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Postharvest Handling Practices of Sweet potato in Kenya: A case of Bungoma and Homabay Counties

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Abstract

Postharvest losses in sweet potato can occur due to poor handling practices and inadequate knowledge on maintaining the quality and safety of the roots by handlers across the value chain. This study involved an assessment of postharvest handling practices of sweet potato in Bungoma and Homabay Counties, Kenya. A survey was carried out between November 2015 and February 2016, structured questionnaires were administered to a total of 165 respondents comprising 96 farmers, 64 traders, and 5 processors drawn from two constituencies of each of the Counties. Four key informants were also interviewed. Results showed that 68%, 87%, and 40% of sweet potato farmers, traders, and processors respectively, were women. Iron bars and wooden sticks were used in piecemeal harvesting while hoes *(jembes)* and ox-ploughs were used in wholesale harvesting of roots. Informal marketing systems that quantified roots using bags, buckets, and heaps were prevalent. Motorcycles, donkeys, bicycles, public service vehicles, foot, and cart were used by 26%, 21%, 11%, 8%, 7%, and 6% respectively to transport roots to the markets. Storage was rarely practiced by 43% of farmers and 45% of traders. Root curing was not common. Processed products included flour, puree, and dried chips. High perishability and unreliable supply of roots were major challenges indicated. The establishment of storage facilities, promotion of processing opportunities as well as formulation and enactment of a comprehensive sweet potato policy could move this industry to a commercial level. There is a need for collective action by policymakers and other stakeholders to address the challenges noted to ensure the reduction of postharvest losses for food security and better incomes.

Keywords: *Sweet potato; postharvest; Homabay; Bungoma; farmers; traders; processors*

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Introduction

Sweet potato (Ipomea batatas) ranks fifth in Kenya among the major staple crops, though its commercial potential is underexploited. The crop is adaptable to a wide range of Agro-Ecological Zones (AEZ) (Mukras *et al.,* 2013). Sweet potato is cultivated in 43 out of the 47 counties in Kenya with major producing counties in the year 2014 in descending order being Bungoma, Homabay, Busia, and Migori at 133037, 127725, 119970, and 69642 tonnes, respectively (MOAL, 2017). Production has mainly been for subsistence as a food security crop but surplus of 40% to 60% is sold as need arises to boost family income.

Typically, sweet potato is mainly produced by smallholder farmers, the majority of whom are women (Andrade *et al.,* 2009.; Omache, 2016). Kenyan grown sweet potatoes are usually in the domestic markets from late September to February. The roots are usually imported from Tanzania by wholesalers between June and August, being a period of scarcity (Mohammed and Facilitator,2019.). Kenya has various sweet potato marketing systems that are dominated by women (Wanyama et al,. 2016; Mukras *et al.,* 2013), running parallel with forward linkages from the villages. Village retail markets sell small quantities in heaps usually supplied from small surpluses of farmers (Mukras *et al.,* 2013; Nations, 2019). Postharvest losses in sweet potato roots are mainly due to poor handling and a general lack of knowledge regarding proper handling of these perishables at the farmer, wholesaler, and retailer levels (Kitinoja *et al.,* 2011., 2011a, 2011b). In a study in Uganda, the roots were noted overfilled in sacks meant for 100kg extended to hold 120kg such that middlemen would benefit at the expense of farmers (Andrade *et al.,* 2009.; CIP, 1998; Low *et al.,* 2009). Poor handling, storage, and transportation can result in roots with a shorter shelf life (3 weeks) and poor quality characteristics (Chang *et al.,* 2016). Losses while transporting to distant markets can be high and have resulted in about 30-50% of roots being unsalable on arrival at the markets in Papua New Guinea due to rots and/or physical damage (Chang and Kewa, 2014; Chang *et al.,* 2008).

Loss of fresh agricultural produce in Kenya is estimated at 30-40% (Ministry of Agriculture Livestock and Fisheries , 2017) and is mainly due to lack of appropriate postharvest handling technologies and practices. Besides, insufficient and poorly maintained transport and market infrastructure for handling food products in urban and rural areas have frequently resulted in a high level of waste and spoilage GoK, 2012). These factors widely contribute to low production, piecemeal harvesting, and less commercialization of the commodity (Kivuva, 2013; Mkuki, 2018). Despite the numerous challenges of production and postharvest handling, sweet potato contributes about USD 23 billion to Kenya's gross domestic product (GDP) (Ministry of Agriculture Livestock and Fisheries , 2017). To realize the maximum potential of this crop for food and nutritional security as well as income generation, there is a need for an assessment of postharvest practices by various handlers to identify the challenges for intervention by relevant stakeholders. Losses occurring after the harvest of sweet potato are costly and can impact negatively on food security and economic status. Reducing postharvest losses of these roots can be more sustainable than increasing production to counter the losses (Kitinoja *et al.,* 2011a). Lack of information on the sweet potato market structure and performance is a constraint to the development of the sweet potato industry (Mukras *et al.,* 2013). There was therefore a need to establish and document information on sweet potato handling in Kenya as a guide to address the weak areas in the forward and backward linkages.

Materials and Methods

***Study area*:** The current study was carried out in Bungoma and Homabay counties between November 2015 and February 2016. Homabay lies within latitudes 0°15'S and 0°52'S and longitudes: 34°E-35°E with an elevation of about 1225m above sea level . The county covers an approximate area of 4,267.1km^{2}with a population of about 963,794 within 206,255 households (Gereffi Karina Fernandez-Stark Phil Psilos *et al.,* 2011). Approximately 89.3% of its land area is arable. The area receives well-distributed bimodal rainfall; between March and April for long rains and from September to December for short rains with annual figures ranging from 1000 to 1250 mm. Most farmers practice semi-subsistence farming. The main crops produced in the county include maize, beans, sweet potatoes, sorghum, peas, millet, kales, sugar cane, sunflower, and pineapples as reported in the Homabay county government Integrated Development Plan of 2013-2017. The county has eight administrative constituencies.

Bungoma lies within 0°35'N and 34°34'E with an elevation of between 1300 and 2073 m above sea level. The County covers an approximate area of 3000km^2 with a population of 1,361,390 within 260,628 households (Gereffi Karina Fernandez-Stark Phil Psilos *et al.,* 2011). Land with agricultural potential is estimated at 88.8% (183,800 ha). The county receives bimodal well-

distributed annual rainfall in the range 1000 - 1800mm. long rains fall from March to July while short rains fall from August to October. Semi-subsistence agriculture is common too with the main crops being maize, beans, Sunflower, potatoes, Sugarcane, Coffee, Tobacco, and cotton. The county has nine administrative constituencies.

Sampling procedure and data collection
Purposive sampling was used to select Bungoma and Homabay counties. Bumula and Kanduyi constituencies (Bungoma), as well as Kasipul and Kabondo/Kasipiul constituencies (Homabay), were purposively sampled as the leading constituencies in sweet potato production. Sweet potato farmers were identified from these four constituencies but spread across the villages with the help of the field guides who resided in the localities. Sweet potato traders were identified and interviewed at the main markets, trading centers, and along the main roads. Sweet potato processors were exhaustively identified by the snowball sampling technique. Structured questionnaires were prepared and pre-tested before being administered to the respondents by the research team comprising the principal researcher and trained research assistants who included the field guides. In the case of the language barrier, the research team members who understood the local languages were asked to interview the specific respondents. A Focused Group Discussion (FGD) of at least 12 farmers was also conducted in each county (Figure 1).

Figure 1. (a) Individual farmer Interview, (b) Focused group discussion in Bungoma, (c) Focused group discussion in Homabay

One key informant from the agriculture extension department in each constituency was also interviewed. Data on socio-demographics, sweet potato varieties, harvesting, postharvest practices (sorting and grading, curing, drying, consumption, transportation, storage, processing, and marketing), and general challenges were obtained. A total of 169 respondents comprising 96 farmers, 64 traders, 5 processors, and 4 key informants were interviewed in addition to two focused group discussions with farmers. The numbers of farmers and traders were derived using the Fisher's (1981) formula, **n** (sample size) = $\mathbf{Z^2pq/e^2}$ (Z^2(confidence Interval) = 1.96^2, P (the probability of finding sweet potato farmers and traders) =0.9, q (1-p) = 0.1 and e^2(the margin of error) = 0.05^2. Processors were exhaustively sampled. Key informants were purposively sampled from among the agriculture extension officers. Observations on postharvest practices by the handlers were also made by the researcher.

***Data Analysis*:** The data collected were analyzed using the Statistical Package for Social Scientists (IBM SPSS Statistics version 20). Frequencies were displayed as percentages comparing the two counties studied as shown in the results section.

Results

Socio-demographic characteristics of respondents in Bungoma and Homabay counties
Gender distribution
A majority (68%) of the farmers interviewed were women (Figure 2) out of which 75% of the total interviewed were married and living with their spouses. The majority of the traders (87%) interviewed were women (Figure3).

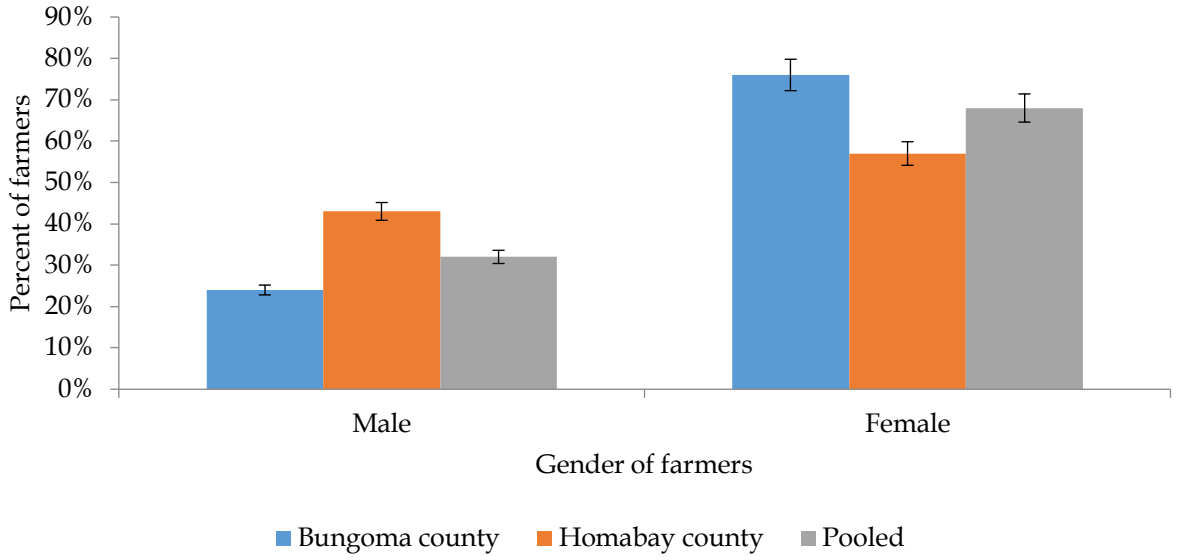

Figure 2. Gender of sweet potato farmers in Bungoma and Homabay counties

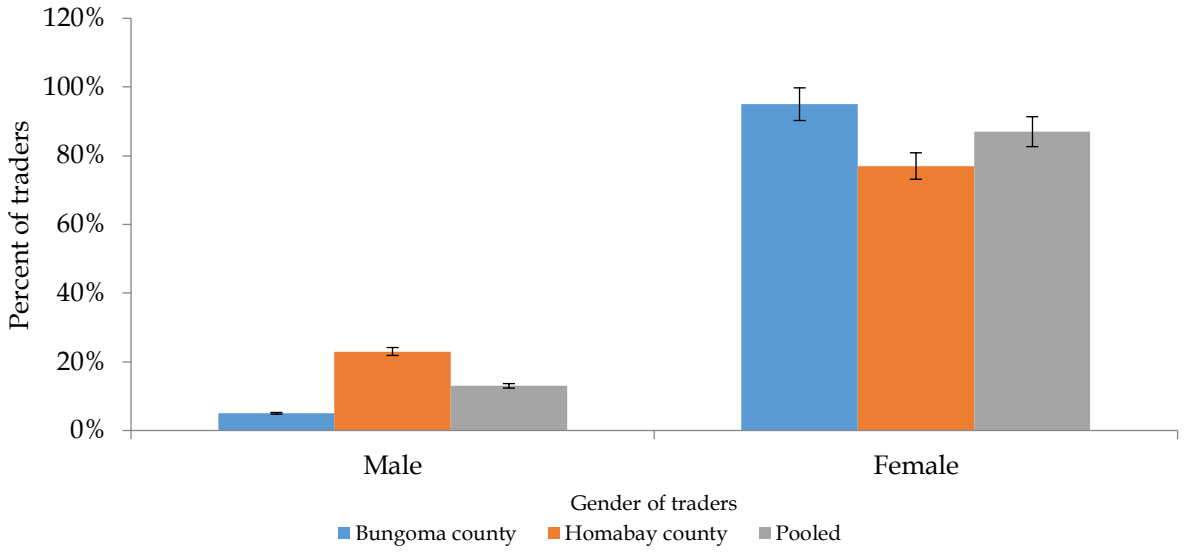

Figure 3. Gender of sweet potato traders in Bungoma and Homabay Counties

A total of five processors were interviewed.

