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Postharvest Handling Practices and Hygiene Knowledge of Cowpea Leaves among Households in the Arid and Semi-Arid Lands in Kenya

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Abstract

Cowpea leaves are highly perishable seasonal crops with limited utilization in the arid and semi- arid lands. The instituted coping strategies among households to enhance the availability of the vegetable for consumption are yet to be elucidated in any documented studies. The study sought to assess the post-harvest handling practices and hygiene knowledge in the arid lands of Kenya. A cross-sectional study involving 405 randomly selected households was used in Taita Taveta and Kitui Counties. A large percentage (97.5%) of households consumed cowpea leaves sourced from their farms. Households producing cowpea leaves in Taita Taveta County had less odds (OR=0.6) of having surplus produce than those from Kitui County ($\chi2=5.4$, df =1, $p<0.05$). Major storage techniques for surplus produce among the households included drying (16.8%) and storage under low temperature (8.4%), there was a significant difference in the storage techniques between the two counties ($p<0.05$). Field heat management was only done among 55.3% households with the higher percentage (71.7%) being from Taita Taveta County ($\chi2=45.2$, df=1, $p<0.05$). Some households have learnt some methods to extend the shelf life but have not been adopted, there was no statistical significance difference between the two counties on the adoption of the preservation methods ($\chi2=0.3$, df=1, $p>0.05$). Losses are majorly attributed by poor storages facilities, at least 59.6 % of farmers from Taita Taveta lack these facilities and 40.4%/ from Kitui, with a significant difference ($p<0.05$, $\chi2=16.2$). Both regions had poor hygiene and post-harvest handling knowledge scores with Kitui County having higher scores, A significant difference ($p<0.05$, x=33.2) in knowledge scores was noted between the two counties. In conclusion, post-harvest management practices in both counties are inadequate and need to be improved in order to increase utilization and reduce post-harvest losses.

Key Words: *Cowpea leaves, Postharvest, Field heat management, Postharvest losses, Knowledge, Hygiene*

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Introduction

Cowpea (*Vigna Unguiculata L. Walp*) is an important significant indigenous vegetable leguminous crop, it is well adapted in the sub-tropical and tropical areas (Aasim *et al.,* 2009; Kirakou *et al.,* 2017). In addition, cowpea varieties have short growth periods can live through drought hence can perform well in arid and semi-arid regions (Owade *et al*., 2019; Peksen and Peksen, 2013). The global production of cowpea grain in metric tons was estimated to be 6.99 million with Africa leading in production with estimated metric tons of 6.74 million (FAOSTAT,

2019). Overall, 12.3 million hectares was used for cowpea production in 2016 with Eastern and Western African occupying over 92.7% of the production area (Owade *et al*., 2020), while in East Africa Kenya is currently having the largest (227,809 hectares) production area (FAOSTAT, 2019). Cowpea leaves in Kenya are mainly grown for domestic market. The main cowpea producing regions in Kenya are Kitui, Makueni, Machakos, Bungoma, Siaya, Kwale, Kilifi, Kisumu, Tharaka Nithi and Migori Counties (Muniu *et al.,* 2017). Cowpea leaves utilization for human food, both vegetable and grain, has positioned it for preference in areas where land is becoming scarce (Saidi *et al.*, 2010).

African leafy vegetables have been shown to have a substantial amount of vitamin C, vitamin B and beta carotene (Kirakou *et al*., 2017). Cowpea leafy vegetable are also rich in iron, protein, vitamin B1, phosphorous and calcium (Owade et al., 2020). For young children aged between four and eight years the vegetable was shown to meet over 75% and up to 50% of the recommended dietary intake of vitamin A and iron respectively by consuming a portion of 90 g of cowpea leaves (Owade *et al*., 2020). Fifty percent of the losses occurring in the cowpea value are mainly due to post-harvest losses, losses could be as low as 10-40% and as 50-70% (Owade et al., 2019; FAO, 2010; Kirakou *et al*., 2017). Post-harvest handling induces deterioration in the sensory, nutritional and physical quality of the cowpea leaves. Cowpea leaves deterioration due to wilting at ambient temperature where vending is done has also become a major challenge (Onyango *et al*., 2007). Unsuitable storage temperatures and extended storage significantly enhanced reduction of beta carotene, ascorbic acid, chlorophyll, carbohydrates and antioxidants (Kirigia *et al*., 2017). It was also seen that storage of cowpea leaves in low temperatures (4°C) enhanced the quality of the leaves by retention of phytochemicals as compared to room temperature storage (Owade *et al*., 2019). A study by Kirigia (2017) showed that cold storage preserved phytonutrients in cowpea leaves up to four days but cold storage facilities remain inaccessible to some farmers in the SSA. There has been a lot of emphasis on the grain leaving out the high potential of the cowpea leafy vegetable not fully exploited. The post-harvest handling of the grains is advanced both at the small-scale and industrial level. The lack of and having inadequate post-harvest treatment technologies leads to waste of the cowpea leaves when they are in season (October to May) and a limited supply of the same when not in season (June to September) in ASALS. Prolonging the shelf-life of cowpea will increase its productivity and marketability, hence higher returns and profits to farmers. In order to extend the consumption period appropriate storage methods are essential. This study is aimed at establishing the current harvesting, post-harvest handing and hygiene knowledge of cowpea leaves handler in Kitui and Taita Taveta Counties in Kenya.

Materials and Methods

Study Area

This study was conducted in the arid and semi-arid lands of Kitui and Taita Taveta counties, Kenya (Figure 1). Kitui County is situated on the eastern part of Kenya and lies between latitudes 0°10 South and 3°0 South and longitudes 37°50 East and 39°0 East.

