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Original Research Article

Perceptions of Smallholder Farmers on Influence of Packaging Postharvest Handling Technology on Quality of Tomatoes in Kisii and Nyamira Counties, Kenya

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Abstract: Reduction of damages, retention of quality of fresh horticultural produce as well as protection against mechanical damages is due to proper packaging. The study aimed at assessing perceptions of smallholder farmers on influence of packaging postharvest handling technologies on quality of tomatoes in the counties of Kisii and Nyamira. The study objective was to assess perceptions of smallholder farmers on influence of postharvest handling methods of packaging on quality of tomatoes in Kisii and Nyamira Counties. The research used descriptive survey research design, multistage sampling technique, purposive sampling to sample counties of Kisii and Nyamira, simple random sampling to sample three sub counties of Kisii Central, Bomachoge Borabu and Borabu Sub Counties. A total of 168 registered smallholder farmers from a target population of 1001 were sampled. Extension officers from Kisii Central, Kenyenya and Borabu were contacted and informed on the purpose of the interview, importance of data in research and the need to respond truthfully to ensure that data collected is reliable. The semi-structured questionnaire was administered to smallholder tomato farmers. Descriptive statistics was analyzed in the form of percentages, means and standard deviation and presented in the form of tables and charts. Inferential statistics was analyzed using Statistical Package for Social Scientists (SPSS) version 20 software. Pearson's Correlation was used to show the relationships between the variables of dependent and independent with results revealing that methods of packaging had weak positive influence on postharvest quality of tomatoes ($r=.286$, $p<.05$). Therefore, necessity to sensitize smallholder farmers on principles of proper packaging of tomato for quality delivery to the market.

Keywords: Perceptions, Smallholder Farmers, Packaging, Postharvest Handling, Tomato Quality.

INTRODUCTION

Tomato (*Lycopersicon esculentum*) as a fruit vegetable belong to the family of solanaceae which is categorized as annual crop. The crop origin is believed to be South America, later spread to Europe in the 16th century, and East Africa in early 1900 by colonial settlers (Wamache, 2005). The fruit is important in income generation, employment creation, foreign exchange earner and boosting living standards of smallholder farmers (Sigei *et al*., 2014). According to Mungai *et al*., (2000), processed tomato product is high in demand, however, the crop is mainly grown for local consumption and export market in Kenya. According to Government of Kenya (2012), horticulture has tremendously grown annually at the rate of 15-20% over decades. Horticultural sub-sector contributes 36% of the agricultural GDP (Gross Domestic Product) and 8% of the country's GDP. Kenya has been ranked 6th African leading countries in terms of tomato production, producing approximately 397,007 tonnes of tomatoes (FAO, 2012). Due to poor handling and inadequate infrastructure, postharvest losses in horticultural crops (including tomato) are estimated to be in the tune of 25 to 40% which is a major setback in

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expansion of the industry. The postharvest losses in tomato fruits are prime factors that affect tomato quantity as well as quality in the market (Meaza *et al*., 2007). Despite the introduction of new technologies on tomato production, some smallholder farmers still rely on traditional methods of farming which impacts negatively in terms of productivity, profitability and sustainability (Government of Kenya (GOK, 2010). Most of the traditional methods tend lower tomato produce quality and quantity due postharvest handling leading to post harvest losses (PHL). Grolleaud, (2002), pointed out postharvest losses to be measurable decline in foodstuffs as a result leading to loss of quantity or quality. Tomatoes at the base of containers are subjected to compressive stresses as a result of overloading leading to crushing of tomato fruits. Kitinoja (2008), suggested use of smooth surfaced containers which are shallow to help prevent overloading thus reducing crushing and mechanical injuries to harvested tomatoes, therefore the research recommended use of plastic basket containers when harvesting tomatoes. According to Hurst (2010), crushing of tomato fruits at the base of container is due to use of oversized baskets and excessive compression forces leading to bruising and crushing subjecting the tomato fruit to entry of disease-causing organism that lowers the quality of harvested tomato. On the other hand, Idah *et al*., (2007), recommends palm baskets which are woven in such a way that smooth sides of the material are turned inside out the basket to reduce mechanical injuries. In addition, Naika *et al*., (2005), to prevent compression stress resulting from postharvest handling, the weight of material and of the produce should not exceed 25kg to reduce crushing and bruising. According to Kitinoja and Gorny (2009), heavier packaging cartons should be stack at the bottom when arranging them followed by less heavy and lighter cartons to help preventing stacking of non-uniform containers that leads to collapse of weaker packages resulting into postharvest losses. It recommends avoidance of rough handling, reduction of handling steps and strict adherence to temperature and relative humidity postharvest handling management.