Age distribution

Figures 4, 5, 6, and 7 show the age distribution of study respondents. There was more youth (18-35 years) involvement in trading (37%) compared to farming (24%) and processing (20%). At ages 36-45years there was peak involvement in farming, trading, and processing sweet potato, and this diminished as age increased from 46 years. All sweet potato processors were aged above 30years (Figure7).

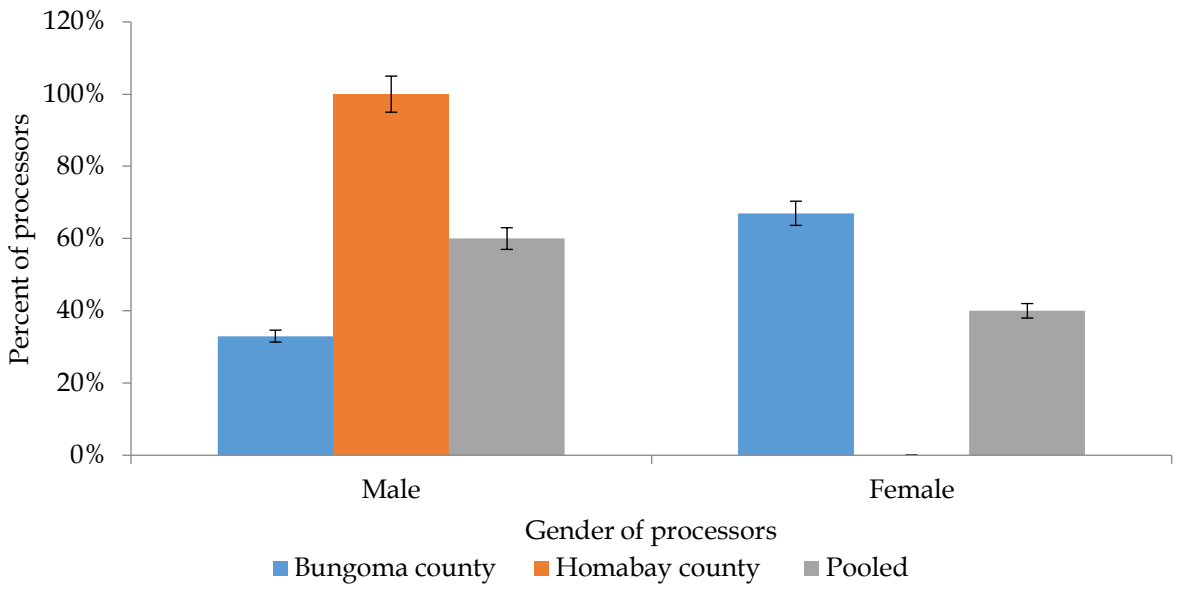

Figure 4. Gender of sweet potato processors in Bungoma and Homabay Counties

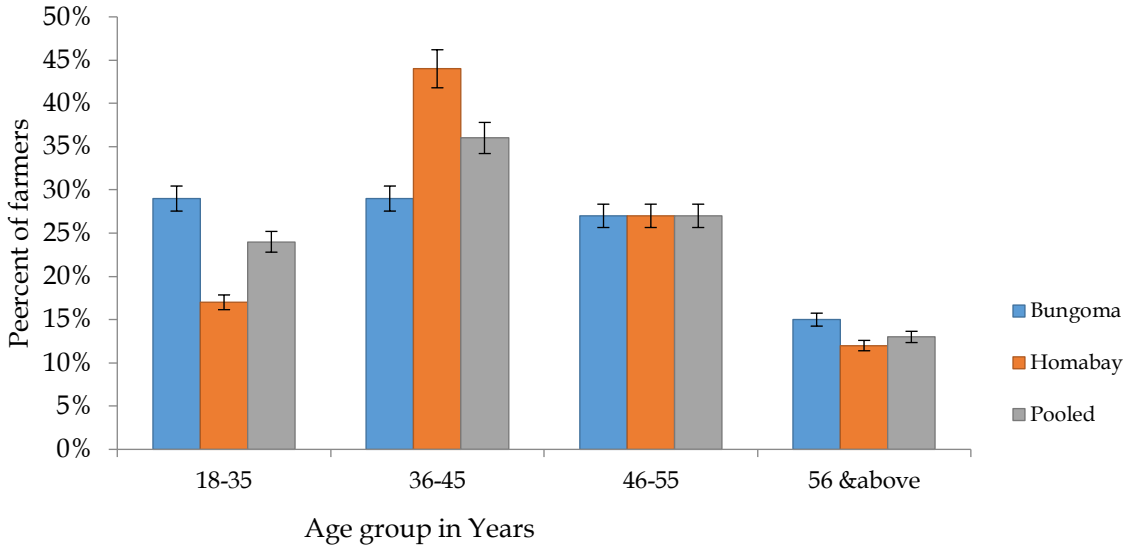

Figure 5. Age group (years) of sweet potato farmers in Bungoma and Homabay Counties

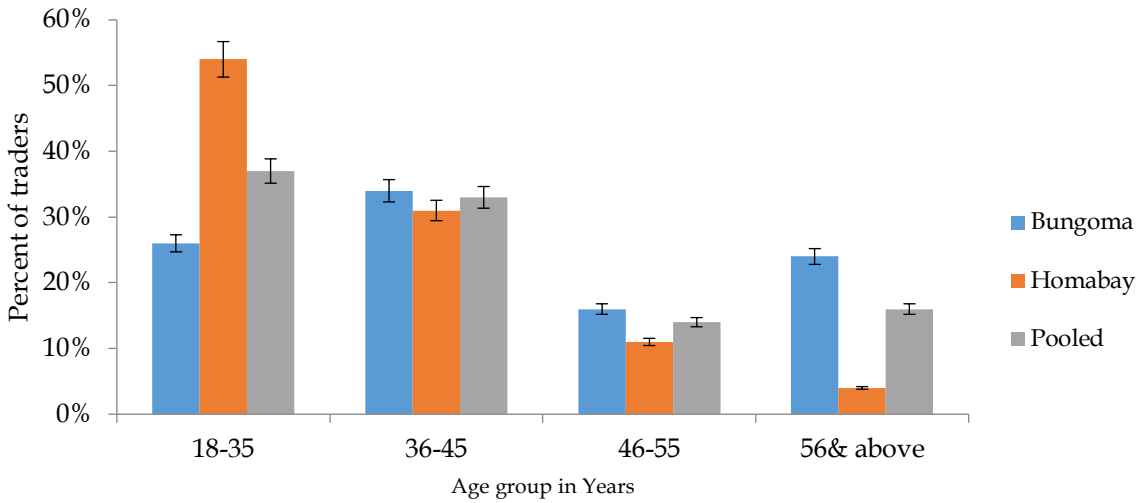

Figure 6. Age group (years) of sweet potato traders in Bungoma and Homabay Counties

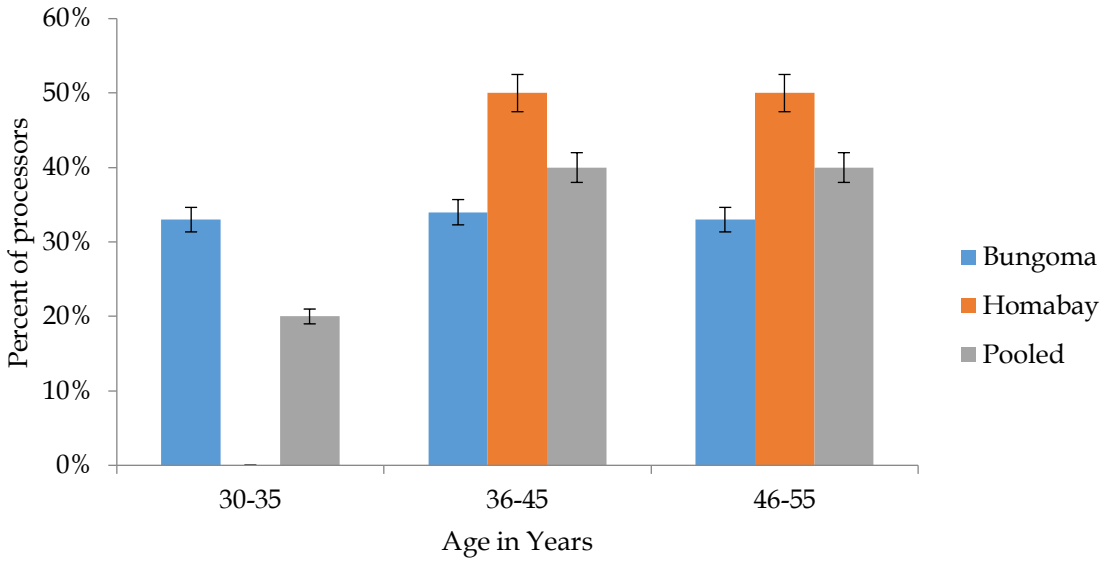

Figure 7. Age group (years) of sweet potato processors in Bungoma and Homabay Counties

Education

About 89% of farmers were of primary and secondary school level of education while 67% and 23% of traders were holders of primary and secondary school education, respectively. 40% and 60% of processors were of secondary and tertiary level of education respectively (Figures 8, 9, and 10).

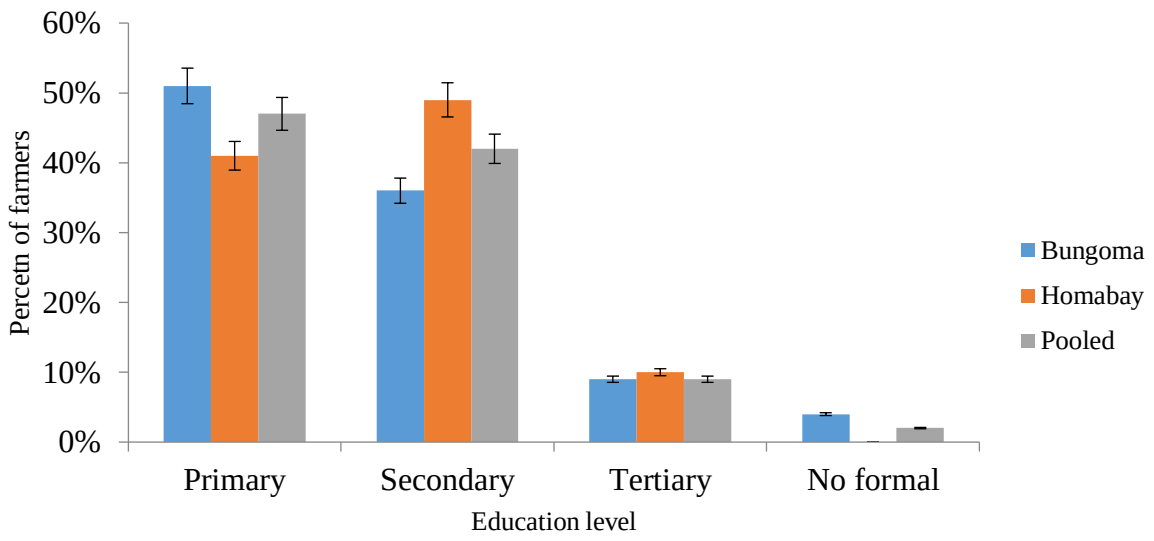

Figure 8. Education level of sweet potato farmers in Bungoma and Homabay Counties

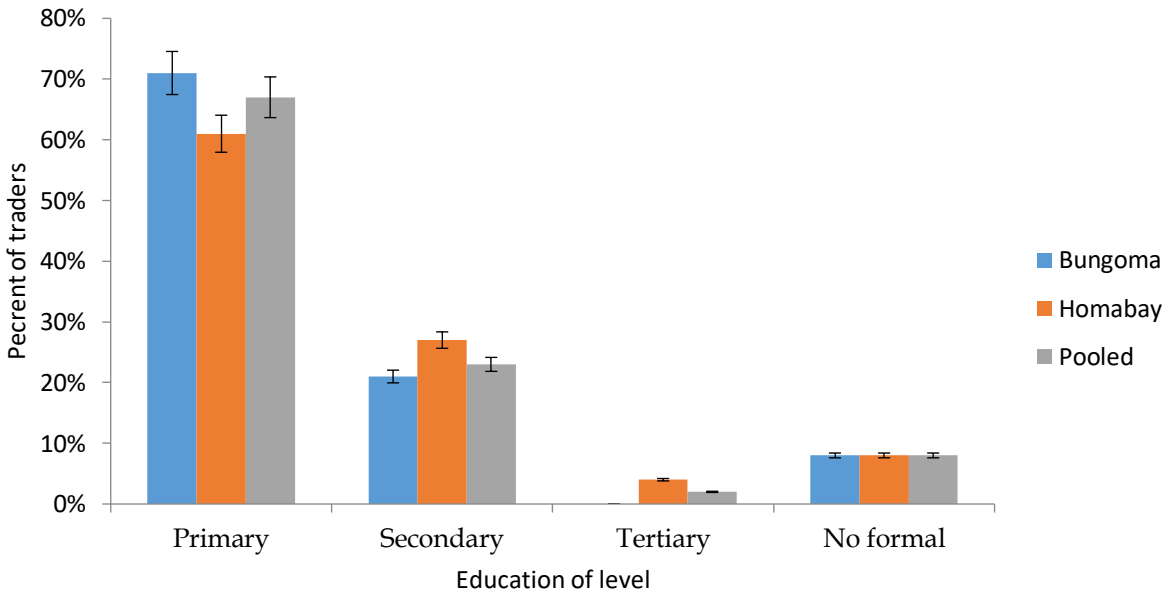

Figure 9. Education level of sweet potato traders in Bungoma and Homabay Counties

