

Full Length Research Paper

Current knowledge and performance of existing charcoal coolers in improving the overall quality and shelf-life of French beans

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This study investigates current knowledge and performance of existing technology, 'charcoal coolers' in improving the overall quality and shelf-life of French beans. Data was collected primarily from a household survey using a semi-structured questionnaire administered to 45 purposively selected farmers who were selected at fixed interval. Data was analysed using the Statistical Product and Service Solutions (SPSS) Version 20 software and Pearson correlation is used to show the relationship between demographic characteristics and farmers post-harvest handling practices. The study revealed that majority of the farmers (80%) harvested late between 9 am to 12 noon and targeted temperature of 16 to 20°C. Only 32% of the farmers interviewed disinfected their produce after harvesting. Majority of farmers (57%) did not belong to any farmers' group or co-operatives. On the other hand, majority of the farmers (80%) had adopted use of charcoal cooler technology and 69% stored their produce for between 1 and 6 h before delivering them to the packing shed, a distance that would take another 6 h. Farmers' age and education level had positive influence on use of cold storage facility. To sustain the use of cold storage facilities and technologies, there is need to support establishment of a community-based cold storage facilities that can be accessed by the small scale farmers to ensure their produce remain fresh before transfer to packing stations. Such a move would considerably reduce food losses and wastes along the value chain, which is an instrumental agenda of the United Nations Sustainable Development Goal.

Key words: French beans, charcoal cooler, cold storage, post-harvest practices, quality, shelf life.

INTRODUCTION

The horticultural sub-sector faces many challenges, the major one being high post-harvest losses. The major

contributor to these losses is temperature (Vorster et al., 1990). The rate of deterioration of perishable goods

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increases two to three folds with every 10°C increase in temperature (Kader, 2005). Besides physiological deterioration, products may host micro-organisms like bacteria and fungi which can cause rotting and decays (Kitinoja, 2013). The higher the temperature the faster the losses through colour, flavour, nutrients and textural degradation (Vorster et al., 1990). It has been reported that when temperature is maintained at 10°C (Q10 quotient) colder than the temperature commonly experienced during ambient conditions, the shelf life of the commodity can double (Kader, 2005; Kitinoja, 2013). The higher the perishability of the produce the more it demands an effective and uninterrupted cold chain system. A cold chain system for fresh commodities can be defined as the continuous handling of the product at low temperatures during the postharvest process such as harvesting, collection, packing, processing, storage, transport and marketing until it reaches the final consumer (Kitinoja, 2013). Cold chain management should start at the time of harvesting and must take into account the time of harvesting (Kathryn and James, 2004). Temperature abuse right from the farm predisposes the produce to faster deterioration. In smallholder farms, the temperature misuse is attributed to factors such as lack of knowledge on good harvesting practice and postharvest management.

There are various options and technologies for providing cold conditions for food commodity handling. Some of the technologies that have been employed include dipping of the fruits or produce in cold water, also called hydro-cooling mixed with disinfectants such as thiabendazole and sodium hypochlorite with clean water available (Arah et al., 2016). This method is very effective in removing field heat and in the same reducing microbial loads on the harvested French beans. Some farmers, especially in developing countries, have had to assemble their produce and put them under the tree to reduce field heat (Olayemi et al., 2011). With refrigeration, possible decay of the produce is reduced and therefore increased shelf life. Vapour compression cycle is the most commonly used preservation technology. The technology depends on electricity driven and mechanical compressor (Lange et al., 2016). Another technology is the evaporative cooling system where water is applied to a porous surface like charcoal and as the temperature begins to rise, it begins to evaporate. As water changes from liquid to gas, it absorbs energy in the form of heat from the surrounding air, thus cooling it. This method releases water as a coolant, running freely over the charcoal or sand surface (Lange et al., 2016). Evaporative cooler is designed to offer an environment with both a lower temperature and a higher level of relative humidity (Nanguwo, 2000). It employs the principle of a porous structure to which water is added and as air flows within the wet wall, the air temperature is decreased due to the loss of heat to the evaporating water. The temperature is normally lowered by about 5 to

10°C, depending on the relative humidity of the ambient air. Farmers have also applied the use of ice making technology as a way of cooling the produce. This system works in two ways, first is the introduction of ice directly on the produce or by adding ice into water in which the produce is then plunged. Secondly, ice can be kept in an ice bank to cool down the surrounding stored produce through heat convection.