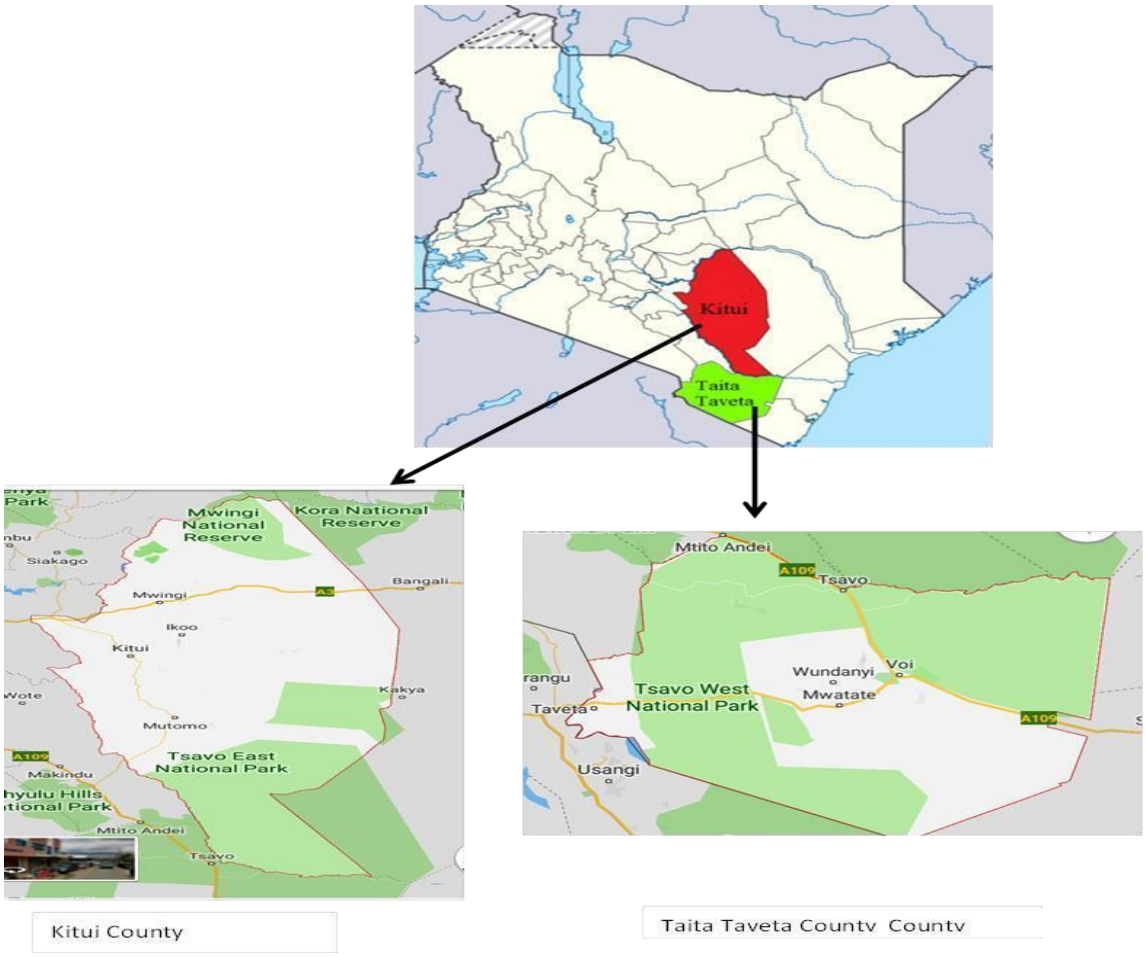

Figure 1. Map of Kenya showing the location of Kitui and Taita Taveta Counties Source: Google Maps, (2019)

According to the 2009 National census report the population of Kitui County was 1,012,236 (County Government of Kitui, 2018). A better part of the county has arid and semi-arid climate with an unreliable rainfall distribution (County Government of Kitui, 2018). Farmers from Kitui mainly practice subsistence farming with cowpea, cotton, pigeon peas, mangoes, tobacco, sisal, maize, beans, millet, and cassava as their main produce crops that are drought resistant are well suited in the area (County Government of Kitui, 2018). Taita Taveta is located North West of Mombasa and lies between latitude 2° 46 South and 4° 10 South and longitude 37° 36 East and 300 14 (County Government of Taita Taveta, 2018). It is predominantly dry excluding Taita hills which receive considerable amounts of rain. The County has a population of 285,516 people as per the 2009 population census (County Government of Taita Taveta, 2018). The main economic activities in the county are agriculture practices such as horticultural in Taita hills, growing of plants with short maturity periods likes cowpeas, sorghum green grams, cashew nuts, sunflower and millet, ranching and sisal growing, wildlife and tourism and gemstone mining (County Government of Taita Taveta, 2018).

Study Design

A cross sectional study was done in Kitui and Taita Taveta Counties, Kenya. The data collected included the demographic and socio-economic status of the farmers, post-harvest handling and storage practices applied at the farm level by the farmers that produce for own consumption and those that produce both for consumption and for sale in Kitui and Taita Taveta counties.

Study Population
The study population included individuals from both Taita Taveta and Kitui Counties that were above age of eighteen and were familiar with cowpea leaves.

Sample size determination
The minimum sample size was calculated as per Yamane 1967:886 formulae, (Israel, 1992).

$$n = \frac{N}{1 + N(e)2} = 400$$

Where N (276,581) was the total number of households in the two counties as per (KNBS, 2013) and e is the maximum variability (0.05) permitted. A sample size of 405 was used to increase the representativeness of the data.