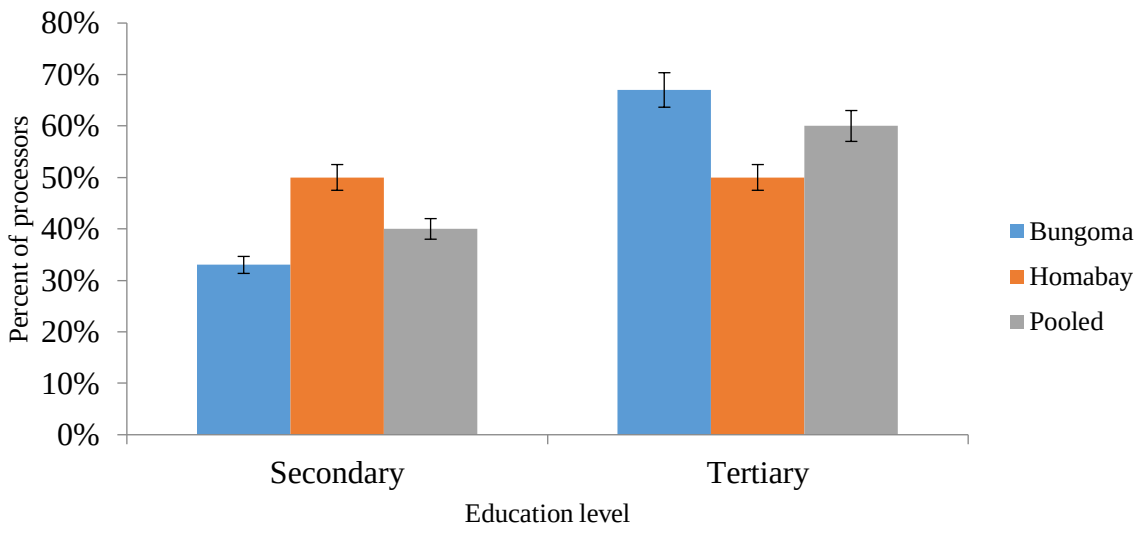

Figure 10. Education level of sweet potato processors in Bungoma and Homabay Counties

Marital status of farmers

Figure 11 shows that 75% of farmers were married and living with their spouses while 10% had their spouses away and 11% were widowed.

Figure 12 shows that 59% of the farmers interviewed were spouses and 37% were heads of households.

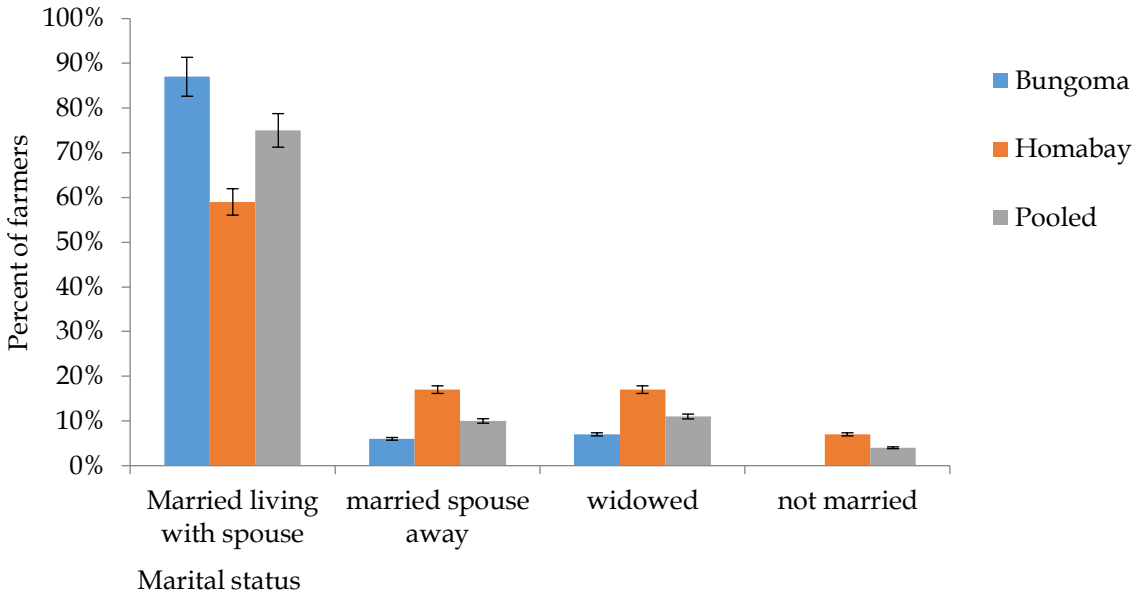

Figure 11. Marital status of sweet potato farmers in Bungoma and Homabay Counties

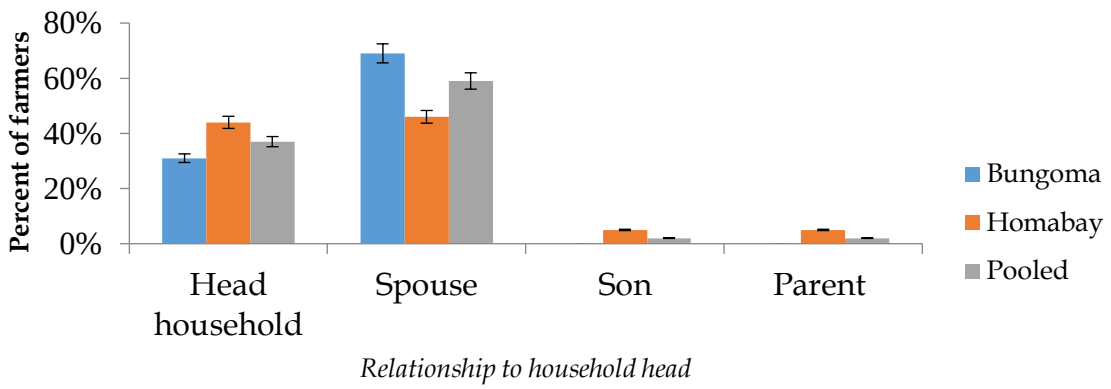

Figure 12. Relationship of respondent to household head in Bungoma and Homabay Counties

Occupation of households

Farming was the main source of livelihood for the majority (80%) of the rural households (Figure13). About 14% of the households were self-employed off-farm while 6% of the households derived their livelihoods from salaried employment.

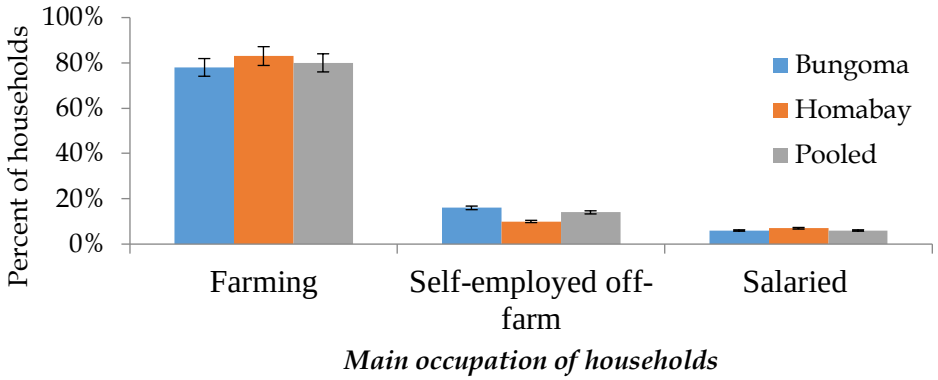

Figure 13. Main occupation of farming households in Bungoma and Homabay Counties

Family sizes

The most prevalent family size (Figure14) was 3-5 persons (43%) followed by 6 -8 persons (26%).

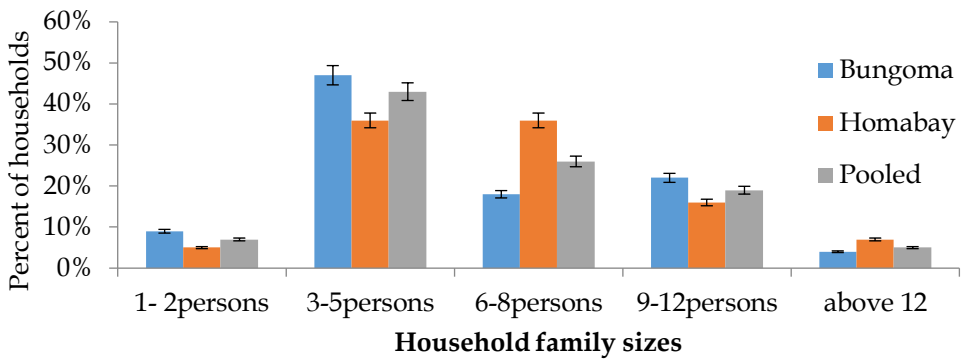

Figure 14. Household family sizes in Bungoma and Homabay Counties

Scale of involvement in sweet potato value chain by farmers Land size and sweet potato acreage

In the current study (Figure 15), a majority (52%) of households owned a total land size of two acres and below. 21% of households owned between two to four acres. About five percent of households owned above 10 acres of land size. A majority (44%) of the households produced sweet potato on a land size of between one to two acres, 31% produced SP on land size half an acre and below while 11% of households produced SP on land size between two to four acres (Figure16).

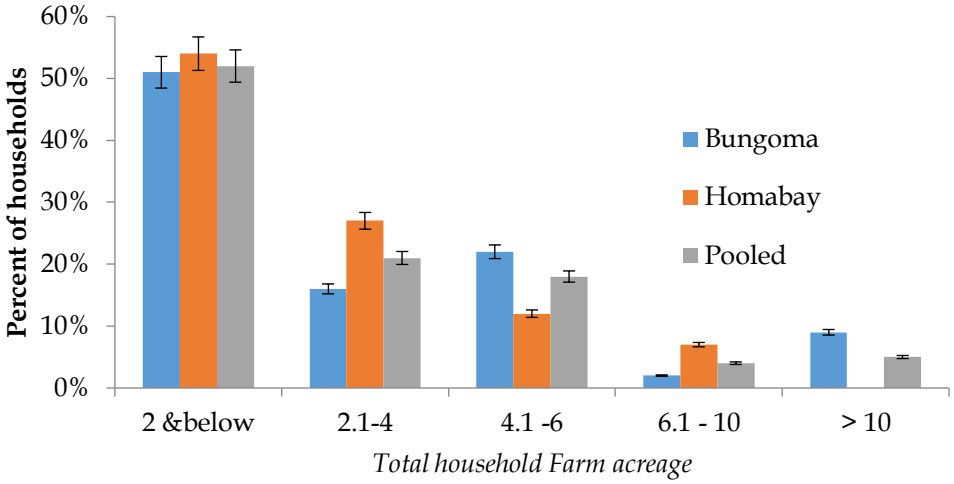

Figure 15. Households' farm sizes in Bungoma and Homabay Counties

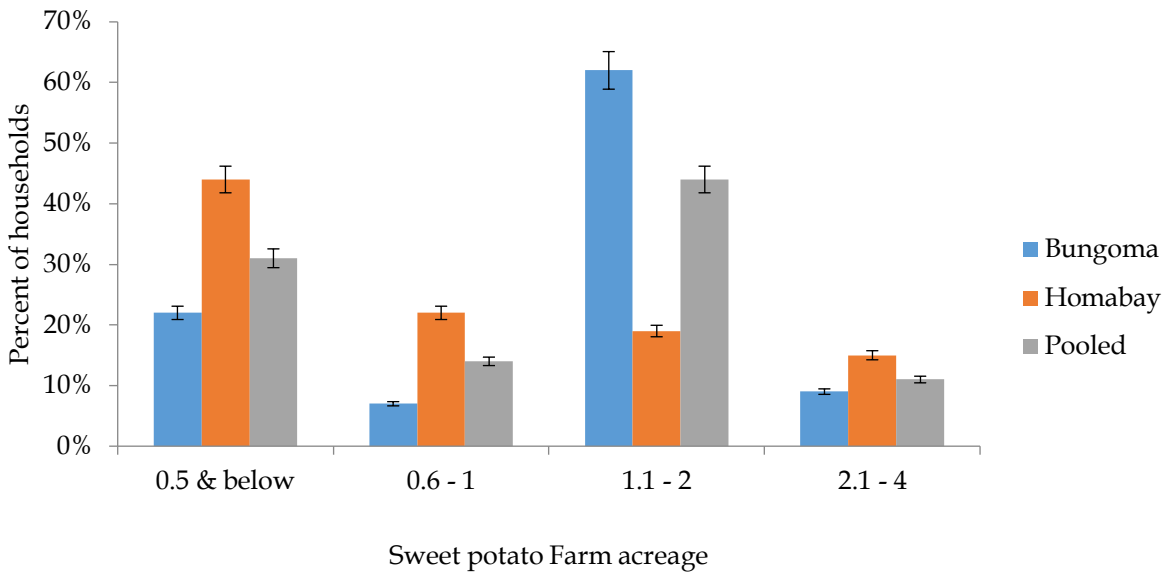

Figure 16. Household sweet potato acreage in Bungoma and Homabay Counties

Source of farm labour

In the current study 87% of households utilized their family members for farm labour while 13% hired unskilled labour (Figure 17).