To address the challenge of fresh produce storage, a lot of research and innovation in Kenya over the last two years have resulted in small scale farmers increasingly adopting the use of low cost cooling chambers that use renewable energy (Toivonen, 2014). One of the most practical inventions is the use of locally made cold storage systems called charcoal cooler for use by smallholder farmers to keep their produce and increase shelf life while awaiting collection by the buyers. The objective of this study was to assess the current knowledge and extent of use of cold chain interventions in French bean production in Kenya. Kenya is a key producer of French beans for export market into Europe and UK, and most recently into Middle and Far East. Majority of the French bean production is by small scale farmers, owning less than one acre of land. French beans production in Kenya is a key income earner and generates a lot of employment in Kenya, either directly or indirectly.

Apart from technical compliance to European market standards, post-harvest losses remain a huge challenge to French bean exports in Kenya. Majority of the small scale farmers are located quite a distance from the packing facilities, and as a result, their produce takes on more hours to get to the exporters cooling facilities. Food waste reduction has become a key topic in the last two years, following realization that over eight hundred million people in the world are at the risk of starvation, while on the other hand, over 30% of edible food goes into waste along the supply chain. With renewed commitment of United Nations through the revised Sustainable Development Goals, in particular goal number 12.3, there is global focus on waste reduction along the supply and production chain. Majority of the major food traders have put in place measures to reduce losses along the supply chain, for example, Tesco, the leading UK Retailer has gone public to commit to reduce food waste along the supply chain by 50% by 2030. Tesco is a leading importer of French beans from Kenya. Findings from this study will be very useful in contributing to food waste reduction and global hunger right at the start of the French bean supply chain.

Value chain for perishable goods requires an integrated approach to cope with post-harvest challenges that are contributed majorly by temperature fluctuation. Efficient operations are essential throughout production, transportation, and storage processes. The absence of a sufficient and working infrastructure in the post-harvest value chain results in the harvested produce being lost

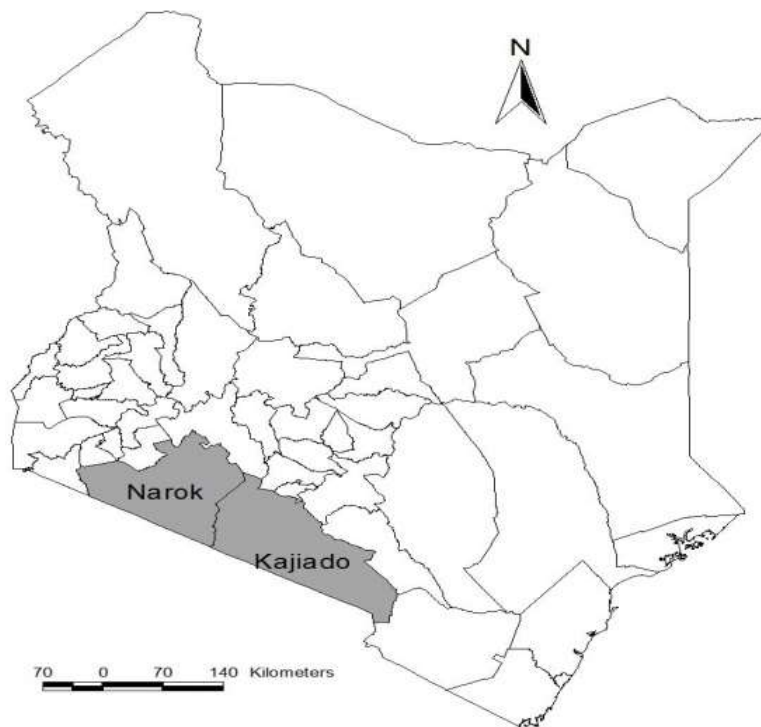


Figure 1. Map showing the study area.

before reaching the consumer market.

MATERIALS AND METHODS

Selection and description of the study site

The study was carried out in two counties of Kajiado and Narok. Kajiado County is located in the southern part of Kenya. It is situated between Longitudes 36°5' and 37°5' East and between Latitudes 1° and 30° South. Narok County is situated in Kenya along the Great Rift Valley. The temperature range is 12 to 30°C and average rainfall range is 500 to 1,800 mm per annum. Its geographical coordinates are 1° 5' 0" South, 35° 52' 0". This area was purposively sampled because of the large numbers of small-scale producers who mostly supply exporters. In addition, Narok and Kajiado counties have in the last decade become important French bean production regions supplementing reducing production from Central Kenya due to reducing fertility and competitive real estates in Central Kenya, thereby leaving less arable land. The prevailing weather and climatic conditions in these regions are also suitable for installation of coolers that use renewable energy (Figure 1).