Sampling Procedure
The counties of Kitui and Taita Taveta were purposely selected for they rank among the highest cowpea producing areas. Then sub-counties, Wundanyi, Mwatate from Taita Taveta county and Mwingi Central from Kitui were purposely selected based on which produced the highest quantity of Cowpea leaves. Wards, Chavia, Bura, Wumingu-Kishushe, Mwanda-Mgange, Nguni and Waita, from the two sub-counties that produced large amounts of cow pea leaves were also purposely selected (Figure 2). The households were systematically selected from the proportionate samples determined based on the population in each ward.

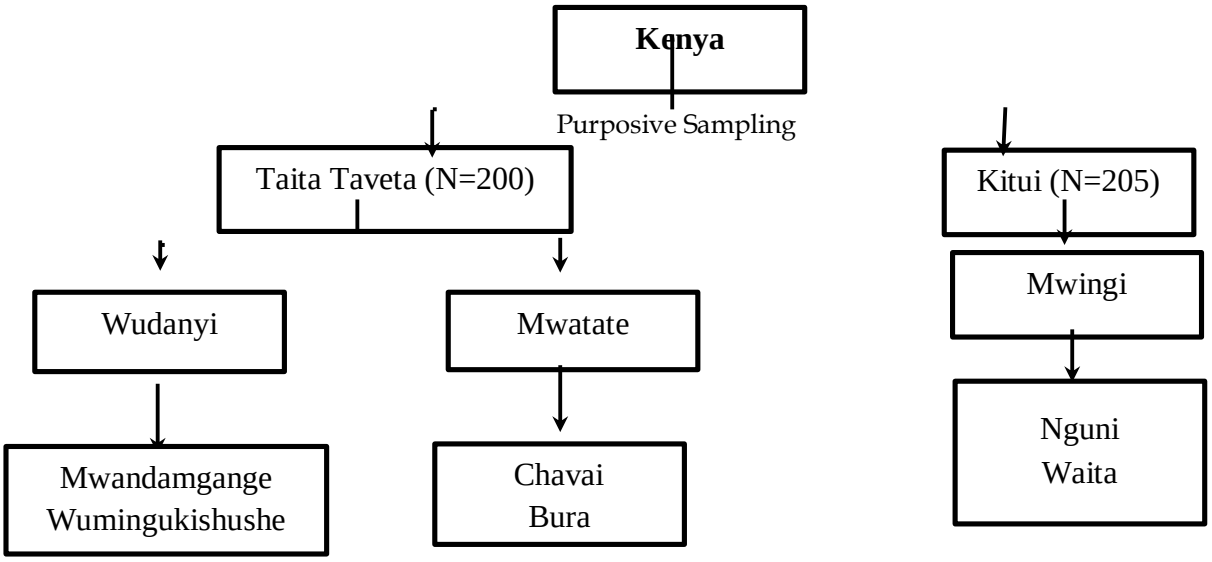

Figure 2. Sampling Schema

Data Collection
A semi-structured questionnaire was used in the data collection. The Data collection was done using the mobile app of Open Data Kit (ODK) to enhance the accuracy of data collection. Consent forms were signed before questioning. The questionnaires were used to collect information on the demographic and socio-economic status of the farmers in both regions. The questionnaires were also used to collect information on post-harvest handling and storage practices applied by the cowpea leaves handlers. The questions on hygiene knowledge and post- harvest handling and storage practices were used to evaluate how aware the farmers are about food hygiene, proper post-harvest practices and storage practices. The answers that were expected were either 'yes', 'no' or 'do not know'. One mark was awarded for all correct answers while the wrong answers together with 'do not know' answers were given zero points. All correct answers were calculated as a percentage. The scores that were less than 50 were considered to indicate poor knowledge on

food hygiene and post-harvest practices. The scores that were between 50 to 75 were considered as average (adequate) post-harvest and food hygiene knowledge, while the scores that were above 75% were considered to indicate good knowledge on food hygiene and post-harvest practices according to methodology described by (Samapundo *et al*., 2015).

Statistical Data Analysis

The field survey data was analyzed using SPSS version 25. Descriptive statistics that is frequencies and means and inferential statistics that is chi square was used to analyze data that was collected on the socio-demographic status and post-harvest handling practices of cowpea leafy vegetables. Chi square was used to determine the differences on post-harvest practices between Kitui and Taita Counties.

Results

Demographic and Socio-economics

Most of the cowpea leaves (97.5%) consumed among the households is sourced from the farm during glut whereas local roadside vendors serve as the source of the vegetable in scarcity with eight in every ten (80%) households getting their vegetables from them. In both counties it was noted that there was low level of education with one out of every 20 persons having university and tertiary education while the highest percentage completed primary education (36.0%). There was a statistical difference ($p<0.05$, $\chi2=47.4$) in the level of education between the two counties. Household heads from Taita Taveta County were found to be more educated compared to those in Kitui County. Table 1 shows the socio-economic characteristics of households producing cowpea leaves.