MATERIALS AND METHODS

Study Area

Research was conducted in Kisii and Nyamira counties, in South Western Kenya, which lies on the latitude: $0^{o}\ 30^{1}0$ S and longitude: $34^{o}\ 38^{1}$E.

Kisii County with hilly topography has several valleys and ridges which lies on elevation of between 1,500m and 1,800 m ASL. The area is approximately 309km northwest from the capital city Nairobi. The county borders Bomet County to the East, Kericho County to the North, Narok County to the South, Homabay and Migori counties to the west. The county enjoys equatorial highland climate with moderate temperature ranging between 15^{0}C-30^{0}C throughout the year. The area also receives an annual average rainfall of 1,500mm. Between March and June the areas experience long rains while September to November short rain sets in and sometimes overlapping patterns of rainfall leading to continuous cropping. The counties have never experienced flooding due to its unique positioning within hills and heavily foliaged Gusii highlands.

Nyamira County borders Homabay County to the north, Bomet county to the south east, Kisii County to the west, and Kericho County to the east. The county covers 899.4km^2 and lies between 1200-2100 m above sea level. Temperature of between 10.1^{0}C-28.7^{0}C and annual rainfall range of 1200 mm-2100 mm per annum which is vital for both agricultural activities and livestock production.

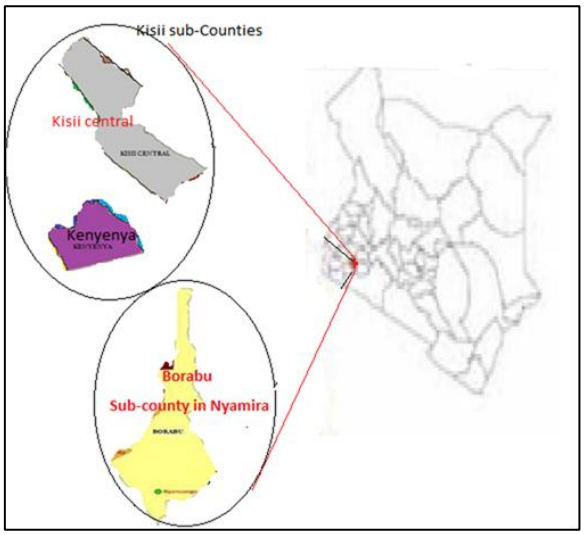

Figure 1: Kisii County map
Source: National Boundaries 2009

Demographic information

Kisii county has been subdivided into eleven sub-counties namely: Kenyenya, Etago, Kisii South, Gucha, Gucha South, Kisii Central, Kitutu Central, Nyamache, Marani, Masaba South and Sameta in Kisii County. These sub-counties are further sub divided into smaller administrative units of 237 sub-locations, 103 locations 45 wards and 33 divisions. Nyamira county has been subdivided into four sub-counties of Masaba North, Manga, Nyamira North and Borabu sub-counties further subdivided into 20 wards. The research was conducted in three sub-counties: Kenyenya and Kisii central sub-counties of Kisii County and Borabu sub-county in Nyamira County.