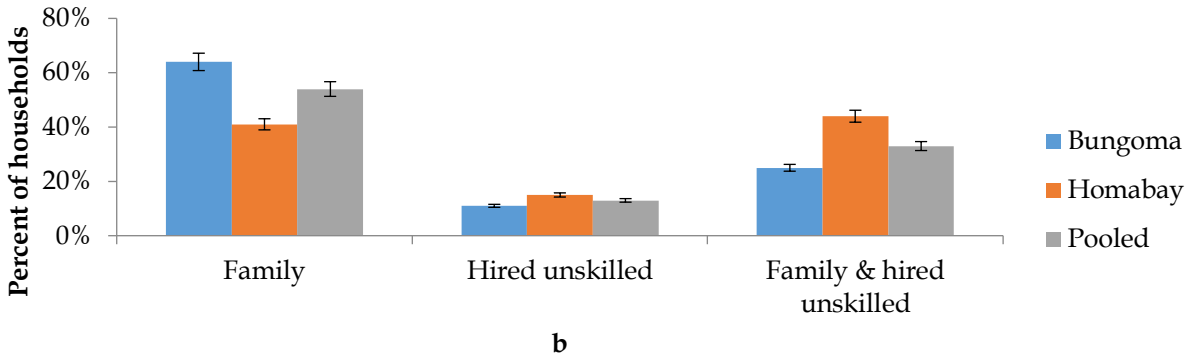

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Figure 17. Source of farm labour for households in Bungoma and Homabay Counties

Traders

Figure 18 shows that 77% of sweet potato traders were retail traders and 23% were middlemen. The retail traders sold products within the local markets while middlemen sold to urban markets.

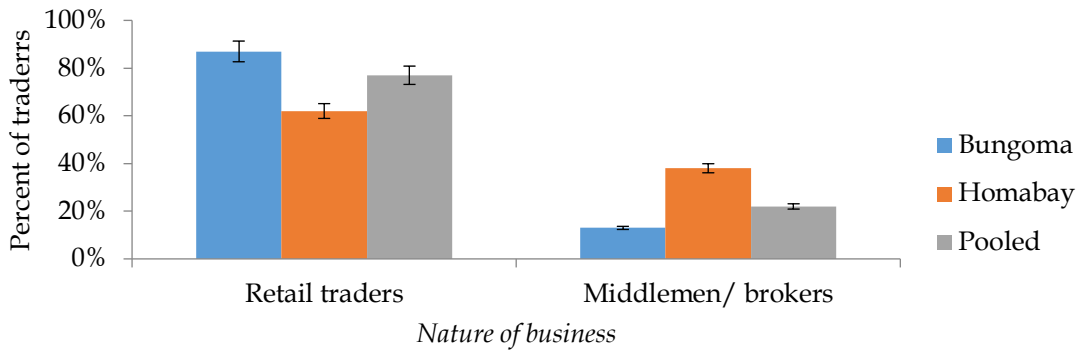

Figure 18. Nature of traders' business in Bungoma and Homabay Counties

Processors

Out of the five processors interviewed, there were two sole entrepreneurs, a cooperative society, a local NGO company, and a group business having been in existence mainly between one and five years. Their operations were on a small scale ranging between 4kg and 400kg of daily production depending on demand for the products and the availability of the raw sweet potatoes.

General Food crops production by households

Farmers practiced mixed crop farming systems with the main crops being maize, sweet potato, beans, bananas, cassava, and local vegetables among others. Sweet potato varieties commonly planted were Kabode, Vitaa, and Ejumula in both counties, Nyathiodiewo (in Homabay), Bungoma, and Kenspot4 (Fundukusia) (in Bungoma) being most popular (Table 1). Kabode and Vitaa (orange-fleshed varieties) had been adopted because of readily available markets and sensitization efforts on nutritional value by various stakeholders. In Bungoma, KSP 4 (Fundukusia) and nyathiodiewo were preferred because of their favorable starch content, high yield, and prolonged continuous harvesting time.

Table 1. Most popular sweet potato varieties grown by farmers in Bungoma and Homabay Counties

Sweet potato variety	% of farmers growing in Bungoma	% of farmers growing in Homabay	Pooled (total % of farmers growing)
Kabode	64%	83%	72%
Vitaa	16%	46%	29%
Bungoma	40%	-	23%
Kenspot4(fundukusia)	36%	-	21%
Nyathiodiewo /nyawoo	-	41%	18%
Ejumula	5%	2%	4%
Miezi tatu	5%	-	3%
Miezi mbili	5%	-	3%
Namaki	4%	-	2%

Harvesting sweet potato roots

A majority of farmers (59%) practiced piecemeal harvesting while 41% practiced wholesale harvesting. Ox-plough, Iron bar (old file), 'Jembe', and wooden stick were tools used by 25%, 21%, 33%, and 21% of farmers respectively for harvesting (Figure 19).

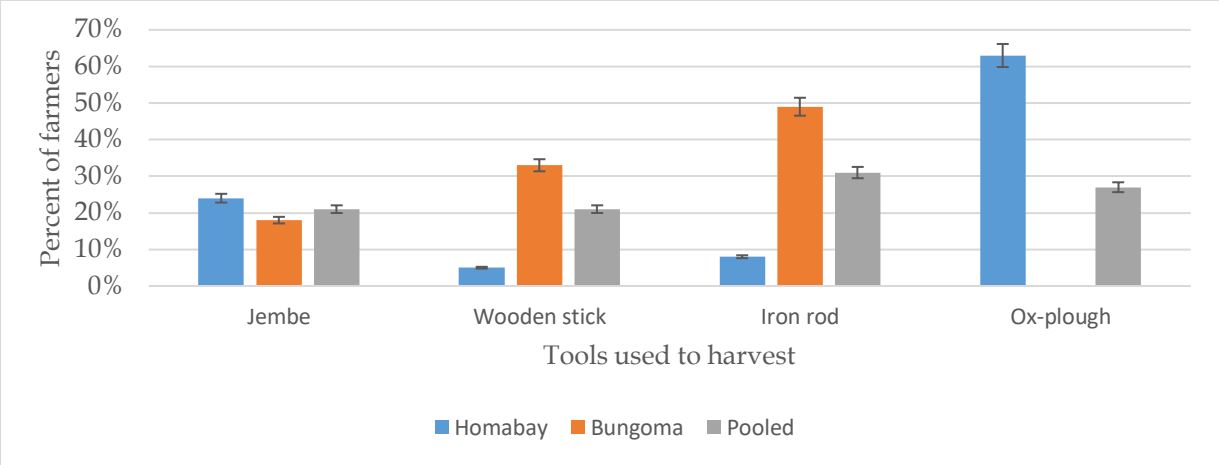

Figure 19. Tools used in sweet potato harvesting by farmers in Bungoma and Homabay Counties

Sorting and grading of sweet potato roots

An overwhelming 93% of farmers carried out sorting and grading of roots mainly according to size, damage, and colour. Five percent did not find it necessary to grade while two percent delivered all roots to cooperative society which did the sorting. It was observed that traders in Homabay county sorted roots according to variety while those in Bungoma sold sweet potato in heaps of mixed varieties as per their customer demand.

Curing sweet potatoes

Curing was limited and practiced by 20% of farmers. About 59% had no idea on curing while 21% did not find it a necessary practice. Curing was not a common practice among the farmers (80%) because they harvested the roots to sell immediately for the readily available market. None of the traders interviewed practiced curing of sweet potatoes. About 40% of the processors had access to curing chambers but rarely used them (Figure 20).

Figure 20. (a) and (b) curing chambers by a processor in Bungoma county and (c) curing chambers by a processor in Homabay County

Storage of sweet potato roots

Farmers

About 57% of the farmers did not practice the storage of roots at all because they reported that they either did not know how to store (43%) or they did not find it necessary since they harvested for immediate sale and had no surplus left (57%). Storage was occasionally practiced by 43% of farmers especially after wholesale harvesting to clear the farm for the next planting. Figure 21

shows storage methods used by those who stored (n=43). Periods of storage varied as follows: 1-14 days (71%), 3weeks to a month (18%), 2-3months (9%), and 5-6months (2%). There was no standardized way of treating the roots before storage (Figure 22); whether to wash or not, sun-dry or not.

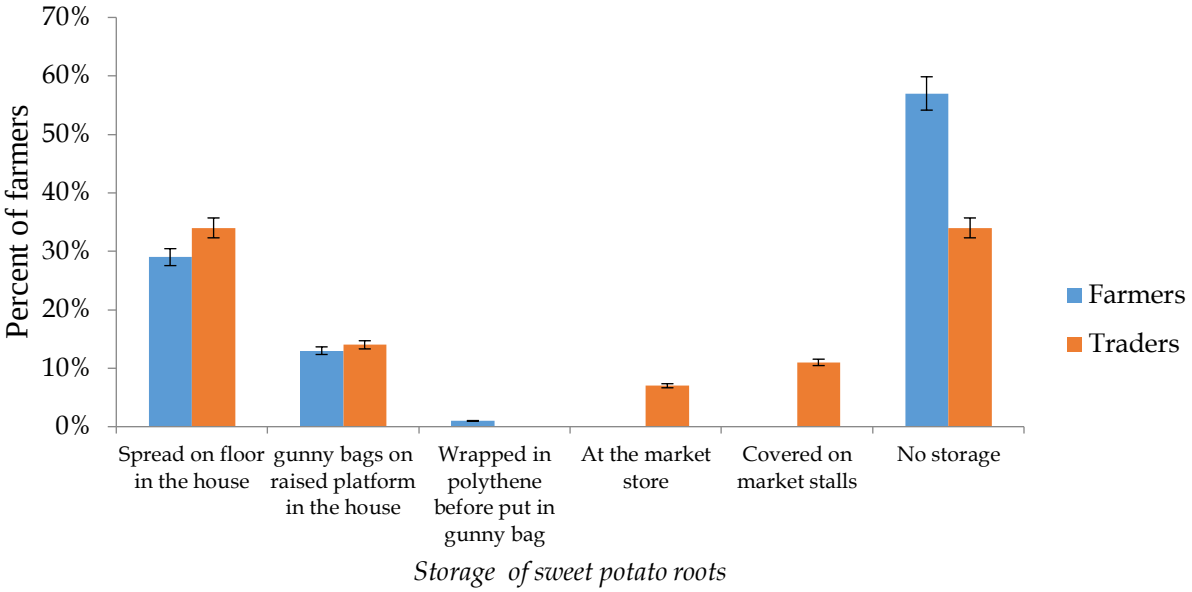

Figure 21. Storage of sweet potato roots by farmers and traders in Bungoma and Homabay Counties

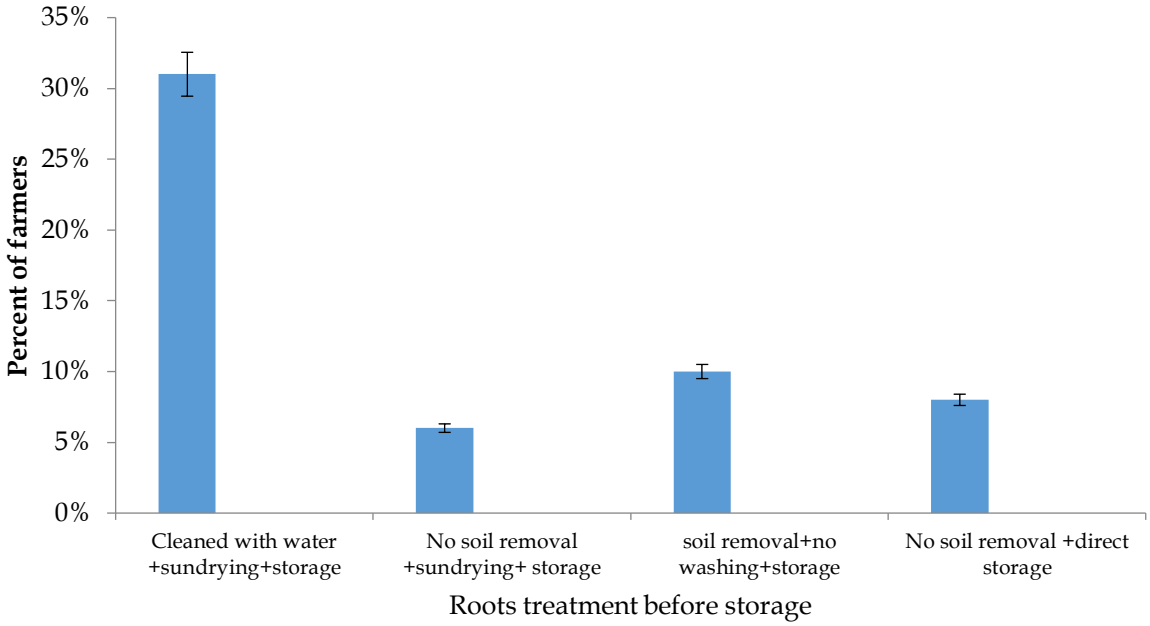

Figure 22. Treatment of sweet potato roots before storage by farmers in Bungoma and Homabay Counties

Traders

The roots were mainly stored at the prevailing room temperature or left on the market stalls. Gunny bags were the most commonly used containers (53%) for storage followed by polyethylene bags (21%). About 19% of those who stored did not use any container.

***Processors*:** Processors did not store raw sweet potato roots with 20% fearing possible rotting (spoilage) but storage of processed products took place. The puree was stored for a maximum of one day in frozen conditions before transportation to prevent spoilage since the product did not have any preservatives. Dried chips were stored for a maximum of six months on shelves within the business premises. Crisps, crackles, and flours were usually stored for a period between one week and one month while bread/scones were stored for two to three days at most on shelves within the business premises at room temperature.