Table 1. Socio-demographic Characteristics of Cowpea Leaves Producing Households in Kitui and Taita Taveta Counties

Socio-demographic characteristics of respondents		Taita Taveta	Kitui	Total	χ2, P-Value, df
Gender of the household head (%)	Male	66.8[a]	78.0[b]	72.3	
	Female	33.2[a]	22.0[b]	27.7	6.314, 0.012, 1
Age of Household Head (%)	18-34	14.3	12.6	13.5	
	35-50	37.9	38.4	38.2	0.241, 0.971, 3
	51-70	38.4	39.4	38.9	
	>70	9.4	9.6	9.5	
Level of education of household head (%)	Never went to school	12.7	21.0	16.8	
	In primary	3.4	21.5	12.4	
	Completed Primary	47.5	24.5	36.1	47.442, <0.001, 6
	In Secondary	1.5	2.0	1.7	
	Completed Secondary	14.2	15.0	14.6	
	University and Tertiary	4.9	5.0	5.0	

	Dropped out of any of the above levels	15.7	11.0	13.4	
Main Occupation (%)	Salaried employment	5.9	7.5	6.7	
	Farmer	71.8	74.0	72.9	
	Trading and other informal businesses	9.4	10.5	10.0	
	Casual laborer	7.9	6.0	7.0	5.814, 0.325, 5
	Unemployed	4.5	1.0	2.7	
	Not applicable (cases of students and under age)	0.5	1.0	0.7	

Post-harvest Handling of cowpea leaves in producing households

Less than half (44.5%) of the households produced cowpea leaves in large quantities that they got surplus for sale. Households producing cowpea leaves in Taita Taveta County had lesser odds (OR=0.627) (table 2) of having surplus produce than those from Kitui County ($\chi2=5.4$, df=1, $p<0.05$). The major storage techniques for the surplus fresh produce practiced among the households included drying then storage in granaries (16.8%) and storage under low temperature (8.4%), there was a statistical difference in the storage techniques between the two counties ($\chi2=99.4$, df=5, $p<0.05$)

Field heat management was only done among 55.3% households with the higher percentage being from Taita Taveta 71.7% (df=1, $p<0.05$). Of all the field heat management techniques, the most practiced among households was leaving the vegetables under shade after harvest; done by three in every ten households (Figure 3).

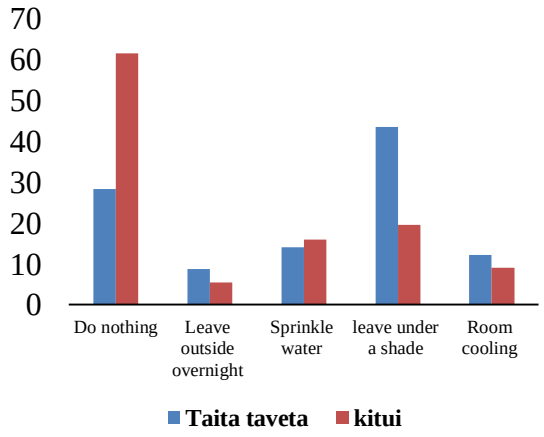

Figure 3. Field Heat Management Methods among Cowpea Leaves Farmers in Kitui and Taita Taveta

Some of the households have also learnt some methods to extend the shelf life but haven't adopted them yet. These methods include, blanching prior to sun drying, use of saline water and salting. There was no statistical significance difference between the two counties on the adoption of the preservation methods ($\chi 2=0.33$, df=1, $p>0.05$). Majority (54.5%) of the households used sacks as the packaging material to store harvested cowpea leaves. Less than five per cent of the households used the cartons (4.4%) and plastic bags (3.7%). The most (16.3%) utilized means of transport was the human labour by carrying on the heads or the backs. Motorbikes, bicycles and carts were used minimally by 6.9%, 1.7% and 1.0% of the households. Farmers in the regions have little to no knowledge of field heat management as a way to extend the shelf life with approximately 45% of them doing nothing to manage field heat.

Post-harvest losses of cowpea leaves among growing households

Almost all farmers from Taita and Kitui Counties (97.1% and 94.5%, respectively) incur post-harvest losses of cowpea leaves of up to 10% while the lesser percentage incur losses up to 30% during transportation of the cowpea leaves to the markets. These losses are majorly attributed by poor storages facilities, at least 59.6 % of farmers from Taita Taveta lack these facilities and 40.4% from Kitui, a significant difference was noted between the two counties ($p<0.05$). There were also other reasons as to why post-harvest losses are incurred at both the farm and market levels that included contamination of produce by pests and hazards (17.3%), low quality cowpea leaves (shriveled) (23.5%) (Figure 4).

Other means of spoilage included high environmental temperatures, lack of water for heat management, long distances to the market, large supply of the vegetables from the farm and lack of preservation methods. About nine in every twenty households (45.4%) employed no mitigation measures to prevent these losses, majority of the households being from Taita Taveta county with a significant difference ($p<0.05$) between the two counties.

Figure 4. Causes of Postharvest Losses among Cowpea Leaves Farmers in Kitui and Taita Taveta

Some have adopted different methods to extend the shelf- life others chose to sell their produce immediately after harvest with significant differences between the two counties as shown in table 3.

Table 3. Methods Adopted to Prevent Postharvest Losses

	Taita-Taveta		Kitui				
Post-harvest Practice to minimize losses	**Yes**	**No**	**Yes**	**No**	**χ^2**	**Df**	**P-value**
Sell immediately after harvest (%)	24.4	75.6	15.5	84.5	5.001	1	0.017
Dry Leaves (%)	62.0	38.0	13.0	87.0	103.199	1	<0.001

Prompt consumption (%)	2.0	98.2	8.0	92.0	7.89	1	0.004

Hygiene and post-harvest handling Knowledge of cowpea leafy vegetable

Less than half (47.56%) of the respondents have acceptable food hygiene knowledge. Both regions had a poor hygiene and post-harvest handling knowledge scores with Kitui being slightly higher (Table 4, Table 5), with mean scores of (49.00±11.41) as compared to Taita Taveta (46.16±10.424), with a significant difference ($p<0.05$, $\chi 2=33.2$) in knowledge scores between the two counties.