Research Design

The study employed descriptive survey research design. Mugenda & Mugenda (1999) points out that survey is very important in describing the area under the study or the situations the way they are. They are less expensive, cost effective and explanatory in nature, therefore, easy to make inferences from them in

the cause and the effect. It aids in the collection of qualitative data and quantitative data without manipulation of treatments. A survey was conducted to help collect data on perceptions of smallholder farmers on influence of postharvest handling technologies on tomato quality in Kisii and Nyamira Countjes with much emphasis being on the technologies that have been adopted.

Target Population

Target population is a set of people that have common characteristics (in this case these are smallholder farmers carrying out tomato production). The target population of the study involved 1001 smallholder farmers practicing tomato production and 3 extension agents in Kisii Central, Kenyenya and Borabu Sub-Counties. The smallholder farmers constituted 325 farmers in Kisii central Sub County, 335 farmers in Kenyenya Sub County and 341 farmers in Borabu Sub County.

Sample Size and Sampling Procedure

The sample size used for the study was obtained as 168 tomato smallholder farmers out of the targeted population of 1001 as proposed by Mugenda & Mugenda, (2003) Fisher's formula. Inorder to determine the working sample size for calculation in Fisher's Formula, the researcher chose to use 20% of the target population (sample frame) as proposed by Mugenda & Mugenda, (2003). Mugenda and Mugenda, (2003), a sample size of 10-50% is good enough if well-chosen and gives good representation of target population. The study used purposive sampling to sample two Counties of Kisii and Nyamira and Simple random sampling technique was used to select 168 smallholder farmers from the three sub-counties of Kenyenya, Borabu and Kisii Central. Multistage sampling was used in selecting 168 smallholder farmers practicing tomato production in both greenhouses and open field farming in various wards across the three sub-counties and interviewing them on a number of postharvest handling technologies they use.

Mugenda & Mugenda, (2003), explains a simplified formula for calculating sample size of a population that is less than 10,000 by using Fisher's formula as stipulated below:

$$\mathbf{Nf} = \frac{\mathbf{n}}{\mathbf{1} + \frac{\mathbf{n}}{\mathbf{N}}}$$

Where,
Nf- Sample Size
N- Sample Frame Population Size
n- Working Sample Size given by {20% of sample frame population (1001)}
∴ **n**= {20/100 x 1001}
n= 201
Implying, $\mathrm{Nf} = \frac{201}{1 + \frac{201}{1001}}$
$= 168$ smallholder farmers

The 168 smallholder farmers were then distributed in the Sub-Counties of Kisii and Nyamira Counties as presented in Table 1.

Table 1: Proportionate distribution of smallholder farmers

County	Sub-county	Target population	Sample size
Kisii	Kisii central	325	55
Kisii	Kenyenya	335	56
Nyamira	Borabu	341	57
Total		**1001**	**168**

Data Analysis

During the study qualitative and quantitative data were collected. Quantitative data were collected using Likert scale and analyzed using descriptive statistics in form of percentages, means and standard deviation, and presented in Tables and charts. Inferential statistics was analyzed using Pearson's correlation Techniques. Pearson's Correlation was used to test the significant relationship between the independent and dependent variables.

RESULTS AND DISCUSSION

Respondents' Characteristics

Gender of respondents

The data on gender of the respondents was collected using the smallholder farmers' questionnaire and the results presented in Figure 3.