Household consumption of sweet potato roots

A majority (68%) of the households consumed roots twice per week (Figure 23.) Estimated consumption per household was as follows: 1-5kg (71%), 6-10kg (21%), 11-15kg (2%), 16-20kg (3%) and 25-30kg (3%). All households reported that they consumed the roots mainly boiled with or without skin and also mashed with other food. About 15% of respondents occasionally consumed fried slices/crisps/chips, roasted roots, sweet potato flour, or composite flour. Flour from the orange-fleshed roots was used in porridges especially for children.

The average per capita consumption of sweet potato for both counties combined stood at about 55.9kg per year (Bungoma County 54.8kg and Homabay 57.29kg) which is about twice the country's figure.

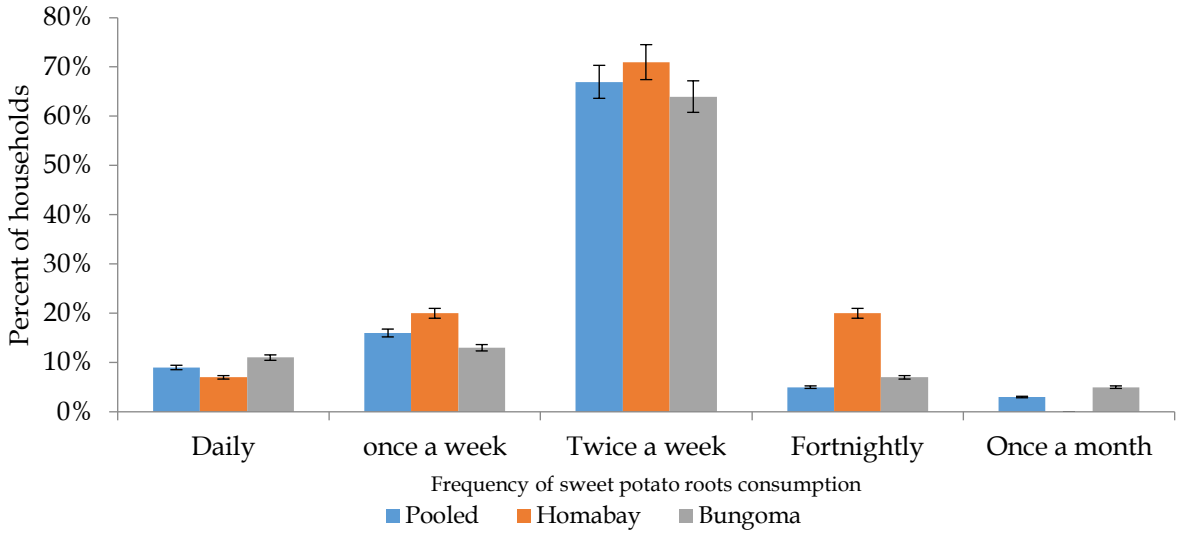

Figure 23. Frequency of sweet potato roots consumption by households in Bungoma and Homabay Counties

Processing of roots

Farmers

About 56% of farmers did not practice any form of processing of sweet potato roots because of lack of knowledge (63%), lack of processing equipment (7%), low sweet potato production (10%), or simply lack of interest (20%). Forty-four percent of farmers did minimal processing due to the availability of the roots to fetch some income or for household consumption. Among those who processed, it was done within 24hours (by 46%), within 49-72hours (by 34%), or 1-2 weeks (by 4%). Processing took place in a room/kitchen in the house or at a yard outside the house. Kabode, vitaa, Bungoma, 'mwezi moja', kanduyi, namaki' and nyathiodiewo/Nyawoo sweet potato varieties were used in processing by 36%, 15%, 3%, 1%, 1%, 1%, and 7% of farmers

respectively because of their nutritional value (orange-fleshed varieties), sweet taste and color. Various products (Figure 24) that farmers processed from sweet potato roots included dried chips and flour (by 36%), juice (by 2%), fried chips (2%), and doughnuts (2%). There was reported evidence of limited processing of roots into dry chips for flour for various uses or fried chips.

Figure 24. Some sweet potato products (a) Dried chips (b) scones and bread (c) flour (d) sweet potato puree

Domestic or small-scale/equipment used in processing included knives, chippers, graters, blenders, pounding mortar, and grinding mill. Major challenges cited by farmers in processing sweet potato roots were lack of appropriate processing equipment/tools, high cost of processing equipment, and inadequate knowledge on processing as rated by 64%, 63%, and 53% of farmers, respectively.

Processors

Table 2 shows the products, volumes, and frequency of production by processors in both counties of study. About 60% of the respondents processed the roots within 24 hours after harvest while 20% processed within 4days at the maximum. The frequency of processing varied from daily to seasonal depending on the products and type of customers. About 20% did processing at the home yard, 20% rented a room at the market centre, 60% processed from designated premises though 20% of these rented the premises. Assorted processing equipment were used by the processors including washers, slicers, manual extruder for crackers, electric sealers, baking equipment, graters, grinding mill, Chippers, solar dryer, 'pangas', knives, Puree machine, and steam boiler (Figure 25).

Figure 25. Some processing equipment: (a) sweet potato washer, (b) flour miller, (c) assorted equipment at the puree processing plant- Homabay, (d) baking chambers in Bungoma

Table 2. Sweet potato products, volume, and frequency of processing

Nature of business		Dried chips	Flour	Composite flour	Crisps	Crackies	Bread and scones	Puree	Animal feed
Sole proprietor	Volume Frequency	4kg daily	- -	- -	50kg monthly	- -	- -	- -	- -
Sole proprietor	volume Frequency	4kg weekly	8kg Weekly	40kg weekly	- -	- -	- -	- -	- -
NGO company	volume Frequency	100kg daily	- -	- -	- -	100kg weekly	24kg weekly	- -	- -
Group business	volume Frequency	- -	- -	- -	- -	- -	- -	300kg Daily	- -
Marketing cooperative society	volume Frequency	- -	300kg fortnightly	200kg daily	- -	- -	- -	- -	200-400kg Daily; fortnightly

Marketing of sweet potato products

Farmers

Only 10% of the interviewed farmers did not sell sweet potato roots compared to 90% who did. About 29% of the respondents did not package their products when selling. Gunny bags were used by 60% of farmers to package the roots while polyethylene bags were used to package products for sale by 11% of farmers (Figure 26). About 15% of respondents sold the roots at the farm gate, 63% sold to the local market, 6% took to the urban markets while 6% took to the marketing cooperative society (Figure 27). The buyers of the roots and other processed products were final consumers (24%), traders (25%), brokers (24%), and processors (20%). Instead of using weighing scales, the roots were sold using bags or buckets to determine the quantity. Challenges experienced in marketing included low prices of products (53%), unstable prices (36%), high perishability of sweet potato roots (21%), middlemen interference (25%), and poor road network (19%). Several coping strategies used by farmers for the challenges they faced included selling at farm gates (27%), selling through marketing cooperative society (35%), preserving for later sale (18%), and direct selling to consumers without passing through brokers (2%). Some farmers (11%) had no idea what to do about their challenges.

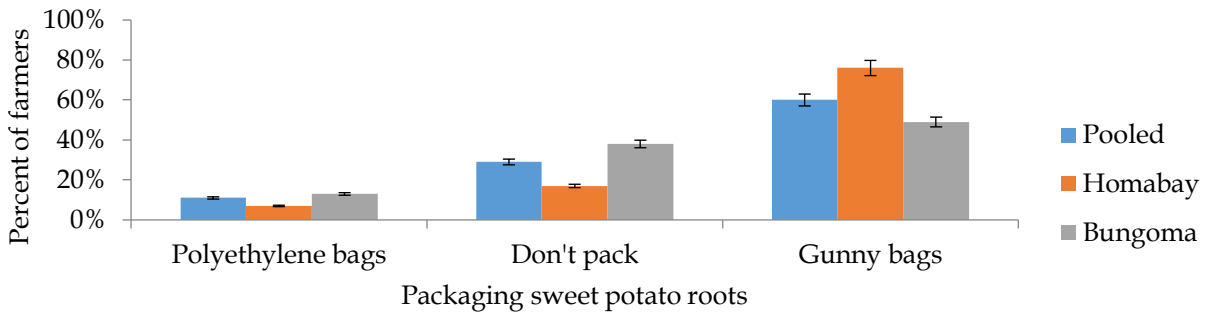

Figure 26. Packaging of sweet potato roots for sale by farmers in Bungoma and Homabay Counties

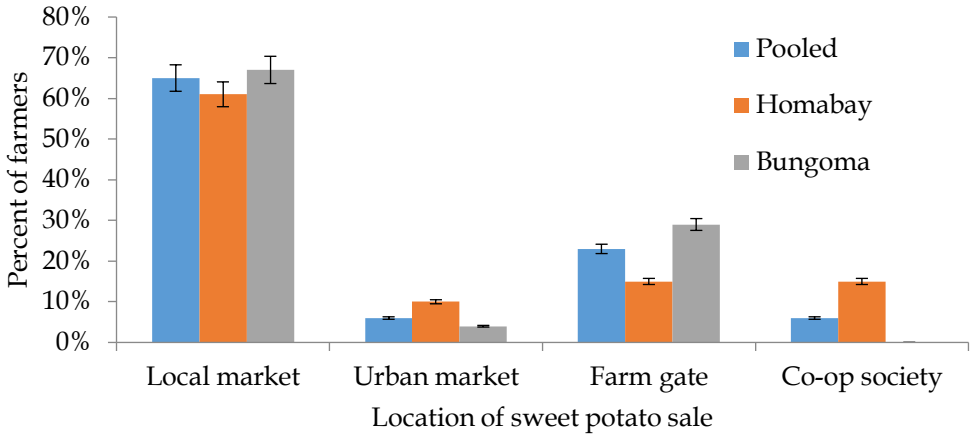

Figure 27. Location of sale of sweet potato roots by farmers in Bungoma and Homabay Counties

Traders

About 97% of the traders sold raw roots while 13% (at the main markets) sold already boiled roots. A majority (78%) of the traders sourced their sweet potato roots for sale directly from farmers, 14% sourced solely from the open markets while eight percent sourced from brokers /middlemen. On average the raw sweet potato roots were bought two to three times per week by a majority (59%) of the traders, followed by daily with 33% of the traders and weekly by 8% of the traders.

Unit of purchase and sale of roots

Figures 28, 29, and 30 show units of purchase and sale of sweet potato roots by traders. The main unit of the sale in Bungoma was heaps/piles at about 94% while in Homabay it was predominant at 42%. The main buyers of the roots were final consumers who constituted 63% in Bungoma County and 46% in Homabay County while 15% of traders sold roots to processors/millers.

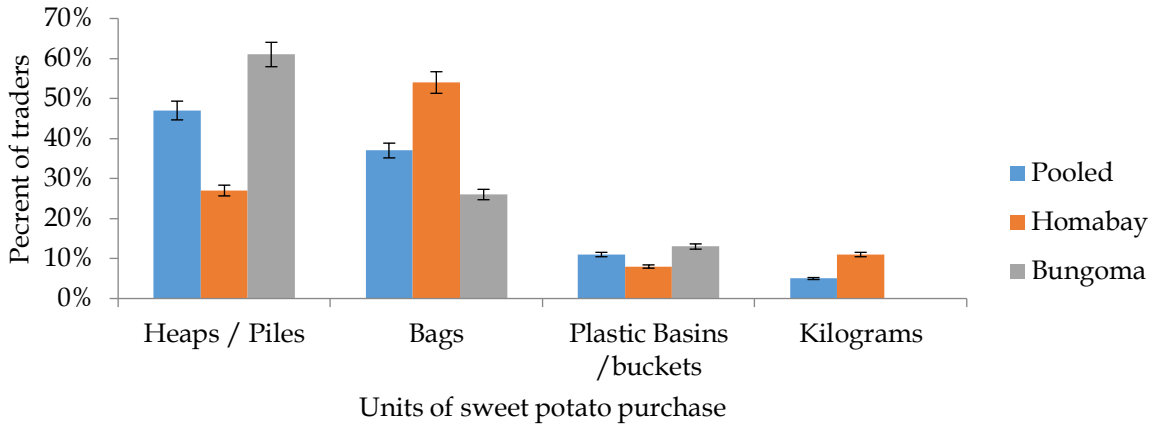

Figure 28. Units of sweet potato purchase by traders in Bungoma and Homabay counties