Table 4. Proportions of Kitui and Taita Taveta Knowledge Scores

		County		
		TaitaTaveta (N=205)	**Kitui (N=200)**	**Total**
Hygiene Group	**Poor Knowledge**	57.7	43.3	100
	Average Knowledge	21.5	78.5	100

Table 5. Postharvest Hygiene Practices Responses

	With Knowledge		**Without Knowledge**	
Post-harvest handling and hygiene practices Questions	**Taita Taveta (205)**	**Kitui (N=200)**	**Taita Taveta(N=205)**	**Kitui (N=200)**
1. There is no need to keep the cowpea leaves under a shade after harvesting.	4%	16%	96%	84%
2. Cooking eliminates all the bacteria and fungi in harvested cowpea leafy vegetables	4%	2%	96%	98%
3. Water for washing cowpea leaves should be clean	93%	93.50%	7%	6.50%
4. Mixing clean vegetables with unclean vegetables can lead to contamination and spoilage	89%	87%	11%	13%
5. Poor hygiene can cause losses of cowpea leafy vegetables during storage	92%	82%	8%	18%
6. Bad odor in food is a sign of food spoilage	83%	77.50%	17%	22.50%
7. Knives and utensils can result into cross contamination of green leafy vegetables	91%	84%	9%	16%
	42%	36.50%	58%	63.50%

8. Hand washing reduces chances of contamination of food.				
9. Selling of vegetables along the roadsides poses no risk to health	54%	70.50%	46%	29.50%
10. Food contact surfaces should not be cleaned everyday but only when they are dirty.	55%	70.50%	45%	29.50%
11. Vegetables from the supermarket and other vendors are very clean and can be taken without washing.	9%	14.50%	91%	85.50%
12. Water used in food preparation can be an agent of food contamination.	88%	75.50%	12%	24.50%
13. All people can be affected by food-borne illnesses.	43%	57%	57%	43%
14. Raw manure is good for vegetables growing in the farm	17%	28.50%	83%	71.50%
15. Transportation of vegetables in the market poses additional risks of contamination of the vegetables	35%	29%	65%	71%
16. Harvesting during hot period doesn't lead to deterioration of cowpea leaves	9%	19%	91%	81%
17. Transportation in open sun leads to deterioration of cowpea leaves	33%	38.50%	67%	61.50%
18. Transportation in polythene do not lead to deterioration of cowpea leaves	7%	16.50%	93%	83.50%
19. Modified atmosphere packaging is a good storage method for cowpea leaves	29%	23.50%	71%	76.50%
20. Damaged leaves have better shelf-life just as the fresh	37%	50%	63%	50%
21. Sprinkling of cold water on leaves does not improve their shelf-life	41%	43%	59%	57%

Table 6. Association of Knowledge Scores to the Socio-demographic Characteristics

Socio-demographic characteristic	χ^2	**Df**	**P-value**
Gender	0.56	1	0.466
Age	5.738	3	0.125
Level of education	13.039	6	<0.05

The level of education of respondent had a significant influence in the knowledge scores while age and gender did not have a significant influence in the post-harvest and hygiene scores (Table 6), the scores are significantly different at $p<0.05$.

Discussion

Demographic and Socio-economics

High consumption of cowpea leafy vegetables was recorded among Kitui and Taita Taveta counties with close to all households consuming the vegetable. Both counties have ASAL conditions that make the production of cowpea leaves favorable. A study by Owade *et al.* (2019) showed that the cowpea leaves production is well adopted in the ASAL regions. Kitui County ranks amongst the highest producers of cowpea leaves in the country (HCDA, 2017). Most of the households practiced farming as their main income generating activities with no significant difference between the two counties. The rate of unemployment was seen to be higher in Kitui County than in Taita Taveta. According to the county integrated plan of both counties, the rate of unemployment in Kitui was high (County Government of Kitui, 2018) while in Taita Taveta the rate of unemployment was seen to be 45% (County Government of Taita Taveta, 2018). A study done by Wambua *et al.,* (2014) showed that dependency of farming as a source of income contributed to farmers low incomes due to low prices of farm products and livestock in the local markets. Lack of employment and low incomes could be a contributing factor to lack of proper and adequate post harvesting technologies due to costs involved in procuring the same, therefore, leading to occurrence of losses of vegetables.

Post-harvest Handling Practices of cowpea producing households

Some of the households that are involved in production of cowpea leafy vegetables produce large quantities giving a surplus. Evidence of surplus production raises the concern of huge post-harvest losses if no proper management is in place. This study reported poor post-harvest handling practices including limited field heat management. Farmers in the regions have little to no knowledge of field heat management as a way to extend the shelf life this could be contributed by their low levels of education and also due to the scarcity of water. The cheapest and most effective method practiced by most farmers was leaving the vegetables under a shade right after harvest. Sprinkling water was a challenge for most of the households due to the ASAL conditions of the area. There were other field heat management methods other than the two that were used by the households as discussed earlier in the results section. According to Kirigia (2017) water was also a major challenge in most arid regions which would make field heat management using the same quite a challenge. Similar findings were reported by Kimiywe and Chege (2015) affirming that water is a limited resource for people living in Kitui. Different preservation techniques are used by the farmers that do not sell their surplus to extend the shelf life. It was notable that some preservation techniques that the households are conversant with include blanching, pickling were not practiced in the regions. It was recorded that most of the households preferred the use of sack for packaging for storage to consume later or during transportation of the produce to the market. Different modes of transportation had been adopted by farmers to transport the fresh produce to the market with walking to the market over long distances to have their produce purchased being one of them. Findings are in agreement with those by Milelu *et al*., (2017) that showed use of motorbikes, cars and walking to the market as the main mode of transportation of fresh vegetables to the market.