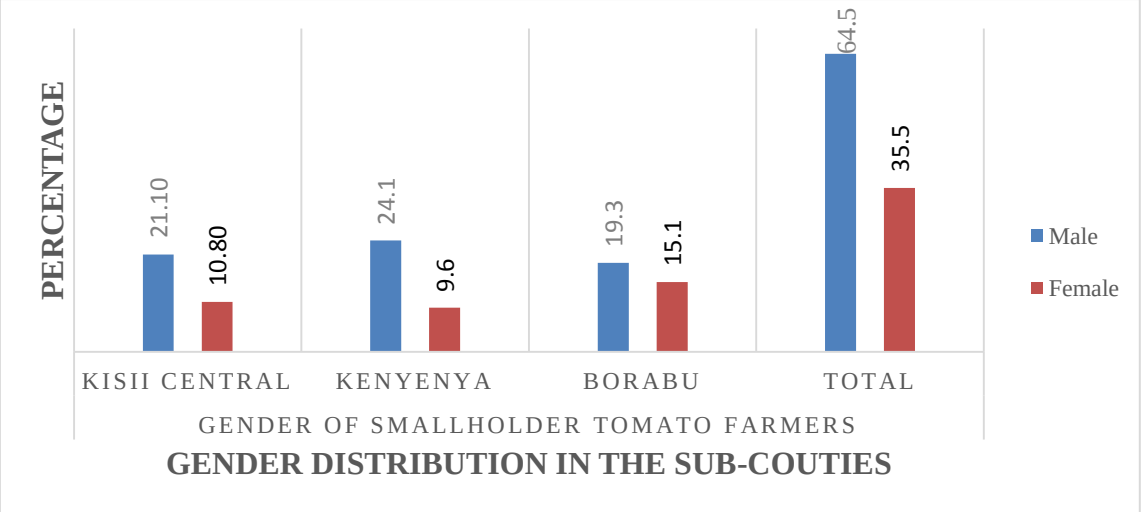

Figure 3: Percentage Gender Distribution of Smallholder Tomato Farmers

Figure 3 indicates that out of one hundred and sixty-six tomato smallholder farmers sampled, 107(64.5%) were male while 59(35.5%) were female. This suggests that a relatively greater number of tomato smallholder farmers in Kisii and Nyamira Counties were male as depicted in the distribution of gender of smallholder tomato farmers across the three sub-counties as indicated in Figure 2. Mwangi and Kariuki (2015), male gender has better information access on new technologies than their female counterparts in the household. Males adopt new agricultural technologies more often than females as established by Uaiene *et al*., (2009); Deressa *et al*., (2009).

Age of respondents

The study sought to determine age distribution of smallholder farmers practicing tomato production in Kisii and Nyamira Counties. Table 3 presents results of analysis of age distribution of smallholder farmers.

Table 2: Age Distribution of tomato smallholder farmers

Age	Kisii Central		Kenyenya		Borabu		Total	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
18-24 Years	12	7.2	17	10.2	15	9.0	44	26.5
25-35 Years	33	19.9	18	10.8	24	14.5	175	45.2
36-50 Years	4	2.4	13	7.8	11	6.6	28	16.9
> 50 Years	4	2.4	8	4.8	7	4.2	19	11.4
Total	**53**		**56**		**57**		**166**	**100**

The Table 2 shows that majority of the smallholder farmers 175(45.2 percent) were in age bracket of 25-35 years while 44(26.5 percent) smallholder farmers were in age bracket 18-24 years, 28(16.9 percent) smallholder farmers were in age bracket of 36-50 years and 19(11.4 percent) were in the age bracket of more than 50 years. This distribution suggests that most of tomato smallholder farmers were energetic and therefore able to effectively carry out tomato postharvest handling practices by engaging minimal human labour. Kibet *et al*., (2011), young headed household family tries to adopt new agricultural innovations than older headed household who doesn't want to risk the adoption of the new technology. However, older household farmers since they have infested in a certain agricultural management practice for several seasons may not risk by trying out new technology, they are not conversant with (Kinyangi, 2014). Therefore, this is in agreement with Kibet *et al*., (2011) and the results of Kinyangi (2014).

Land size of smallholder farmers

According to Babalola *et al*., (2020), established that the larger the farm area that has been put under cultivation, the higher the produce quantity harvested and the higher the likelihood of postharvest losses due to poor postharvest handling technologies. Consequently, the study sought to determine land size of smallholder farmers as would be a limiting factor to tomato production. The results of analysis were presented in Table 3.

