices and quantities depend on the season or availability of the vegetables. Similar findings have been reported [19, 20, 21] where perishable and nutritious foods like vegetables are provided at lower prices in the traditional food supply chains. The traditional food supply chains provide vegetables in their fresh state; however, fresh vegetables deteriorate faster in both sensory and nutritional quality and loss is often higher as the value chain becomes longer/complex.

The study established that farmers mostly delivered vegetables to the market but in cases where they were unable to, middlemen delivered to the markets and marketed them on their behalf. Additionally, farmers also sold vegetables to local traders (within the area) who took and sold from their stalls to the final consumers. Moreover, as farmers had direct contact with wholesalers, local traders and retailers; the role of middlemen was almost limited, which helped farmers get reasonable profit from their vegetables.

The wholesale areas were open to every customer, meaning that even consumers could buy from the wholesalers. This has advantages; firstly, consumers buy the vegetables at a reasonable price; secondly, consumers are able to access vegetables when they are still fresh; and thirdly, because of high perishability of vegetables, direct access to wholesalers reduces the number of actors in between, hence reducing contamination and postharvest losses.

Assessment of Postharvest Practices of *Solanum aethiopicum* (S.) and *Amaranthus lividus* (L.) leafy vegetables along the supply chain

Postharvest practices on farm and during transport

The practices documented included loading, transport, hygiene and sanitation.

Loading and Transport of vegetables

No packaging material was used for the leafy vegetables transported to the market. However, they were tied using ropes into bundles (ngandas) to ease loading on to the truck. The farmers reported that packaging is not cost effective but preferred the practice if they had an export market as paraphrased below:

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"Using a package will reduce the quantity of what we sell and will also increase the costs." "*May be if we are packaging for the international market, because there we are assured of increased income." (Vegetable farmer)*

However, on-farm packaging of vegetables using cheap materials including wooden crates, bamboo baskets, boxes and sacks to ease transportation to the market has been reported in other countries [22, 23, 24]. Moreover, inappropriate packaging has been reported to be one of the major causes of postharvest losses in vegetables [17].

Vegetables were carried on the head to be loaded on to the truck. They were packed in a way that the roots faced each other and likewise the leaves. Additionally, *A. lividus* was observed being packed on top of *S. aethiopicum*. The main transport means used were trucks (100%) with each one hired by one or more farmers. Farmers and transporters that were interviewed delivered their vegetables in the evening hours (20:00 to 00:00hrs). Evening hours were reported to be cool and convenient with fewer traffic jams on the road. Among the farmers interviewed (n=10) only 10% owned a truck while 80% hired and 10% used middlemen. Open trucks were used for transportation of vegetables to the market. This is similar to previous reports [25, 26] that trucks were the main means of transporting vegetables. Moreover, the trucks used were open without a proper covering to protect the vegetables from the dust or any other detrimental external factor. Covered and refrigerated vehicles are recommended for transport of fresh vegetables. The loading of vegetables on the truck by head is reported as inappropriate as it can lead to bruising of the vegetable leaves. This loading and offloading by head coupled with improper stacking of fruits and vegetables is one of the causes of mechanical injury, which reduce vegetable quality [17]. Other alternative transport means reported included motorcycles and bicycles. Motorcycles were used when the vegetables to be sold were less than five (5) bundles and also for those who could not afford truck hire. It was also observed that the farmers with bicycles delivered to stalls within and around the production area. However, the use of motorcycles and bicycles was reported to be out-of-date because farmers and transporters preferred delivering their vegetables to bigger markets in the city.

It was further observed that vegetables were delivered to the markets immediately after harvest and, thus, requiring no special storage and aspects of changes in vegetable quality were assumed to be minimal. The other practice reported was that of spreading the vegetables outside overnight to prevent wilting. Exposure to cold temperature following harvest in order to minimize the effect of wound stress is recognized as one of the main factors to control quality of fresh leafy vegetables [27].

Hygiene and sanitation

A good hygienic practice observed on farm was that of trimming-off the roots after bundling to avoid soiling of the leaves and also as a requirement by the city council to reduce waste in the markets. This was observed as an appropriate practice and is therefore recommended [16] though not encouraged by some traders. The traders argued that trimming-off roots facilitates wilting and spoilage of the vegetables within a short period of time. However, other hygienic practices including sorting and grading were not observed. Whatever was harvested was transported to the market. This finding is related

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to that by Cadilhon *et al.* [28] who reported that farmers were neither encouraged to sort nor grade the vegetables since city wholesalers would always pay for all types of produce supplied.