Post-harvest Losses among cowpea-growing households

Nearly all farmers in both regions incur a certain percentage of post-harvest losses when taking their produce to the market. According to Owade *et al*. (2019) losses could rise up to 70% and are aggravated by poor post-harvest handling practices. Studies have shown that there were minimal losses to small scale farmers that were closely in touch with the value chain partners (Lotter *et al.,* 2014). According to Kirigia *et al*. (2017) and Affognon *et al.,* (2015), quality deterioration that is physical damage and decay is a major reason for fruits and vegetable losses. These were observed at different levels of the chain. Surface water of cowpea leafy vegetable gives microorganism conducive environment to thrive in thus leading to microbial decay and thus post-harvest losses are incurred (Kirigia *et al.*,

2017). Another study by Kader (2004) also supported fresh vegetables are mainly lost due to bio-deterioration. Quality deterioration of fresh vegetables was seen as overwhelming at all stages of the vegetable value chain (Mishili et al., 2007; Kitinoja, 2011; Affognon *et al.*, 2015). A higher percentage of the farmers from both counties lacked proper storage facilities which were a major contributor towards post-harvest losses among others. A study by Gogo *et al.*, (2018) showed that farmers are well conversant with cold storage but are not using the same for storage of AIVs due to lack of facilities and high cost of electricity. Other studies have shown that majority of the small-scale farmers lack refrigeration and proper storage facilities hence use other methods such as shades and use of cold water to remove field heat for storage for later storage (Kirigia *et al.*, 2017; Onyango and Imungi, 2007; Owade *et al.*, 2019). According to (Kirigia *et al.*, 2017) there is lack of both transportation and packing materials to most of the small-scale farmers, with some of the farmers walking over 16 Km to get their vegetables to the market. A study by Kimiywe and Chege (2015) showed that Kitui had poor road networks that were a challenge to get produce to the market. A different study also showed that areas with poor transportation networks experienced increased post-harvest losses of cowpea leaves (Owade *et al.*, 2019).

Poor quality vegetables including shriveling were found to be the leading causes of cowpea leaves losses in the arid areas. A study has shown that some climatic conditions especially in ASAL are unfavorable for storage of fresh produce (Wafula *et al.*, 2016). The occurrence of losses is due to insufficient knowledge on the right after harvest treatments and preservation methods (Gogo *et al.*, 2016). It was seen that some of the farmers either sold their produced immediately after harvest or harvested just enough for prompt consumption to prevent losses. The farmers also have adopted certain preservation methods for prevention of post-harvest losses with most of them using sun drying. Studies have shown that sun drying despite loss of phytonutrients prolonged the shelf of cowpea leafy vegetables (Chikwendu *et al.*, 2014; Natabirwa *et al.*, 2017; Owade *et al.*, 2019).

Hygiene and Post-harvest Knowledge of cowpea leafy vegetable

Majority of the households were aware that poor food hygiene could lead to post-harvest losses of cowpea leafy vegetables during storage. A study showed that incorporation of GMPs in many fruits and vegetable distribution facilities all over the word were a major challenge (da Costa Ferreira *et al.*, 2020). The presentation of produce in an undesirable hygienic condition facing risk of contamination during handling which leads increase of post-harvest losses and the occurrence of food borne illnesses (da Costa Ferreira *et al.*, 2020). These factors of contamination will compromise the safety of food consumed therefore the importance of utilization of certain resources to prevent contamination of food during all stages of production from farm to folk (Uçar *et al.*, 2016). Most of the respondents also agreed with use of clean water to clean vegetables and also a higher percentage agreed that mixing of clean vegetables with unclean vegetables could lead to contamination. The use of contaminated water for food production among others was found to be a potential threat caused by foods to consumers (Uçar *et al.*, 2016). A better part of the households thought that it was more hygienic to always clean food contact surfaces everyday rather than when the surfaces are dirty. Also, close to half of the respondents did not believe that hand washing reduced food contamination. A study showed that improper washing of hands after using the toilet led to contamination of food with infectious microorganisms (Taylor *et al.*, 2000). According to a different study by Medeiros *et al.*, (2001), a higher incidence and cost of pathogens that were associated to lack of good personal hygiene, recommendations were made to food safety educators to primarily focus on hand washing. A higher percentage of the respondents did not have knowledge that sprinkling of cold water on freshly harvested cowpea leafy vegetables did not improve the shelf life. Majority agreed that selling vegetables along the roadsides posed some risk to health while the rest disagreed. There was also a concern that most of the respondents said that vegetables from supermarkets and other vendors are normally clean and could be taken without washing. Street-vended foods have been seen to be a major concern causing food borne illnesses due to microbial contamination (Feglo and Sakyi, 2012). The studies indicated the need to assess street vendors by assessing knowledge and practices and provided them with education on

food safety (Reddi *et al*., 2015). Gender and age of respondents did not influence the post-harvest and hygiene knowledge while the level of education had a significant influence on the scores. This finding agrees with a study in Poland which showed that the level of education had a significant influence in knowledge where the highly educated respondents gave more correct answers as compared to respondents that had low levels of education (Tomaszewski *et al*., 2018). Other studies showed a positive correlation between the knowledge scores and the level of education (Akabanda *et al*., 2017; Carbas *et al*., 2013). Findings by Carbas (2013) showed that age increment had a positive effect on knowledge. A study showed that women were seen to be more knowledgeable in food hygiene knowledge since most of the food preparation is done by them (Tomaszewska *et al*., 2017).