Table 3: Distribution of land size

Land Size	Kisii Central		Kenyenya		Borabu		Total	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
1-2 acres	31	18.7	40	24.1	20	12.0	91	54.8

2-5 acres	19	11.4	13	7.8	35	21.1	67	40.4
> 5 acres	3	1.8	3	1.8	2	1.2	8	4.8
Total	**53**		**56**		**57**		**166**	**100**

The results in Table 3 indicate that majority of tomato smallholder farmers 91(54.8 percent) owned between one and two acres of land size while 67(40.4 percent) smallholder farmers had between two and five acres of land size while 8(4.8 percent) smallholder farmers owned land size of more than five acres. Moges and Taye (2017), established that land ownership and size of land highly influences smallholder farmers perception to carry out conservation measures to soil and water. Ownership of land as well gives smallholder farmers security for investment in their farms whereas size of land gives possibilities of new technology trial especially to small pieces of land. In addition, Uaiene *et al*., (2009), pointed out that the larger the size of land the higher the likelihood of farm mechanization technology.

Land tenure system of smallholder farmers

Land tenure systems determine who can use what resources for how long, and under what conditions. Therefore, in order to establish land tenure systems in Kisii and Nyamira Counties, the study required smallholder farmers to state their land tenure system. The data collected were analyzed and results presented in Table 4.

Table 4: Smallholder farmers land tenure system

Land Tenure	Kisii Central		Kenyenya		Borabu		Total	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Individual	37	22.3	32	19.3	17	10.2	86	51.8
Leasehold	11	6.6	18	10.8	35	21.1	64	38.6
Communal	5	3.0	6	3.6	5	3.0	16	9.6
Total	**53**		**56**		**57**		**166**	**100**

Table 4 shows that majority 86(51.8 percent) of smallholder farmers held individual land tenure system, 64(38.6 percent) smallholder farmers were leaseholders while 16(9.6 percent) of smallholder farmers were communal land tenure system holders in Kisii and Nyamira Counties.

Moges and Taye (2017), established that land ownership and size of land highly influences smallholder farmers perception to carry out conservation measures to soil and water. Ownership of land as well gives smallholder farmers security for investment in their farms whereas size of land gives possibilities of new technology trial especially to small pieces of land.

Perceptions of Smallholder Farmers on the Influence of Tomato Postharvest Methods of Packaging

In order to achieve the objective, smallholder farmers were asked to rate on a scale of 1-5, the extent to which various methods of packaging tomato influence postharvest quality of tomato fruits. Methods of packaging included were: jute bags, woven palm baskets, wooden boxes/crates, plastic crates/perforated plastic baskets, nylon sacks and polythene bags. Influence of method used in packaging tomatoes was rated as very low, low, moderate, high and very high.

A summary of analysis of responses on influence of each method of packaging on postharvest quality of tomato fruits are presented in Table 5.

Table 5: Influence of methods of packaging on postharvest quality of tomatoes

Methods of Packaging	Mean	Std. Deviation	Ranking
Jute bags/sacks	1.93	1.305	6
Woven palm baskets	2.55	1.337	3
Wooden boxes/crates	3.66	1.224	2
Plastic crates/Perforated plastic baskets	3.91	1.293	1
Nylon sacks	2.14	1.227	4
Polythene bags	1.96	1.375	5

Interpretation key
1.00-1.44 = Very low 1.45-2.44 = Low 2.45-3.44 = Moderate
3.45-4.44 = High 4.45-5.00 = Very high

The results in Table 5 showed that smallholder farmers rated plastic crates or perforated plastic baskets (M=3.91, SD= 1.293), perforated wooden boxes (M=3.66, SD= 1.224) and woven palm baskets (M=2.55, SD= 1.337) to have had moderate influence on postharvest quality of tomatoes while nylon sacks (M=2.14, SD= 1.227), polythene bags (M=1.96, SD= 1.375) and jute bags (M=1.93, SD= 1.305) had low influence on postharvest quality of tomatoes. Also, the mean ratings on methods of packaging tomatoes suggest that smallholder farmers preferred use of perforated plastic baskets or plastic crates to perforated

wooden boxes, woven palm baskets, nylon sacks, polythene bags and jute bags.