Sampling technique and data collection

Data used in the study was obtained primarily from a household survey that targeted French bean producing farmers in both Kajiado and Narok Counties. Farmers were selected through a systematic random sampling procedure. Farmer register from the two counties was used to serve as the sampling frame and each farmer in this list was numbered sequentially. The targeted farmers were selected at fixed interval from the list to come up with 45 farmers from the

two counties. A semi-structured questionnaire was used to collect both quantitative and qualitative data. Data was collected on attitude and extent of use of charcoal coolers, temperature at harvesting and at storage, the type of storage facility, produce storage time, changes in French bean and washing of the produce.

Data analysis

The data was checked and open-ended questions were coded before data entry. The data was analysed using the Statistical Product and Service Solutions (SPSS) Version 20, an IBM product acquired by IBM in 2009 (Hejase and Hejase, 2013) by computing descriptive statistics including frequencies, percentages, means and averages. The Pearson correlation was used to show the relationship between demographic characteristics and farmers post-harvest handling of French beans and knowledge on cold storage usage.

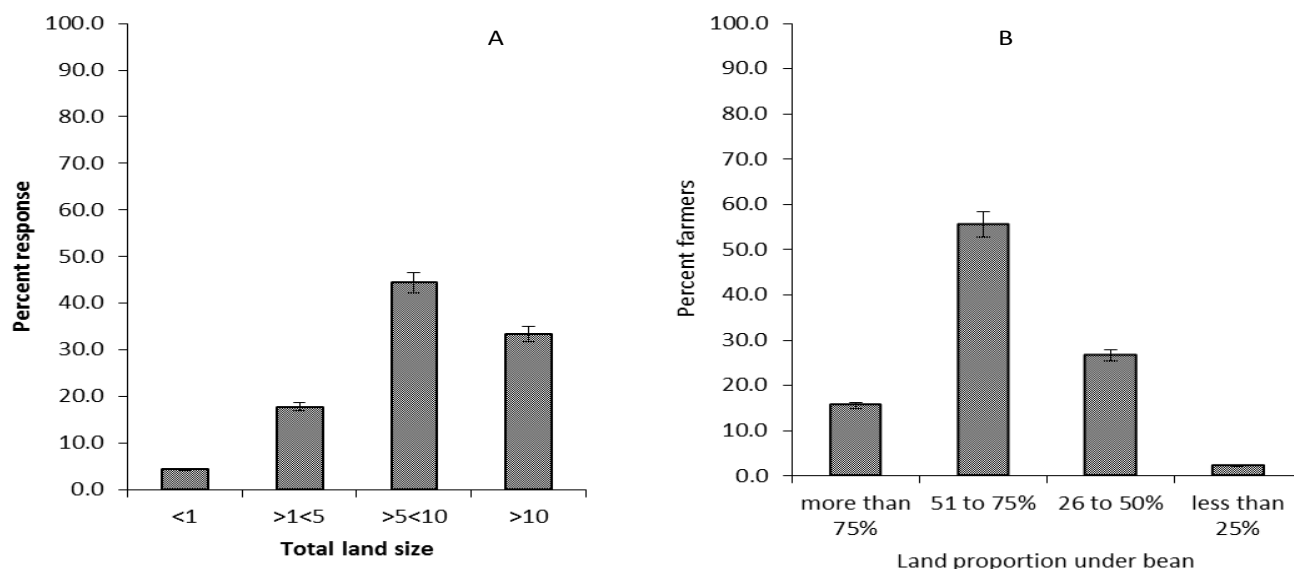
RESULTS

Household socio-economic characteristics of the farmers

Results show that 75% of the respondents are male farmers across the counties and the proportion of male farmers is also higher in both Kajiado (71%) and Narok (86%) (Table 1). 33.3% of the interviewed farmers are between the ages of 41 and 50 years, however, the age ranged from 19 years to over fifty years. 97.8% of all the farmers were married except one who was a widow. The

Table 1. Socio-economic characteristics of French bean farmers in Narok and Kajiado counties.

Variable	Description	Frequency	Percentage
Gender	Female	11	24.4
	Male	34	75.6
Age	Over 51 years	11	24.4
	41 to 50 years	15	33.3
	31 to 40 years	12	26.7
	19 to 30 years	7	15.6
Marital status	Widowed	1	2.2
	Married	44	97.8
Literacy level	Post-secondary	12	26.7
	Secondary	18	40.0
	Primary	15	33.3

**Figure 2.** Proportion (%) of (A) land owned by the farmers and (B) land allocated to French bean production.

distribution of sampled farmers in terms of education showed that 40% of the respondents have basic education followed by 33.3 and 26.7% who have primary then post-secondary education, respectively.