The lack of sorting and grading was also observed in the markets with the majority of the traders (83.3%) not practicing it at all and 16.6% practicing. However, in order to ensure hygiene of the vegetables, the vendors put a bag/kavera down before splitting. The lack of sorting and grading facilitates transmission of fungal and bacterial diseases from the infected leaves to the healthy ones [16] and it could be the reason for poor quality produce being sold in the markets. Strict hygiene as a requirement at all stages of handling perishable crops is emphasized as this will help to minimize infection by pathogens [29].

Postharvest practices of leafy vegetables in the wet markets

The practices observed in the markets included handling, packaging, storage, hygiene and sanitation. Two main markets for delivery were Kalerwe market in Kawempe division and Kireka market in Nakawa division. Vendors from other markets and consumers (Nakasero, Owino and Nakawa) purchased from these two main markets and most deliveries were made between 20:00 and 00:00 hrs in the morning.

Handling of vegetables

At the point of sale, vegetables are divided in an orderly manner from side to side as a means of reducing physical damage. However, during splitting some parts of the vegetable were lost and this contributed to quantitative loss of the produce.

Umbrellas were observed as being used in the markets by retailers to cut off direct sunlight on the vegetables to reduce the high temperatures, which are detrimental to fresh vegetable appearance. This practice can also be recommended for all vegetable farmers and wholesalers in order to maximize vegetable quality.

Packaging

Out of the traders interviewed (n=30), only 53.3% packaged for their customers using black and white polythene bags at the point of sale while 46.7% did not package. However, a key informant interview revealed that packaging was only done on request from the buyer and one of the vendors was noted saying:

"Yes, we do package but we normally do so, on a request from the customer" (Vegetable trader)

The lack of proper postharvest packaging of fresh vegetables in the market was reported [25]. Furthermore, Devkota *et al*. [17] reported that inappropriate packaging was second to improper storage as a major cause of postharvest loss of fruits and vegetables. Other studies that have shown leafy vegetables to be packaged reported the use of inappropriate and poor-quality packages, which facilitated postharvest loss [16, 30]. Lack of appropriate packaging, transportation and handling resulted in physical damage that later resulted in losses [25].

Storage

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Most (56.7%) of the traders sold their produce in one day, while 43.3% sold within two days. There was not any formal storage practice observed; however, traders sprinkled water on the vegetables from time to time and others placed the vegetables in a bucket of water as a method to preserve them. Overnight, the practice was to use a kavera/bag soaked in water to cover the vegetables to prevent wilting. The majority (61.5%) practiced this mode of storage and preservation. This is similar to findings from a previous work where no storage facilities were available for fresh vegetables in Cameroon [25]. However, traders devised means of preserving these vegetables by rehydrating them using water during the day and at night covered with wet sacks. Though it is appropriate to rehydrate the vegetables, the hygiene of the water used was worrying as this can be a possible contaminant that compromises safety of the vegetables and thus a threat to consumer health.

Despite the lack of storage facilities both on the farms and in markets, storage of leafy vegetables can lead to loss of nutrients and quality deterioration even in one day. Furthermore, it has been argued that the longer the time food is stored, the greater the deterioration in quality and the higher the chance of damage and loss [31, 32]. The researchers emphasized storage time as being a critical factor in loss of foods that have short shelf lives like leafy vegetables. However, this does not rule out advances in storing vegetables as storage prolongs the time food is available both to a household and in the markets. There is therefore, the need to encourage and improve storage practices especially during times of plenty to reduce postharvest losses.

CONCLUSION

The postharvest practices carried out along the supply chains included transport of vegetables in open trucks, no on-farm storage, packaging, sorting and grading. Similarly, there was no proper storage system and packaging in the market; however, sorting and grading was practiced to a lesser extent (16.6%).

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Table 1(a): Respondent Characteristics

Respondent characteristics	Percentage (%)
Sex	
Male	32.5
female	67.5
Type of respondents	
Farmers	25
Traders	75
Age	
Less than 21 years	2.5
Between 21-68 years	97.5
Education level	
None	38
Formal education (primary & secondary)	62
Experience handling vegetables	
Less than 1 year	2.5
1 year and above	97.5
Land ownership	
Hired	50
Owned	50

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Table 1(b): Characteristics of vegetable supply chains in Central Uganda

Supply chain	**Actor**	**Mode of transport**			**Harvesting time**	**Transport Time**	
Simple supply chain		**On head**	**Truck**	**Motorcycle**	**Evening**	**Morning**	**Night**
	Farmer-Wholesaler		✓	✓	✓		✓
	Wholesaler-Retailer	✓			✓	✓	
	Retailer-Consumer				✓	✓	
Complex supply chain	Farmer-Transporter		✓		✓		✓
	Farmer-Wholesaler		✓	✓	✓		✓
	Farmer-Retailer		✓		✓		✓
	Transporter-Wholesaler		✓		✓		✓
	Wholesaler -Retailer	✓			✓	✓	
	Retailer-Consumer				✓	✓	

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