Conclusion

In both Kitui and Taita taveta counties, post-harvest handling and storage practices of cowpea leaves were far from the best and high losses are still being incurred since production by the households remains high. Aside from that the poor infrastructure, lack of storage facilities, water scarcity and poor road networks tend to contribute to the loss of cowpea leaves. The lack of knowledge on hygiene and post-harvest handling practice of cowpea leaves also contributes to losses of the crop. Lack of the crop getting enough attention from researchers and agricultural institutions due to its limited economic value there is still under-utilization hence resulting to high post-harvest losses.

It is recommended that some of the practices that have already been adopted by the households may not be the best and could be improved to enhance their effectiveness. The current postharvest treatments already in place need to improve while new methods need to be developed and adopted. Further, more households need to be reached through the dissemination of the study's findings, in addition, capacity building and training on postharvest management and hygiene practices should be done to the farmers and householders in order to assure quality and safety of cowpea leaves comes as a recommendation.

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References

Aasim, M., Khawar, K.M. & Özcan, S., (2009). In vitro micropropagation from plumular apices of Turkish cowpea (Vigna unguihculata L.) cultivar Akkiz. *Scientia horticulturae*, *122*(3), pp.468- 471.

Affognon, H., Mutungi, C., Sanginga, P., & Borgemeister, C. (2015). Unpacking Post-harvest losses in sub-Saharan Africa: A Meta-Analysis. *World Development*, *66*, 49–68. https://doi.org/10.1016/j.worlddev.2014.08.002

Akabanda, F., Hlortsi, E. H., & Owusu-Kwarteng, J. (2017). Food safety knowledge, attitudes and practices of institutional food-handlers in Ghana. *BMC Public Health*, *17*(1), 40.

Carbas, B., Cardoso, L., & Coelho, A. C. (2013). Investigation on the knowledge associated with foodborne diseases in consumers of northeastern Portugal. *Food Control*, *30*(1), 54-57.

Chikwendu, J. N., Igbatim, A. C., & Obizoba, I. C. (2014). Chemical composition of processed cowpea tender leaves and husks. *International Journal of Scientific and Research Publications*, *4*(5), 1-5.

County Government of Kitui. (2018). *Kitui County integrated development plan 2018-2022*. Kitui, Kenya: County Government of Kitui.

County Government of Taita Taveta. (2018). *Taita Taveta County Integrated Development Plan 2018-2022*. Taita Taveta, Kenya: County Government of Taita Taveta.

da Costa Ferreira, A. G., de Sousa Ferreira, L., Júnior, F. G. B. F. F., Santos, M. P., da Silva, M. D. S., dos Santos Aguiar, F. I., ... & Freitas, J. R. B. (2020). Postharvest Losses of Fruits and Vegetables Marketed in Seven Municipalities of the East Mesorregion, Maranhão, Brazil. *Journal of Agricultural Studies*, *8*(3), 335-351.

FAO (Food and Agricultural Organization of the United Nations), (2010). FAO/World Bank Workshop on Reducing Post-Harvest Losses in Grain Supply Chains in Africa: Lessons

Learned and Practical Guidelines. (pp. 1–121). Rome, Italy: FAO and World Bank.

FAOSTAT, F. (2019). Food and Agriculture Organization of the United Nations-Statistic Division https://www. fao. org/faostat/en/# data.

Feglo, P., & Sakyi, K. (2012). Bacterial contamination of street vending food in Kumasi, Ghana. *Journal of Medical and Biomedical Sciences*, *1*(1), 1–8.

Gogo, E. O., Opiyo, A., Ulrichs, C., & Huyskens-, S. (2018). Loss of African Indigenous Leafy Vegetables along the Supply Chain Loss of African Indigenous Leafy Vegetables along the Supply Chain. *International Journal of Vegetable Science*, *24*(4), 361–382. https://doi.org/10.1080/19315260.2017.1421595.

Gogo, E., Opiyo, A., Ulrichs, C. &, & Huyskens-Keil, S. (2016). Post-harvest Treatments of African Leafy Vegetables for Food. *African Journal for Horticultural Sciences*, *9*(June), 32–40.

Google Maps (2019). Map of Kenya showing the location of Kitui and Taita Taveta Counties. https://www.google.com/maps

HCDA. (2017). Horticultural Crops Directorate Validated Report. *Agriculture and Food Authority (AFA), Data Validation Report*, 1–61.

Israel, G. D. (1992). Determining sample size.

Kader, A. A. (2004, June). Increasing food availability by reducing postharvest losses of fresh produce. In *V International Postharvest Symposium 682* (pp. 2169-2176).

Kimiywe, J., & Chege, P. M. (2015). Complementary feeding practices and nutritional status of children 6-23 months in Kitui County, Kenya. *Journal of applied Biosciences*, *85*, 7881-7890.

Kirakou, S., Hutchinson, M., Ambuko, J., & Owino, W. (2017). Efficacy of Blanching Techniques and Solar Drying in Maintaining the Quality of Cowpea Leaves. *African Journal of Horticultural Science*,*11*(0SE-Articles). Retrieved from http://www.hakenya.net/ajhs/index.php/ajhs/article/view/175

Kirigia, D., Kasili, R. and Mibus, H., (2017). African Leafy Vegetables Pre-harvest and Post- harvest constrains and Technologies for losses reduction along the field to consumer chain. *African Journal of Horticultural Science*, *12*, pp.51-60.