Land size and land allocated to French bean production

French bean farmers in the two counties own land in various categories out of which 44.4% own land between 5 and 10 acres. Few farmers own land less than 5 acres while others own land above 10 acres (Figure 2). 55.5% of the interviewed farmers allocate 51 to 75% of their land to French bean production. Farmers in Kajiado County

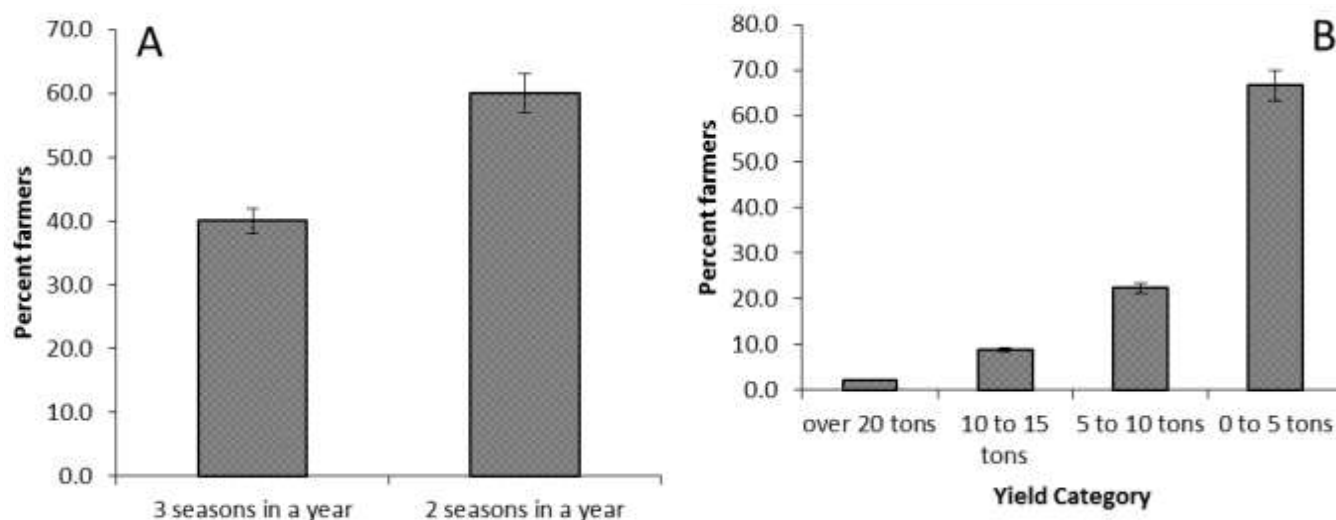
had significantly more land allocated to French bean production than farmers in Narok County.

Daily farm operations

Farmers (91.1%) report that they were solely responsible for their daily farm operations. However, 8.9% employ people either on permanent basis or as casual labourers to handle the daily farm operations (Table 2). Among the few employees, around 50% had post-secondary education, while the rest had either secondary or primary education levels. 50% of the employees are either salary employees, 25% are casual labourers or 25% offer free helping hands to the farmers.

Table 2. Characteristics of farmers responsible for daily farm operations.

Description	Category	Frequency	Percentage	Std. Dev
Daily management operation	Farmer	41	91.1	0.31
	Employee	4	8.9	
Education level of employee responsible	Pre-primary	1	25.0	0.95
	Secondary	1	25.0	
	Post-Secondary	2	50.0	
Occupation of employee responsible	Salaried employee	2	50.0	1.50
	Casual labour	1	25.0	
	Not employed	1	25.0	

**Figure 3.** Main seasons of French bean production and yield achieved by the farmers.

Yields and main season of French bean production

Figure 3 shows that 60% of the farmers interviewed produce French bean in two seasons in a year while the rest or 40% produce French beans in three seasons per year. The study reveals that 67% of the interviewed farmers harvest 0 to 5 tonnes of French beans from their farms, while only a few or 2.2% obtain yield above the 20 ton mark (Figure 3).

Current status post-harvest practices

Table 3 shows some of the post-harvest handling activities that were practiced by the farmers in the two counties. 68% of the farmers do not wash the French beans, 80% harvest late when the sun is up, 76% target the highest temperature of 16 to 20°C and 69% store their produce for 1 to 6 h. 20% of the farmers, however, store their produce for less than an hour then deliver

them to the buyer.

Farmer practices recommended by the buyers

Buyers always specify the qualities of the produce they require from farmers. To achieve the required qualities the farmers performed certain practices (Table 4). 40% of the farmers report management of pest and diseases, 24% report good fertilizer application as a way of achieving the demanded quality. Other practices performed by the farmers included planting certified seeds, timely irrigation, timely harvesting and grading and proper land preparation.

French bean qualities required by the buyer

Many farmers understood the qualities demanded by the buyers (Table 5). Some of the qualities mentioned are pests and disease-free products, products with no

Table 3. Post-harvest practices by French bean farmers.