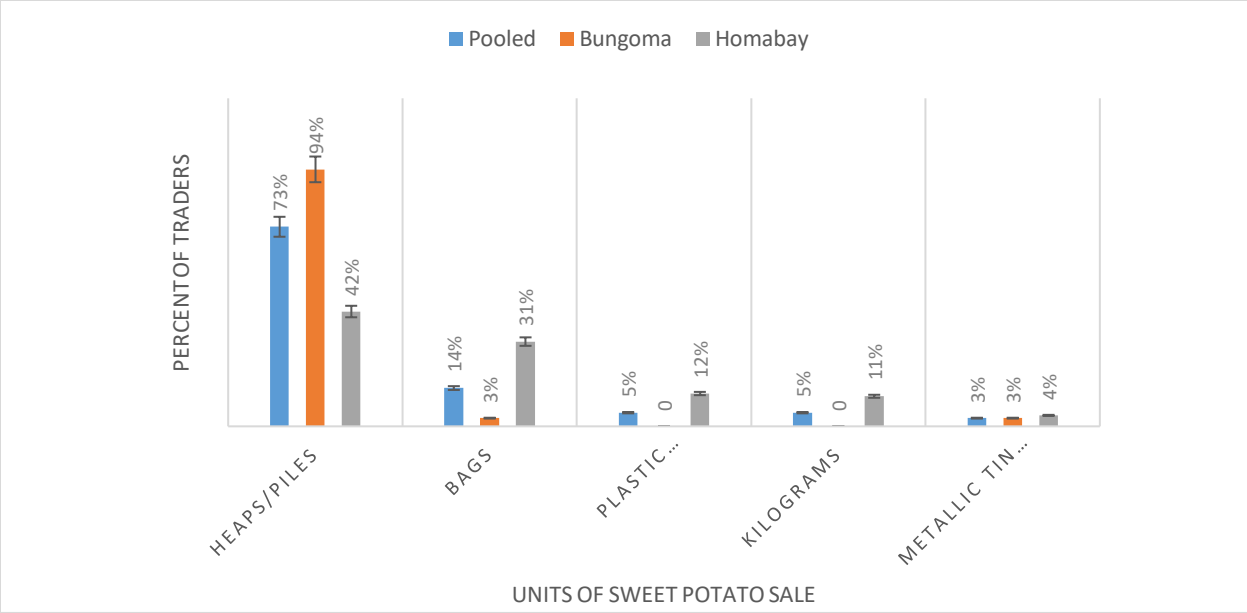

Figure 29. Units of sweet potato roots sale by traders in Bungoma and Homabay Counties

Figure 30. Units of trade for sweet potato in Bungoma and Homabay counties. (a) traders at market selling in heaps, (b) trader along with the highway selling in buckets, (c) a trader selling in bags, (d) a farmer selling in kilograms

Processors

Flours, dried chips, puree, and animal feeds were sold by weights. Loaves of bread were sold in pieces (numbers), scones were sold in packets of a dozen pieces, crackles and crisps were sold in sachets of 100g. Processed sweet potato products were sold to both final consumers and retailers a majority of who were within the counties. Sweet potato puree was transported daily to Nairobi City for use in bread making. Flour was sold locally and consumers blended the flours for use in making porridge, bread, and cakes for home consumption or sold for household income generation. Crackles and crisps were mainly sold to school pupils. Dried chips were sold to consumers who mixed them with other grains like millet, maize before milling.

No marketing promotion was done for products like puree, crackles, and bread. Puree production daily took place in a newly established company in Homa Bay County, which operated below its design capacity. Dried chips, flour, crisps, and animal feeds, however, required sales promotion.

Transportation of sweet potato roots

From the farm, sweet potato roots were either transported directly to the local trading centers / open-air markets (40%) or the marketing cooperative society (14%) or the homestead first (39%) or sold directly to buyers on the farm (6%). The roots were carried in gunny bags (88%) or buckets (9%) or baskets (3%). Distance from households to the markets ranged from 20metres to 20km. About 66% of respondents covered 1-5km to deliver roots to the markets, 16% covered not more than 500metres, 2% covered 6-10km

while 3% covered 11-20km to the markets. The modes of transport used are shown in Figures 31 and 32.

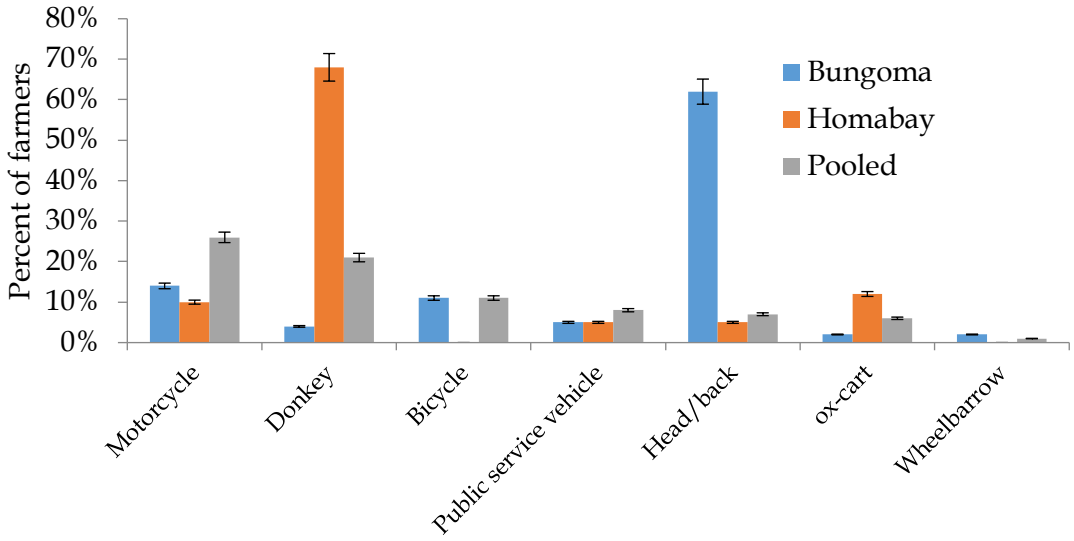

Figure 31. Mode of transport for sweet potato roots by farmers in Bungoma and Homabay Counties

Figure 32.Donkey and ox-cart used to transport roots to the markets

Traders

Ox-cart usage was high in Homabay County at 31% while bicycle and back/head usage were common in Bungoma at 26% each (Figure 33).

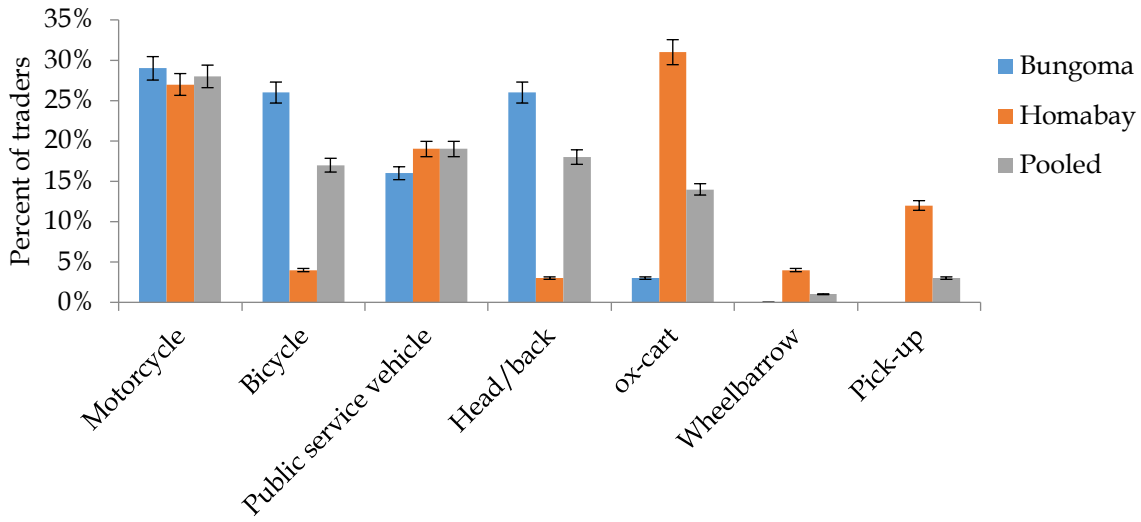

Figure 33. Transport mode for sweet potato roots by traders in Bungoma and Homabay Counties

Sweet potato Losses

Farmers

Table 3 shows estimated percentage of losses by famers at different stages of handling. Losses occurring during harvesting were mainly due to mechanical injuries. Losses of roots during transport were due to dropping off, bruises, and tearing of the bags.

Table 3. Causes of sweet potato losses incurred by farmers

	Percent of farmers		
Causes of loss (%) during harvest	**Pooled (overall)**	**Bungoma**	**Homabay**
Mechanical injury/bruising	61	59	65
Theft	5	6	3
Pests damage	30	25	35
Rotting	31	31	32
Causes of loss (%) during transport			
Bruises	24	36	-
Theft	`16	16	17
Falling off	72	59	96
Estimated loss (%) at the storage			
Theft	12	17	-
Rotting	67	57	92
Pests	38	43	25

Traders

Nearly half of the traders (44%) experienced some losses during transportation of the roots, about 45% experienced losses at storage, while 31% experienced losses at the market. The causes of losses experienced are also indicated in Table 4.

Table 4. Causes sweet potato losses incurred by traders

	Percent of respondents		
Causes of loss (%) during transport	**Pooled (overall)**	**Bungoma**	**Homabay**
Mechanical damage	57	59	9
Theft	21	23	18
Package tearing /Falling off	22	18	18
Causes of loss (%) during storage			
Theft	23	29	13
Rotting	45	29	74
Pests/molds	23	28	13
Causes of loss (%) at the market			
Theft	44	36	60
Withering	50	55	40

Processors

Crisps and sweet potato flour losses of 10-20% were experienced during storage by 40% of the processors while sweet potato puree, flour, and composite flour losses of less than 10% were experienced by 60% of the respondents (Figure34).

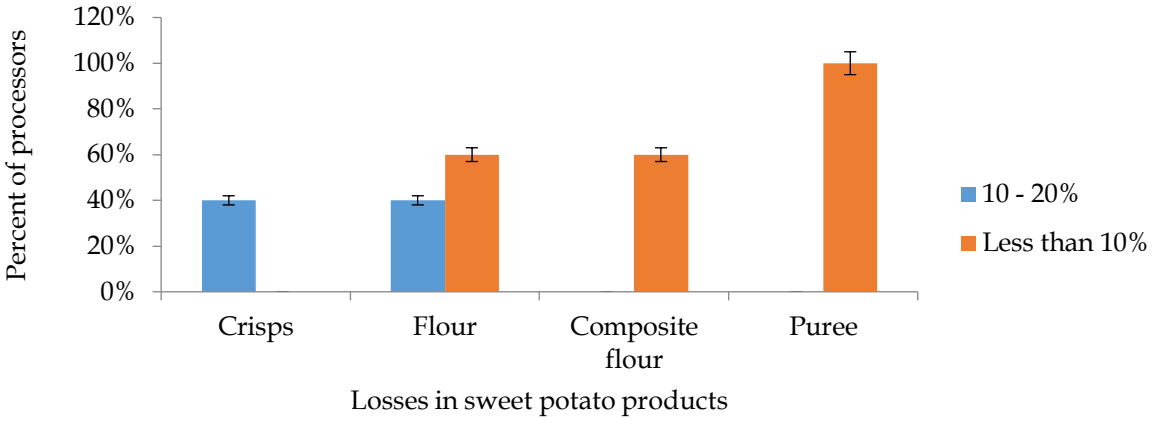

Figure 34. Losses in Products processed from sweet potato roots in Bungoma and Homabay Counties

Challenges encountered in the sweet potato trade

The major challenge cited by all the processors was the seasonal supply of roots. Minor challenges were lack of appropriate packaging, Low demand by consumers, high perishability of roots, and non-uniform quality of materials. Figures.35 and 36 show the challenges experienced in the sweet potato trade by farmers and traders respectively.

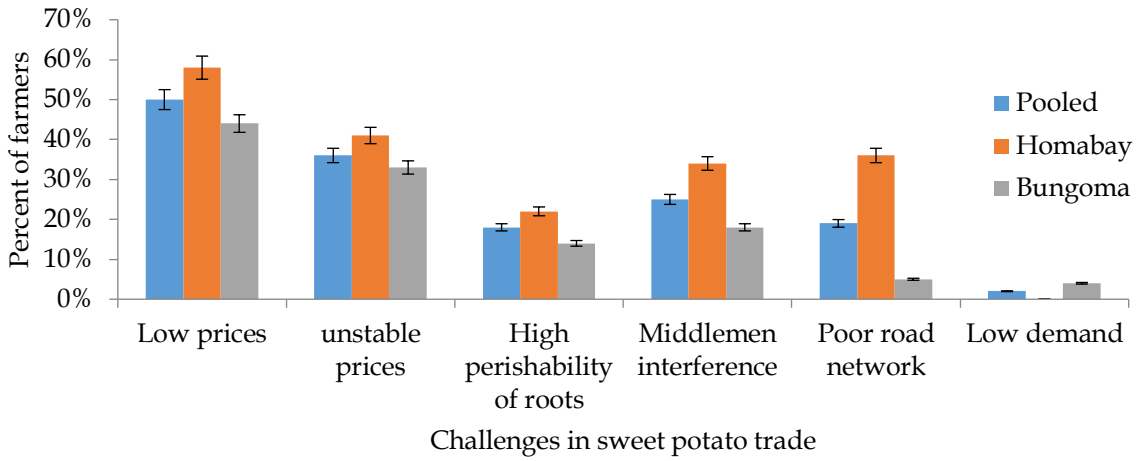

Figure 35. Challenges experienced by farmers in the sweet potato trade

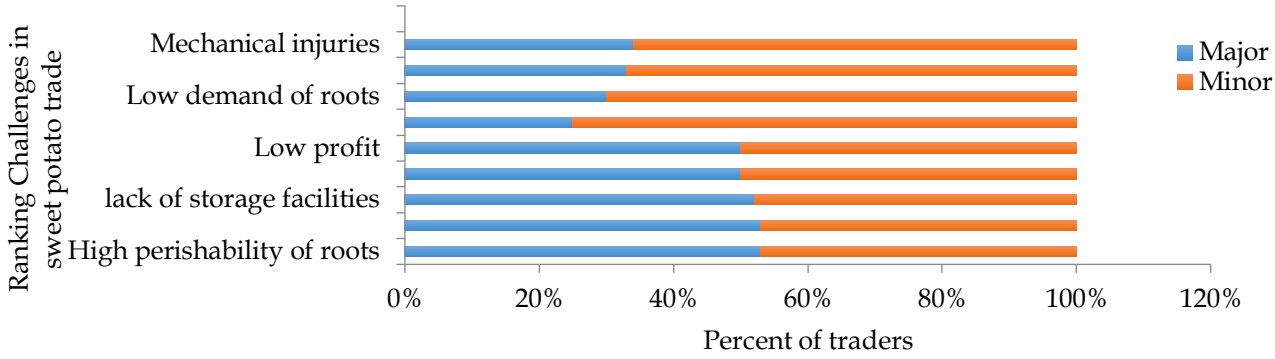

Figure 36. Ranking challenges in sweet potato trade in Bungoma and Homabay counties by traders

Suggestions on improving postharvest handling of sweet potato roots

Farmers

Figure 37 shows farmers' suggested areas of assistance**.** Training of farmers on storage, preservation, curing, and processing technologies.