Also the study sought to find out whether smallholder farmers clean and disinfect tomatoes before packaging or not, majority of smallholder farmers 56.6 percent affirmed they clean and disinfect tomatoes before packaging for either storage or transportation while 43.4 percent smallholder farmers confirmed that they do not clean and disinfect tomatoes after harvest. The result is presented in Figure 4 given below.

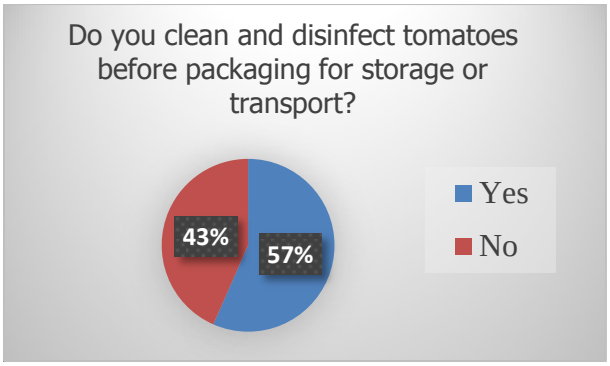

Figure 4: Proportion of smallholder farmers cleaning and disinfecting tomatoes

Similarly, smallholder farmers were required to state the method of packaging tomatoes that they commonly use and explain. The responses of smallholder farmers were analyzed and results presented in Figure 5.