Description	Category	Frequency	% of responses
Produce washing	Yes	15	33.3
	No	30	66.7
Time of harvesting	6 am - 9 am	8	17.8
	9 am - 12 pm	36	80.0
	12 pm - 3 pm	1	2.2
Measure Temperature	Yes	9	20.0
	No	36	80.0
Targeted temperature (°C)	6 - 10	3	6.7
	11 - 15	7	15.6
	16 - 20	34	75.6
	More than 20	1	2.2
Storage duration (h)	less 1	9	20.0
	1 to 6	31	68.8
	6 to 12	5	11.1

Table 4. Distribution of respondents based on the farming practices recommended by the buyer.

Factors considered to meet buyers demand	Frequency	% of responses
Fertilizer application	11.0	24.4
Control of pests and diseases	18.0	40.0
Planting certified seeds	9.0	20.0
Proper land preparation	1.0	2.2
irrigation in time	8.0	17.8
harvesting and grading	12.0	26.7
Total	59.0*	-

Table 5. Distribution of the farmers based on qualities of French beans demanded by the buyer.

Quality demanded by buyers	Frequency	% of responses
Pest and disease-free products	33.0	73.3
products with no blemishes	9.0	20.0
Non-dehydrated products	7.0	15.6
seed diameter 8 mm (11 - 15 cm)	5.0	11.1
well graded seed	4.0	8.9
Total	58*	-

blemishes, non-dehydrated products, pods diameter 8 mm and length of (11 to 13 cm), and well graded pods. 73% of the interviewed farmers report pest and disease free produce as the most demanded quality by the buyers. 20% mention products with no blemishes and 15.6% mention non-dehydrated produce. A few other farmers mention pods with 8 mm diameter and well

graded pods.

Farmers' group membership

The results show that there is low participation in farming groups amongst the interviewed farmers (Figure 4A). The

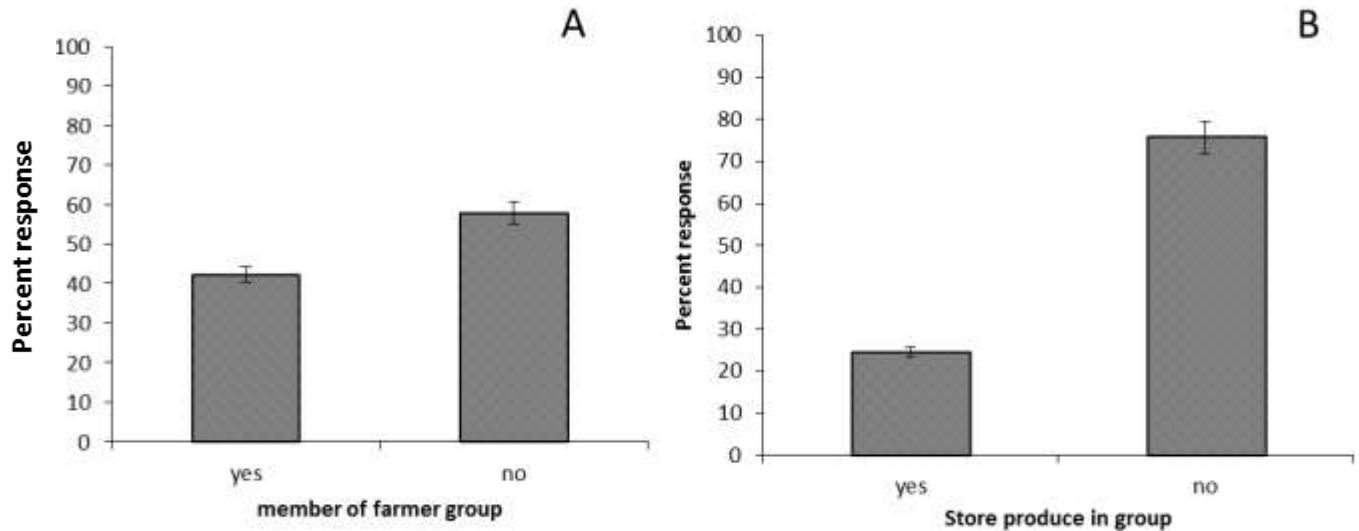


Figure 4. Group membership by the farmers and storage of produce in group storage facilities.