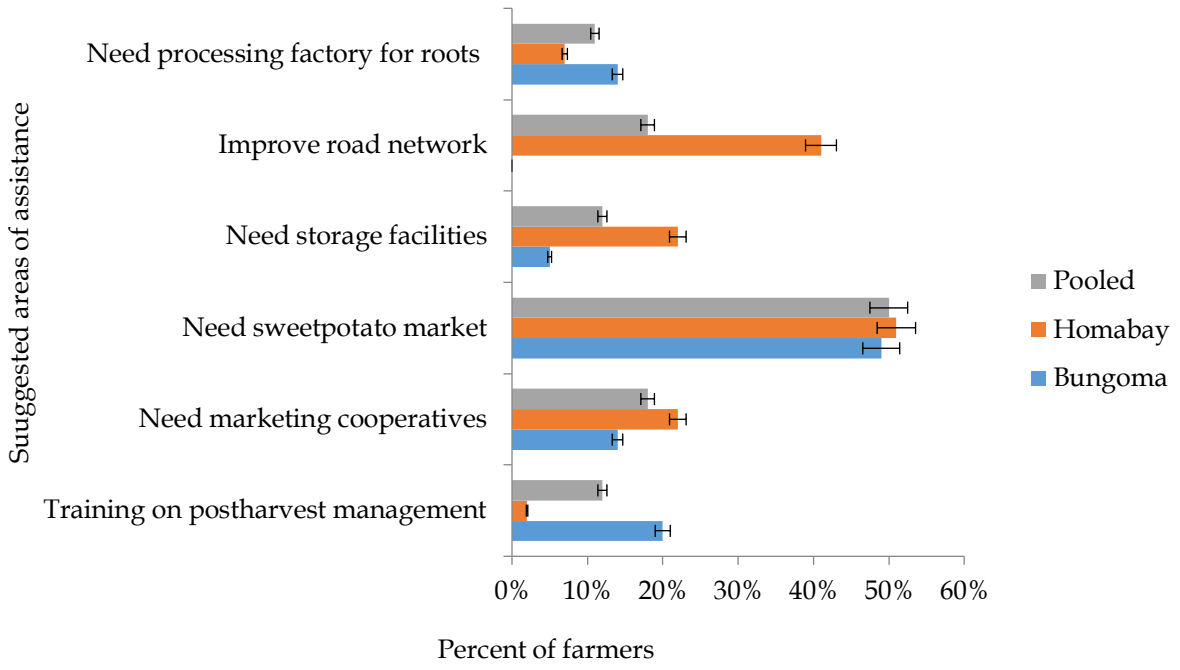

Figure 37. Farmers' suggested areas for assistance

Traders

Figure 38 shows the traders' suggested areas of assistance such as the need for trade associations (29%), need for storage facilities (22%), financial assistance (12%), need for weighing scales (8%), need training on marketing (7%), improve road network (7%) and better packages for the roots.

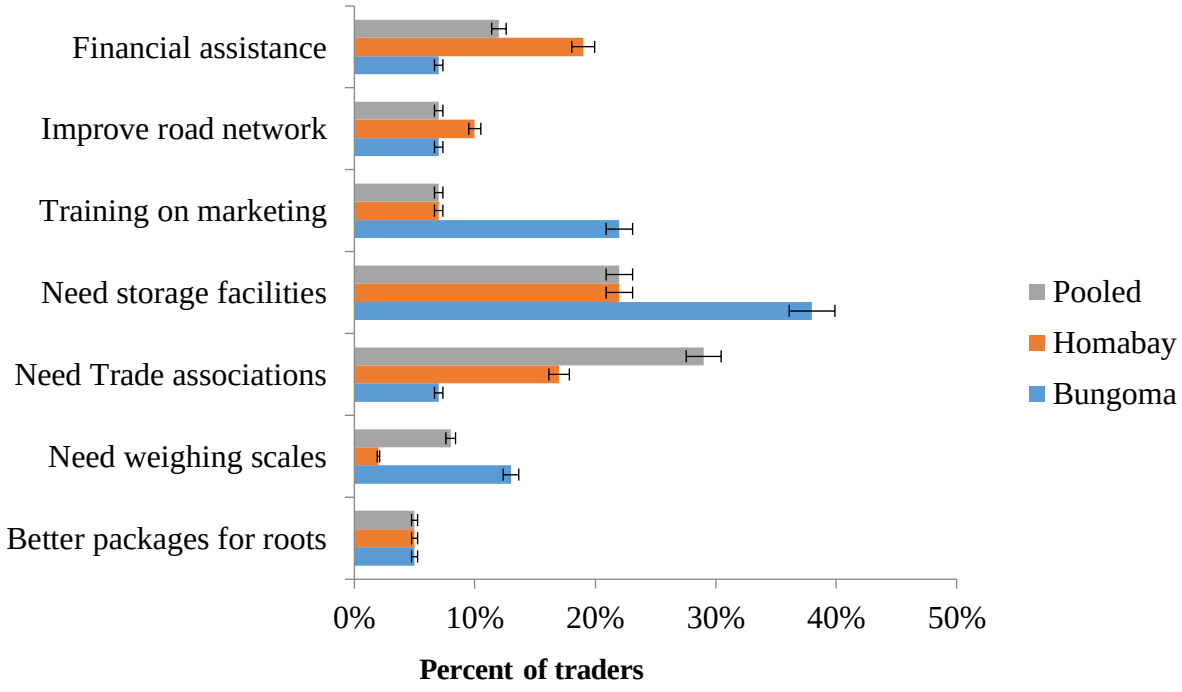

Figure 38. Traders' suggestions for assistance in Bungoma and Homabay Counties

Processors.
Suggestions (Figure 39) varied from financial assistance to purchasing large-scale processing equipment (40%), more training on processing skills (40%), need for sweet potato policy to encourage consumption (20%), and storage facilities for sweet potato when in season (40%).

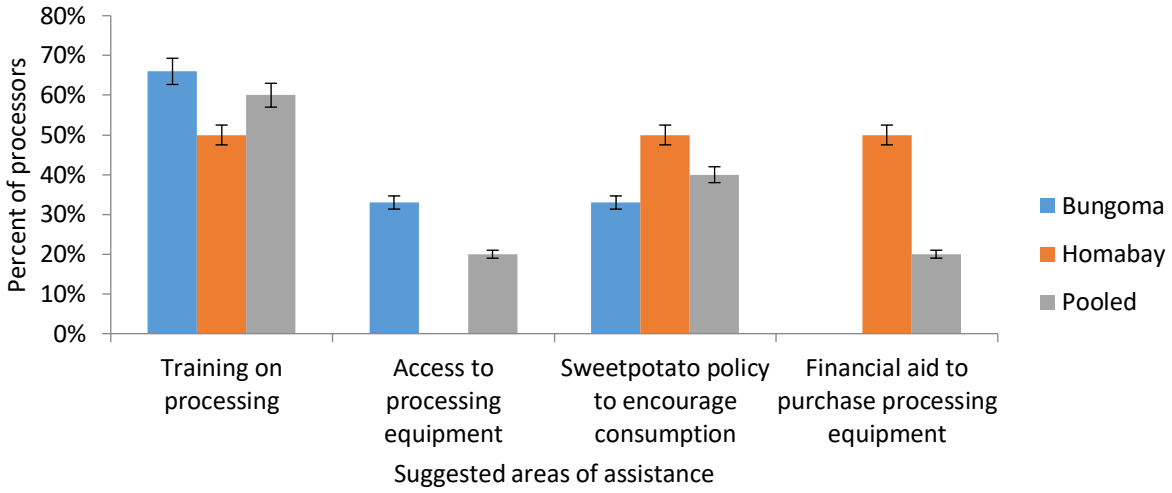

Figure 39.Processor's suggested areas of assistance in Bungoma and Homabay Counties

Discussion

Socio-demographic characteristics of respondents in Bungoma and Homabay counties
Gender distribution
It could be assumed that either some of the men were employed elsewhere, the reason they were not available for interview, or sweet potato was perceived as a woman's crop especially in Bungoma County. It has been cited elsewhere (Andrade *et al.,* 2009) that non-commercial production of sweet potato was mainly under the control of women. The dominance of women may be a possible indicator of the low-income returns from the crop and cultural perceptions towards the sweet potato being viewed as a feminine crop as explained by the agricultural extension officers. This is similar to an earlier study finding that women were dominantly involved in the sweet potato marketing systems (Mukras *et al.,* 2013).

The numbers of processors were very few probably because sweet potato processing is less developed in Kenya. Probably lack of knowledge and skills in sweet potato processing could be one of the reasons for low processing. The involvement of men in sweet potato processing was slightly higher than women's in Bungoma County while only men were involved in the same in Homabay County (Figure4). This can be attributed to the scale of processing and nature of products. A previous study noted that sweet potato processing in the villages in western Kenya was mainly carried out by members of women groups after being trained on value addition by home economics officers of the Ministry of Agriculture (Mkuki, 2018). The role of women in the sweet potato value chain should therefore not be underestimated since they are actively involved in all the areas along the value chain.

Age distribution
There was more youth (18-35 years) involvement in sweet potato trading compared to farming and processing. It is common knowledge in Kenya that most of the youth do not own land since family lands especially in rural areas are ancestral thus the discretion of being apportioned ownership usually lies with the parents. This has also been reported in a different study, that many of the farmers used family land which is usually not yet subdivided to persons aged between 15

and 35 years (Kivuva, 2013; Mkuki, 2018). At ages 36-45years there was peak involvement in farming, trading, and processing sweet potato, and this diminished as age increased from 46 years. This indicates that sweet potato has the potential to offer employment opportunities to the most productive age groups of the population, especially in rural areas. All sweet potato processors were aged above 30years, at which point most people in Kenya have completed tertiary education and have had some work experience hence have a high possibility of possessing skills and some capital for starting up business ventures.

Education

Literacy levels were generally high among the farmers, traders, and processors implying that there was the ease of comprehension of ideas during the interviews thus saving on time that would have been used for translation. It is highly unlikely that college graduates will be involved in sweet potato farming and trading in rural areas. This may be perceived to mean that the crop gives minimal returns thus college graduates would opt to be employed elsewhere in urban towns. Processing was likely to be undertaken by people with tertiary education since advanced skills are required. This agrees with the observations of other authors (Bihari Singh *et al.,* 2017; Mukhtar *et al.,* 2010).

Marital status of farmers.

Males are usually heads of households and in most cases regarded as decision-makers in the Kenyan context. Culturally, the women usually have little say on-farm use since most rural farms are inherited from parents. This phenomenon was also observed in other studies (Malavi, 2017).

Occupation of households

Farming being the main source of livelihood for the majority of the rural households (Figure13) implied the need for sweet potato farming to be carried out as a commercial activity to sustain rural livelihoods as well as improve incomes.

Family sizes

Traditionally in African societies, large families were cherished because they would provide readily available labour for the farms.

The scale of involvement in the sweet potato value chain by farmers

Land size and sweet potato acreage

Sweet potato being dominantly a small-scale farmers' crop finding, agrees with a previous past study Kenya (Malavi, 2017; Nations, 2019). Land sizes in Kenya continue to diminish due to subdivisions occasioned by ever-increasing population and this can result in over-use and reduced soil fertility. Sweet potato is therefore a potential crop that can survive under such marginal conditions. Production of sweet potato was could be an indication that farmers also have other priority crops planted on their farms and the sweet potato could be primarily for domestic consumption. Sweet potato was grown on half an acre or less by most households in Kenya (Malavi, 2017; Nations, 2019).

Source of farm labour

In the current study where a majority of households utilized their family members for farm labour, this could be in line with low acreage under the crop that would not require hired labour and hence a possible indicator of low income from the crop promoting the use of family members as a cheaper source of labour. The use of family members for farm labour could also be due to the inability of the households to fully hire farm labour since their main occupation was farming.

Traders

The retail traders sold products within the local markets while middlemen sold to urban markets. Middlemen become particularly important when they have to access the farmers in the furthest remote places to buy their sweet potatoes since farmers themselves may lack knowledge of markets and means to transport their produce.