Kitinoja, L., Saran, S., Roy, S. K., & Kader, A. A. (2011). Post-harvest technology for developing countries: Challenges and opportunities in research, outreach and advocacy. Journal for Science, Food and Agriculture, 91(4), 597–603.

KNBS (2013). Population distribution by sex, number of households, area and density by Adwbinistrative Units. Detail Census Rep; 2013.

Lotter, D. W., Marshall, M. I., Weller, S., & Mugisha, A. (2014). African Indigenous and Traditional Vegetables in Tanzania: Production, Post-harvest Management and Marketing. *African indigenous and traditional vegetables (AITVs) hold excellent potential to improve nutrition and increase dietary diversity in Tanzania*. *22*(3), 181–189.

Medeiros, L. C., Hillers, V. N., Kendall, P. A., & Mason, A. (2001). Food safety education: What should we be teaching to consumers? *Journal of Nutrition Education and Behavior*, *33*(2), 108– 113. https://doi.org/10.1016/S1499-4046(06)60174-7

Milelu, M. M., Kigaru, D. M. D., & Kuria, E. N. (2017). *Demographic and socio-economic determinants of availability and access dimensions of household food security in Kitui County, Kenya*. *2*(5), 93–101.

Mishili, F. J., Fulton, J., Shehu, M., Kushwaha, S., Marfo, K., Jamal, M., et al. (2007). Consumer preferences for quality characteristics along the cowpea value chain in Nigeria, Ghana and Mali. Working Paper #06-17. Department of Agricultural Economics, Purdue University. Available at http://ageconsearch.umn.edu/bitstream/28684/1/wp060017.pdf.

Muniu, F. K. (2017). Characterization and evaluation of local cowpea accessions and their response to organic and inorganic nitrogen fertilizers in coastal Kenya (Doctoral dissertation, University of Nairobi).

Natabirwa, H., Mukiibi, J., Zziwa, E., & Kabirizi, J. (2017). Nutritional and physicochemical properties of stored solar-dried cowpea leafy vegetables. *Uganda Journal of Agricultural Sciences*, *17*(1), 1. https://doi.org/10.4314/ujas.v17i1.1

Onyango, C.M. and Imungi, J.K., (2007). Post-harvest handling and characteristics of fresh-cut traditional vegetables sold in Nairobi-

Kenya. In *African Crop Science Conference Proceedings* (Vol. 8, pp. 1791-1794).

Owade, J. O., Abong', G., Okoth, M., & Mwang'ombe, A. W. (2019). A review of the contribution of cowpea leaves to food and nutrition security in East Africa. *Food Science and Nutrition*, *8*(1), 36–47. https://doi.org/10.1002/fsn3.1337

Owade, Joshua Ombaka, Abong', G. O., Okoth, M. W., & Mwang'ombe, A. W. (2020). Trends and constraints in the production and utilization of cowpea leaves in the arid and semi-arid lands of Kenya. *Open Agriculture*, *5*(1), 325–334. https://doi.org/10.1515/opag-2020-0038

Peksen, A., & Peksen, E. (2013). Agronomic and Morphological Characters of Newly Registered Peksen and Reyhan Vegetable Cowpea Cultivars in Turkey. *Int.J. Curr.Microbiol. App.Sci*, *2*(9), 133–140.

Reddi, S. G. D. N. L., Kumar, R. N., Balakrishna, N., & Rao, V. S. (2015). Microbiological quality of street vended fruit juices in Hyderabad, India and their association between food safety knowledge and practices of fruit juice vendors. *International Journal of Current Microbiology and Applied Sciences*, *4*(1), 970–982.

Tomaszewska, M., Trafialek, J., Suebpongsang, P., & Kolanowski, W. (2018). Food hygiene knowledge and practice of consumers in Poland and in Thailand-A survey. *Food Control*, *85*, 76- 84. https://doi.org/10.1016/j.foodcont.2017.09.022

Saidi, M., Itulya, F. M., Aguyoh, J. N., & Ngouajio, M. (2010). Effects of cowpea leaf harvesting initiation time and frequency on tissue nitrogen content and productivity of a dual-purpose cowpea-maize intercrop. *HortScience*, *45*(3), 369–375.

Samapundo, S., Climat, R., Xhaferi, R., & Devlieghere, F. (2015). Food safety knowledge, attitudes and practices of street food vendors and consumers in Port-au-Prince, Haiti. *Food Control*, *50*, 457–466. https://doi.org/10.1016/j.foodcont.2014.09.010

Taylor, J. H., Brown, K. L., Toivenen, J., & Holah, J. T. (2000). A microbiological evaluation of warm air hand driers with respect to hand hygiene and the washroom environment. *Journal of Applied Microbiology*, *89*(6), 910–919. https://doi.org/10.1046/j.1365-2672.2000.01122.x

Uçar, A., Yilmaz, M. V., & Çakiroglu, F. P. (2016). Food Safety – Problems and Solutions. *Significance, Prevention and Control of Food Related Diseases*, 1–26. https://doi.org/10.5772/63176

Wafula, E.N., Franz, C.M., Rohn, S., Huch, M., Mathara, J.M. & Trierweiler, B., (2016). Fermentation of African indigenous leafy vegetables to lower post-harvest losses, maintain quality and increase product safety. *African Journal of Horticultural Science*, *9*.

Wambua, B.N., Omoke, K.J. & Mutua, T.M., (2014). Effects of Socio-Economic Factors on Food Security Situation in Kenyan Dry lands Ecosystem. *Asian Journal of Agriculture and Food Science (ISSN: 2321–1571)*, *2*(01)