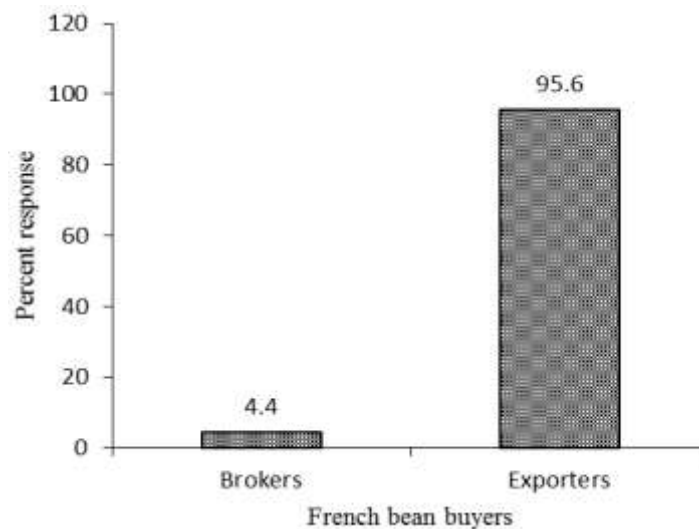


Figure 5. Market outlets for French beans from farmers.

interviews revealed that 57.7% of the farmers are not members of farmer groups and therefore were not involved in farmers-group activities. 42% are members of a known group; however, only 24% of these farmers collectively store their produce in farmer groups (Figure 4B).

French bean buyers

When the farmers were asked about the buyers, 95.6% supply their produce directly to exporting companies while only a few (4.4%) sell their produce through the brokers (Figure 5).

Charcoal cooler usage and construction materials

The usage of charcoal cooler among the farmers was common knowledge as majority (80%) of the respondents report having either used the charcoal cooler or borrow from another farmer, while only a few of the farmers did not use the cooler (Table 6). The farmers were also asked about the materials they used in constructing the charcoal cooler in terms of the floor, the walls and roofs. 73% cement their floor while others either put concrete floor or wooden planks. All the farmers use iron sheets as the roofing materials while they use the charcoal to construct the wall. However, in terms of humidifier installation, only 31% install humidifiers while the rest did

Table 6. Distribution of farmers based on the use and the material for construction of charcoal coolers.

Variable	Description	Frequency	Percentage
Charcoal cooler usage	Yes	36	80.0
	No	9	20.0
Floor	Cemented floor	33	73.0
	Concrete floor	2	4.4
	Wood planks	1	2.2
Roof	Iron sheets	36	80.0
Walls	Charcoal wall	36	80.0
Presence of humidifiers	No running water	22	48.9
-	water	14	31.1

Table 7. Factors employed by the farmers to improve the efficiency of the charcoal cooler.

Description	Category	Frequency	% of responses
Efficiency of the cooler	Yes	32.0	71.1
	No	5.0	11.1
What could be done to improve the cooler	Cementing floor	1.0	2.7
	More charcoal	2.0	5.4
	Size enlargement	2.0	5.4
	Wall mesh	3.0	8.1
	Roof cooling	5.0	13.5
	Air circulation	5.0	13.5
	Installing humidifiers	19.0	51.4

not.

Effectivity of the charcoal cooler

Results in Table 7 show that 71% of the respondents confirm that the charcoal cooler was effective as a storage facility while only 11% of the respondents suggest otherwise. In addition, when the farmers were asked how to improve the storage cooler, over 50% of the respondents suggest installation of humidifiers. 5% suggest improvement in air circulation within the coolers while a further 5% suggest installation of cooling system in the roof. Other suggestions included enlargement of the cooler plant, addition of more charcoal, and reinforcing of the wall by using wire mesh.

Correlation coefficient among demographic characteristics of farmers and various post-harvest practices

Demographic characteristics were correlated with various post-harvest practices (Table 8). Harvesting time was

both negatively correlated and statistically significant ($P \leq 0.05$, $r = -0.332$) with age. Temperature storage was also both positively correlated and statistically significant ($P \leq 0.05$, $r = 0.367$) with gender. However, education level ($p \leq 0.01$, $r = -0.383$) and harvesting ($p \leq 0.01$, $r = -0.444$) were both negatively correlated and statistically significant with charcoal cooler effectivity.

DISCUSSION

Demographic and socio-economic characteristics play an important role in understanding the differences between farmers and hence explaining their behaviour regarding adoption of certain technologies. The major characteristics of farmers covered in the survey were distribution of farmers by gender, educational level, marital status and farmers' age. Results show that 75% of the interviewed farmers were males. This implies that French bean production in the two regions was dominated by males. This result could be due to the fact that French bean production is labour intensive (Usman et al., 2016). However, this contradicts many findings which have reported women as the leaders in agricultural

Table 8. Correlation coefficient among demographic characteristics of farmers and various post-harvest practices.