Processors

Processing sweet potato seems a new venture since the local population has been used to the consumption of boiled roots for much of the time, they have known the sweet potato.

General Food crops production by households

The practice of mixed crop farming is common among small-scale farmers who grow crops firstly for subsistence and secondly for income

generation when there was a surplus. This phenomenon was also observed in another study[14]. This could be attributed to the small size of farms which required maximum utilization since the main occupation of more than half of the farmers interviewed was farming. Sweet potato ranking second among crops grown and first among roots and tubers is an indication that it has high potential whose value should not be underestimated. New varieties of sweet potato will always be adopted cautiously by farmers while still holding on to the local familiar varieties[14]. Varieties with consumer-desired attributes are most likely to be adopted since they will have ready markets. There is a need for breeders to develop varieties that encompass all the desired attributes.

Harvesting sweet potato roots: Piecemeal harvesting was practiced mainly to extend the crop's season since the crop served both roles of food security and income generation. Besides, the farmers harvested the exact amounts for sale as per the demand hence the use of wooden sticks and iron bars. Wholesale harvesting was mainly practiced when the land was required for the establishment of a new crop hence the use of '*jembes*' and ox-ploughs. Piecemeal harvesting can be time-consuming and tricky to plan since it is dependent on the availability of an unpredictable market. Wholesale harvesting can be economical in terms of labor and time requirements. Sweet potato roots are susceptible to mechanical injuries due to the tools used in harvesting. A lot of care is thus required during harvesting to ensure minimal injuries occur.

Sorting and grading of sweet potato roots
Sorting and grading are two practices that are important in marketing and value addition. It is common knowledge that most of the time consumer behavior dictates the market practices.

***Curing sweet potatoes*:** Curing may be necessary for large-scale farmers who practice wholesale harvesting and probably for storage when the market for the roots is not immediately available. Cured roots can maintain their desired market quality attributes like insignificant loss of weight, no rotting, and absence of sprouting (Chang *et al.,* 2016). None of the traders interviewed practiced curing of sweet potatoes. This could be attributed to either lack of knowledge or storage facilities for the roots, or both. Processors' access to curing chambers that were rarely used was probably because they received a lower volume of roots then processed them immediately. Poor linkages between farmers and processors may be the cause of inadequate supply of the roots. Since the processors had curing chambers that were rarely used (Figure 20), perhaps the facilities could be utilized for curing roots for the farmers to encourage storage. There is a need to establish the behavior of different sweet potato varieties when subjected to curing conditions.

Storage of sweet potato roots
Farmers
From the current findings, storage by farmers seemed an afterthought since it would happen especially after wholesale harvesting in clearing the farm for the next planting and storage would take place in the houses and not designated stores. Lack of knowledge and appropriate facilities could be the main hindrance to storage hence farmers did piecemeal harvesting to avoid incurring huge losses after harvesting. Besides, the roots are also bulky and would consume a lot of space in the houses where they were most likely to be stored. There was no standardized way of treating the roots before storage, probably the reason why most farmers would not risk trying it.

Traders
There is a high likelihood that the market centers do not have enough storage space for sweet potato roots such that many traders had limited options to either leave them on the stalls or carry them back home. This could be cumbersome since the roots are bulky to transport and also highly perishable. This situation could be one of the main reasons why traders would purchase roots several times in a week in small manageable volumes.

Processors
Processing of roots can be a way of ensuring longer shelf life for supply throughout the year. The processors require training on how to preserve sweet potato products for a longer period so that they can be able to process in large volumes.

Household consumption of sweet potato roots

The frequency of roots consumption was likely increased when the roots were in season. This finding is similar to what has been reported by another study that the frequency could be due to the sweet potato being a second staple crop (Chang *et al.,* 2016). The quantity consumed was influenced by the family size and seasonality of sweet potato roots, among other factors. It was evident that boiling was still the main form of preparation and consumption. This could be due to fact that boiling was the easiest and less costly cooking method as it requires only water while frying would incur extra cost for cooking oil. Sweet potato consumption in the study areas was still low probably because it was consumed as an accompaniment to tea and mainly as boiled.

Kenya has an average per capita consumption reported as 24kg per year (Rose and Vasanthakaalam, 2011; Shekhar *et al.,* 2015), while Uganda has 90 – 100kg, and Rwanda has 100 – 300kg (Jones, 2012; Rose and Vasanthakaalam, 2011; Wie *et al.,* 2017). Kenya's national per capita consumption is lower than those for Homabay and Bungoma counties probably because consumption by other counties with less or no sweet potato production could be presumably very low. Consumption in Kenya could probably be increased if the sweet potato can be prepared in different ways or processed into various products.

Processing of roots

Farmers

The on-farm processing was perhaps occasioned by the availability of roots during the harvesting season. The level of processing by farmers in the current study was informal and subsistence since most of the farmers were secondary school leavers with little knowledge on processing probably acquired informally through friends. The simplicity of tools/equipment used, processing at home, and products show a desperate desire by farmers to process sweet potato to reduce waste and increase consumption especially in seasons of plenty. The challenges of lack of processing skills and equipment could be the main hindrance to the processing of sweet potato roots and subsequent low production of roots due to lack of market to absorb them.

***Processors*:** As evidenced by the results, several products can be processed from sweet potato roots. The demand within localities was already above the volume of production. This calls on the processors to up-scale production to reach even wider markets. Perhaps up-scaling production could provide a market for the volumes of roots supplied by farmers. Low production by processors was attributed to an inadequate supply of roots or low capacity processing equipment. Setting up processing facilities is a big investment that may require efforts from organized groups or a good source of funding.

Marketing of sweet potato products

Farmers

Instead of using weighing scales, the roots were sold using bags or buckets to determine the quantity. In most cases, the buyers came with their gunny bags which were notably bigger than the normal gunny bags used by the farmers. Farmers are thus vulnerable to exploitation by buyers due to the existing informal marketing systems. Most of the challenges experienced in marketing could be as a result of farmers operating as individuals. If they organized themselves in marketing groups they would stand better chances of benefiting more due to greater bargaining power.

Traders

The main target consumers for boiled roots were the traders in the market since it's where they spent many hours of the day. This seemed to be a new venture whose adoption is yet to be observed. Majority of the traders sourced their sweet potato roots for sale directly from farmers, implying that the main marketing channel is farmers selling the roots directly to retailers who sell directly to consumers as was also observed in an earlier study (Mukundi *et al.,* 2013). The frequency of purchase of the roots was influenced by the local market days and seasonality of availability of sweet potato roots. The traders said that they bought to sell immediately during the market days since they did not have storage facilities. Most markets did not have storage facilities thus traders had to transact in small volumes to avoid incurring huge losses of roots,

this means that it can be very costly to transport roots several times in a week depending on how far the source of the roots is and/or the state of the road network. Perhaps the availability of storage facilities would encourage traders to buy roots in larger consignments which would be economical to transport.

Unit of purchase and sale of roots

The most commonly used measurement units of purchasing and sale of sweet potato roots by traders were non-standardized. Maybe the traders earned more by selling in heaps after buying in bags. These traditional (non-standardized) practices could be happening due to a lack of weighing scales among farmers and traders. These informal units of measurement are therefore subjective and pose a great risk of exploitation for both the seller and the buyer since the objects and containers used are not standardized. The use of informal measurements can make it difficult to quantify actual economic value or losses in the sweet potato trade.

A different research showed that over 70% of sweet potato produced in Kenya were sold in unorganized and informal markets where farmers fetched low prices (Rose & Vasanthakaalam, 2011). Formal measurements should therefore be encouraged and gradually adopted by all to realize the maximum commercial potential of the sweet potato and ensure fairness in trade.

Processors

Processed products had higher demands than supply and this is probably the reason why sales promotion was never done. There is a need for sales promotion and increased production to tap in to the unexploited markets outside the localities. The processed products will likely get acceptance even in new regions.

Transportation of sweet potato roots

The mode of transport and packaging of the roots was likely determined by the destination and distance to be covered. Gunny bags seemed the most preferred and convenient package because they could carry more roots conveniently and saved space during storage. The mode of transport was also likely influenced by the accessibility and state of the respective road network.

Traders

Transporting roots can be costly depending on the distance to the local markets and state of the roads. The use of carts, donkeys, motorcycles, walking, and wheelbarrow to transport sweet potato roots from the farm could be an indication that local markets were not far from the homesteads. Besides, it can portray the low demand and hence use of cheaper means of transport may be because farmers aren't sure of the income from the sales. The choice of transport mode could also be probably influenced by the volume of product, cost, and distance to the market. In remote areas without proper roads, motorcycles, bicycles, back/head and ox-cart would be the most appropriate means of transport. It can therefore be costly to transact in small volumes. The use of motorcycles and donkeys in transportation is common (Shekhar *et al.,* 2015).

Sweet potato Losses

Farmers

Mechanical injuries on roots during harvest are likely due to the tools like metal bars or carved sticks used in harvest since the roots are usually buried in the soil. Losses of roots during transport were due to dropping off, bruises, and tearing of the bags.

Traders

Packaging excess roots in gunny bags can result in tearing. Rough roads can result in injuries to roots due to abrasion during transport. Injured roots need to be utilized immediately since they become more susceptible to rotting and pest attack. If the mechanically damaged roots are to be stored they need to undergo curing to minimize rapid spoilage. Rotting and molding of roots may be exacerbated by bruising caused during transport since the roots are never cured. Rough handling, poor packaging, lack of curing, poor product ventilation, and delays in transit contribute to large losses that occur from farm to the market, and up to 40% loss can occur due to rotting during shipping (Chang *et al.,* 2016). Since the traders notably had gunny bags of extended sizes, it was likely that the roots were closely packed resulting in poor ventilation. The longer

the distance to the markets, therefore, the greater the expected damage and loss.

Processors
minimal losses experienced by processors could be because the frequency and volumes of processed commodities were low.

Challenges encountered in the sweet potato trade
Seasonal availability of sweet potato roots could be a major determinant of prevailing prices. The use of non-standardized measurements like bags, heaps, and buckets by the seller perpetuate unfairness in the trade as there is no objectivity. Middlemen are essential in the sweet potato trade even though they are always viewed negatively. This segment of the value chain actors are risk-taking entrepreneurs who help even the remote inaccessible farmers to sell their roots.

It is an advantage to the middlemen when farmers sell individually without belonging to the cooperative or trade association. High perishability of roots compounded with lack of appropriate storage facilities perhaps limited the ability of the traders to purchase roots in large volumes due to the fear of incurring losses in case they are not sold in time. An unreliable supply of roots could be due to low harvests in the off-season, among other factors. If storage facilities were available, the traders would ensure enough stock even when the roots are out of season. The poor road network can lead to high transport costs, delayed delivery of roots to the markets, and hence low profitability. Mechanical injuries, variation in quality, low demand by consumers, and lack of appropriate packaging were viewed as minor challenges. This may imply that buyers did not mind the presence of mechanical injuries nor the variability in the quality of tubers. The market for roots seemed always readily available. Packaging was probably viewed as a minor challenge since buyers came with their packages.

The profitability of the sweet potato trade could be dependent upon the various challenges earlier mentioned that were specific to each farmer or trader.

Suggestions on improving postharvest handling of sweet potato roots

Farmers
Training of farmers is vital because for a long time in Kenya farming has been done as a social activity where knowledge and skills have informally been passed on from one generation to the next. To commercialize sweet potato farming, farmers need to be informed on appropriate postharvest handling practices for improved incomes. Marketing cooperative societies for farmers can help minimize exploitation from brokers since they can be able to fetch better prices through the use of standard weights.
The establishment of collection centers can ease the burden of transport especially to those farmers who reside far from the markets. Community storage facilities would go a long way in prolonging the shelf-life of sweet potato roots thus reducing losses. There's a need for increased processing of sweet potato roots to absorb the roots from farmers for increased production. The poor road network can be a hindrance to the movement of sweet potato roots from the rural farms to the markets because of time wastage and high cost of transport. The Government of Kenya has a responsibility to protect farmers from exploitation by middlemen in terms of pricing and size of gunny bags as well as encourage consumption of sweet potato in Kenya through the enactment of relevant laws and formulation of appropriate policy.

Traders
Traders who failed to sell the whole stock of roots would often require storage facilities to sustain their stock in good condition until sold since sweet potatoes are generally perishable and bulky to transport. The need for modern market facilities is real since the open market facilities offer limited or no shelter thus exposing the sweet potato roots to the sun and rain (Chang *et al.*, 2016).

Processors
Large-scale processing equipment seemed too expensive to be afforded by processors and there is, a need for subsidies to enable them to acquire these vital items. Inadequate skills capacity of processors can negatively impact the quality of processed sweet potato products in the ever-competitive market. A government policy on sweet potato is one sure way of encouraging

consumption thus unlocking the commercial potential.

Conclusion and Recommendation

The sweet potato value chain faces several challenges right from farmers, traders to processors and at every stage of handling. The practices and challenges are similar in both Bungoma and Homabay counties. Lack of storage facilities and knowledge of appropriate storage conditions seems to be critical and determine transaction volumes since the handlers are cautious about incurring huge losses. Sweet potato roots storage and processing could be sure ways of accommodating the glut when the roots are in season while ensuring continuous supply when the roots are out of season. The Government of Kenya should intervene in the sweet potato industry by formulating and enacting a comprehensive sweet potato policy that will ensure increased consumption of sweet potato and its products, increased utilization of processing opportunities, and minimal exploitation of farmers.

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