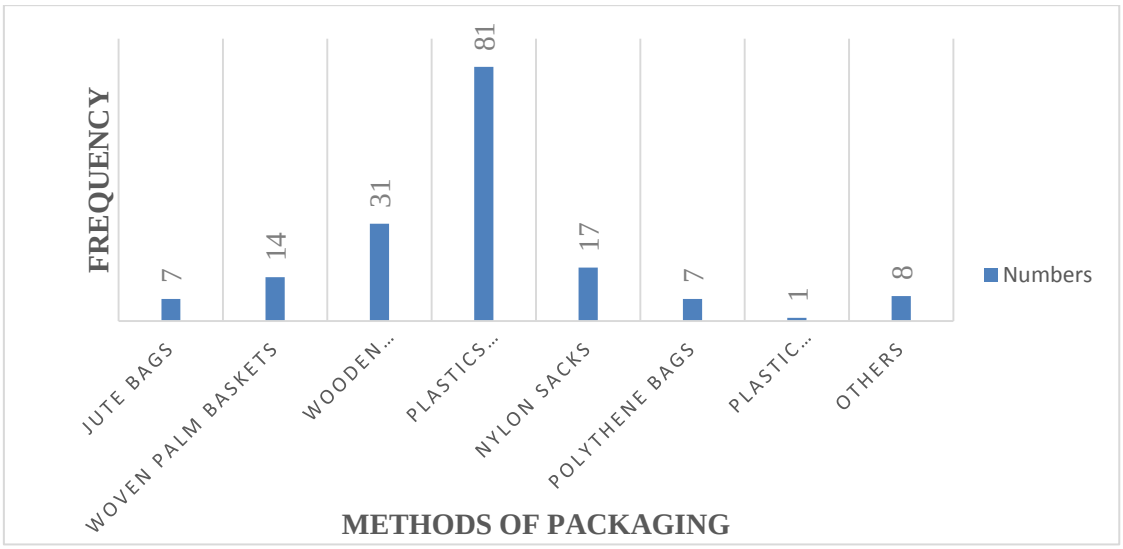

Figure 5: Commonly used postharvest methods of packaging tomatoes

The results in Figure 5 indicate that 48.8 percent of smallholder farmers use plastic crates or perforated plastic baskets, 18.7 percent of smallholder farmers were using perforated wooden crates, 10.2 percent were using nylon sacks or bags, 8.4 percent woven palm baskets, 4.2 percent were packaging tomatoes in jute bags, 4.2 percent in polythene bags and point six percent using other methods of packaging tomatoes such as plastic buckets and basins. This implies that plastic crates or perforated plastic baskets and perforated wooden crates were most commonly used methods of packaging tomatoes after harvest for either short term storage or during transportation.

The perforated nature of most commonly used plastic crates or plastic baskets and wooden boxes or crates suggest that tomato smallholder farmers were aware that packed tomatoes require good aeration to minimize postharvest losses due to deterioration of quality. However, jute bags were not highly used though they could serve similar purpose since they were not commonly available in the study location. Srinivasa *et al*., (2006) and Akbudak *et al*., (2007), in addition to provision of protection to packaged commodity, packaging material offers modification to tomatoes therefore influencing postharvest quality by changing gas compositions. However, quite a number of studies have established that storing tomatoes in polyethylene plastic films modifies gas composition therefore benefiting tomatoes by maintaining their quality (Akbudak *et al*., 2007, 2012). To test the null hypothesis, data on ratings of methods of packaging tomatoes and postharvest quality of tomatoes were analyzed using Pearson's correlation technique and results of analysis presented in Table 6.

Table-6: Correlation between methods of packaging and postharvest quality of tomatoes

		Methods of packaging	Postharvest quality
Methods of packaging	Pearson Correlation	1	.286*
	Sig. (2-tailed)		.000
	N	166	166
Postharvest quality	Pearson Correlation	.286*	1
	Sig. (2-tailed)	.000	
	N	166	166
*. Correlation is significant at the 0.05 level (2-tailed).			

Table-6 indicates that methods of packaging tomato fruits after harvest had a positive and significant relationship (r=0.286, p<.05) with postharvest quality of tomatoes. This suggests that methods of packaging tomatoes positively influence postharvest quality of tomatoes. According to Kader (1992), postharvest losses mostly is due to bulk of packaging without proper sorting and grading, damages on transit and during storage that results into mechanical injuries of bruising and crushing. Hurst (2010), at the base of packaging containers, crushing of tomato fruits occurs due to overloading leading to build up of excessive compressive forces after harvest. In addition, Kitinoja (2008), recommended the use of plastic baskets for tomato harvesting due their shallow and smooth surfaces that prevents overloading therefore reducing crushing of harvested tomatoes and reduce mechanical injuries. The results of the finding agree with Hurst (2010), who argued that use of oversized basket crates creates excessive forces resulting into crushing of tomato fruits located at the basket base by subjecting them to crushing and bruising lowering quality of tomatoes exposing the fruit to disease causing micro-organisms breaking marketability of the produce. However, Idah *et al*., (2007), established that use of palm baskets for packaging, turning of the material inward is necessary to form a smooth surface that reduces mechanical injuries as well as giving smooth touch to tomatoes. Kitinoja and Gorny (2009), use of non-uniform containers for packaging and when stacking them on top each other care must be taken to avoid collapse due to heaviness and weaker cartoons.

CONCLUSION

Smallholder farmers level of knowledge on postharvest handling technologies had moderate influence on postharvest handling of tomatoes in Kisii and Nyamira Counties. Smallholder farmers methods of packaging tomatoes had a weak positive influence on postharvest quality of tomatoes. Therefore, there is necessity to blend both educated and less educated smallholder farmers to boost their know-how on principles of postharvest handling technologies. Donors and county governments are encouraged to source for proper packaging materials and train smallholder farmers on the proper usage.

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