Correlation	Age	Gender	Marital status	Study level	Harvesting time	Measuring temperature	Targeted temperature	Storage	Storage time	Charcoal cooler	Effectivity
Age	1										
gender	-0.017	1									
Marital status	0.050	0.265	1								
Study level	-0.114	0.116	-0.182	1							
Harvesting time	-0.332*	-0.159	0.056	0.037	1						
Measuring temperature	0.028	0.071	-0.247	0.142	-0.215	1					
Targeted temperature	-0.072	0.079	0.066	-0.132	0.532**	-0.273	1				
Storage	-0.051	0.367*	-0.047	0.128	-0.257	-0.057	-0.247	1			
Storage time	0.065	-0.204	-0.249	-0.171	0.147	0.186	0.336*	-0.442**	1		
Charcoal cooler	-0.169	0.323*	0.351*	-0.111	-0.130	-0.129	-0.099	0.295	-0.410**	1	0 ^b
Effectivity	0.413*	0.011	0 ^b	-0.383*	-0.444**	-0.071	-0.093	0.255	-0.304	0 ^b	1

*, **: Correlation is significant at the 0.05 level (2-tailed) and at the 0.01 level (2-tailed), respectively.

activities, mainly in large commercial set-ups like for the case of the exporters. Gender of the farmers captures the differences in post-harvest handling between female and male farmers with either expected to have higher tendency to carefully handle the produce (Garikai, 2014). Age is an important demographic feature because it determines the quality of labour (Babalola et al., 2010). 33.3% of the farmers were aged 41 to 50. This implicates that majority of the farmers are still in their active age of agricultural production and therefore there is possibility of high productivity. However, there was evidence that the youth (ages between 19 and 30 years) were the least involved, a true reflection of the diminishing interest of the young generation towards Agriculture. The study further revealed that 97.8% of the farmers were married and therefore had family responsibilities. These results concur with the findings by Adamu (2005) who found that the majority of arable farmers were married and therefore they were enthusiastically engaged in agricultural production activities in order to improve the living standard of

their households (Siri et al., 2012). Older farmers with huge farming experience are expected to easily adopt new technologies and that includes appropriate post-harvest handling technology to reduce losses associated with increased temperature (Martey et al., 2012).

The interviewed farmers had different levels of education with 40% attaining the basic level of the Kenyan education system. Education enables farmers to make choices based on their own understanding as well as work together easily with other farmers (Martey et al., 2012). It is often assumed that farmers with better education standards have better managerial skills and are able to search for appropriate technologies (Siri et al., 2011) and would find it easy to invest in post-harvesting technologies to avoid losses (Garikai, 2014). Farmers with post primary education can appreciate and use post-harvest technologies (Babalola et al., 2010). This implies that farmers in the present study are open to new ideas and may not necessarily stick to old methods of agriculture. With introduction of a new technology, adoption

rate is expected to be high amongst educated farmers.

Land ownership and land size are factors often considered important in technology adoption. Farmers with larger pieces of land are more likely to adopt an improved technology compared with farmers owning small pieces of farms. Of the sampled respondents, majority were small scale farmers owning small pieces of land. Land ownership, size and quality positively influence adoption of technology (Abera, 2009). Majority of the farmers were not members of any farmer group. Farmer group membership helps in accessing information important in production, post-harvest practices and marketing (Garikai, 2014). Ortmann and King (2007) stated the reasons for the formation of farming cooperatives and farmer group organisations including promotion of self-help, improving negotiating strength with input suppliers and buyers of farm products, assurance of input supplies and/or product markets mainly for perishable crops like fruits and vegetables, and reduction of

opportunistic behaviour brokers. The lack of participation in these farmer groups meant lack of access to information on production, post-harvest handling of French bean and marketing and this may have negative effect on the overall yield achieved by the farmers.

Farmers (80%) interviewed harvested French beans from 9.00 am to 12 noon while others also harvested in the afternoon. The time a farmer decides to harvest may impact positively or negatively on losses associated with post-harvest handling. Harvesting in the morning when the temperatures are not high results in low post harvest losses. Morning hours are characterized by high humidity and low temperatures with the produce still turgid while in the afternoon the weather is characterized by high temperatures and high evaporation resulting in less turgid and shrivelled produce (Kereth et al., 2013). Therefore, biological reactions such as respiration are expected to increase in the afternoon (Mashau et al., 2012). Field heat is usually high and detrimental at harvesting and should be removed quickly as possible (Arah et al., 2016).

When handling perishable produce like French beans, high standards of hygiene are paramount. Unfortunately, cleaning or disinfecting was not a common practice in the two counties as majority of the interviewed farmers admitted not to cleaning or disinfecting their produce. This can be attributed to very stringent rules on post-harvest wash as outlined in the Food Safety Standards that most exporters subscribe to, mainly Global GAP that has strict control on the quality of water that can be used to wash fresh produce, such water must be potable/drinkable quality, a requirement that may not be achieved by most of the smallholder farmers or sheer ignorance of the practice by the farmers (Arah, 2016). Few of them use water guard to wash their produce. Kader (2005) reiterated that good hygiene while handling the produce minimises contamination hence reduction in post-harvest losses.

Precooling minimizes the effect of microbial activity and immediate cooling is very important. Low temperature for French bean handling can be attained either in the early hours of the morning or late in the evening (Kader, 1984). Results show that many farmers stored their produce for around 1 to 6 h. French bean in its harvested form contains high percentage of water and therefore carries out physiological respiration (Idah et al., 2007). As the produce respire and loses water, their quality depreciates as they shrivel. This leads to deterioration during transit and storage, hence the need for minimal storage times. It has been reported that the longer the produce is stored the higher the change in texture, aroma and even spoilage (Yahia, 2006). Post-harvest handling and processing of fresh produce may impact on the biochemical changes and microbial contamination (Rico et al., 2007). To avoid contamination and degradation of the fresh produce, Kader (2005) suggests reducing potential contamination of the produce during growth,

harvesting and up to storage. Conformity to sanitation standards is necessary to limit losses.

Considering 80% of farmers have cold storage rooms, storage period of up to 6 h was reported. Storage period is an important aspect when handling French beans, majority of the interviewed farmers' stored French beans for between 2 and 3 h. It has been reported that longer storage periods result in quality deterioration. Fresh produce like French beans continues to break down and utilize their nutrients from harvesting through packing, distribution, marketing and even sale. This results in rapid loss of the produce when the temperatures are high (Gikaria, 2013). Carbohydrates, proteins and other nutrients are broken down into simpler compounds often resulting in reduced quality or quantity of the foods (Kitinoja, 2013). Minimizing the storage time at the farm will help in reducing postharvest losses as suggested by Kader (2005) who argued that as the time from the time of purchase, the produce in the market increases, and its deterioration increases.

The present study revealed that many of the farmers used a cooling storage facility before transporting to the respective customers; this ensured reduced post-harvest losses associated with high temperatures. Kader (2005) reported that overheating during storage and transportation results in increased water loss. Provision of optimum temperature and relative humidity is the most important tool for maintaining quality of vegetables (Kader, 2003). 73% of the farmers in the present study used mainly cement for floor construction, charcoal for wall and iron sheets for roofing. As suggested by the farmers, increasing the size of the cooler is important. Enough floor space provides ready access to all the produce stored in the room. It is recommended that the floor should be equipped with a suitable inside drain to dispose of waste water from cleaning and condensation. A charcoal cooler employs the principal of evaporative cooling to maintain cool interior temperature for produce preservation. The facility is constructed from an open timber frame with charcoal filled wall which should be continuously moist. Many of the farmers with cold storage facility did not install humidifiers. As the warm dry air passes through the moist charcoal, water is evaporated into the air resulting into the cooling. This facility has benefits of increasing the air moisture content, preventing produce from drying out, then extending the shelf life. Evaporative cooling is based on the principle that water requires heat energy to evaporate. In hot environment, the evaporation of water in hot dry air creates a cooling effect.

In most cases, small scale farmers depend on middlemen or brokers for selling their produce. In this study, 95.6% farmers preferred to sell their produce to well-established exporters. According to Lange et al. (2016), large number of middlemen involved in value chains can significantly affect the viability of introducing and maintaining cold chains.

This study is very important, considering that majority of the small holder farmers rely on the use of charcoal coolers as a means of cooling their produce, and majority of them are convinced that the charcoal coolers are effective in terms of cool chain improvement, the findings from this study provide an excellent opportunity for policy makers to include provision of cold storage facilities in the local areas, especially targeting export small scale farmers.

For the exporters who have contracted the small scale farmers to grow French beans for export, findings on time of harvesting is very important, considering that majority of the farmers harvest between 9 am and 12 noon, at this time normally the sun is always up and temperatures high, it is indeed a good opportunity for the exporters to review their operating procedures to ensure that the farmers harvest early in the morning between 6 and 9 am before temperatures rise.

With regards to the efficacy of the existing charcoal coolers, majority of the farmers were not bothered to measure the produce temperature, as such the effectiveness of the charcoal coolers was not a priority. There is definitely a gap in terms of working to improve the effectiveness of the charcoal coolers, which can only be validated by measuring the produce temperature.

From the results, majority of the small scale farmers did not belong to any farmers group, a factor that would make it impossible to benefit from economies of scale with regards to National Government Infrastructural Development. In addition, this provides an opportunity for the Kenyan Government to implement the Food Crops Act, which requires that farmers get organized into groups and sell their produce through an organized group through a collective consolidation centre.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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