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Influence of Postharvest Handling and Packaging Technologies on Tomato Quality Among Smallholder Farmers in Kisii and Nyamira Counties, Kenya

Joseph Mbunde[1*], David K. Bunyatta[2], Joseph K. Langat[3], Job O. Omweno[4]

[1,2]Department of Agricultural Education and Extension, Kisii University, Kenya P.O Box 408-40200, Kenya.*
ORCiD ID: https://orcid.org/0000-0003-2477-5209
[3]Department of Agricultural Sciences, Kisii University, Kenya P.O Box 408-40200, Kenya.
ORCiD ID: https://orcid.org/0000-0003-0587-8640
[4]Department of Natural Resources and Environmental Sciences, Kisii University, Kenya P.O Box 408-40200, Kenya.
ORCiD ID: https://orcid.org/0000-0002-0528-94274

Corresponding Email: [1]mbunde90@gmail.com*

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Abstract: ***Tomato, Lycopersicon esculentum is a highly perishable horticultural crop, which requires high level of post-harvest management to prevent losses during harvesting, packaging and transport. The study aimed at assessing the influence of knowledge levels of postharvest handling technologies on tomato quality among smallholder farmers in of Kisii and Nyamira counties, Kenya. The study sampled 168 respondents from the target population of 1001 registered smallholder tomato farmers in the two counties using random and purposive multilevel sampling designs. Data was collected using semi-structured questionnaires and interview schedules after determining the validity and reliability of the data collection tools. Descriptive statistics; mean, frequencies and percentages, and one-way ANOVA were performed using the Statistical package for social sciences (SPSS version 21, IBM Inc.) and the statistical significance of the differences of knowledge among the smallholder farmers levels judged at p = 0.05. There were significant differences (p < 0.05) in postharvest management knowledge levels among smallholder farmers. The overall mean (3.24 ± 0.822) indicated that smallholder farmers had moderate level of knowledge on tomato postharvest handling technologies. The means for packaging (3.49 ± 1.210) and transport (3.48 ±1.229), were significantly higher (p < 0.05) than other post-harvest technologies, with precooling (2.1±1.3) recording the lowest mean. Adoption of recommended post-harvest practices is determined by knowledge levels among the small holder farmers. Therefore, the study recommends the involvement of other advisory***

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channels in training smallholder farmers to improve their awareness on postharvest handling technologies to reduce tomato quality deterioration.

Keywords: Knowledge Level, Postharvest Technologies, Tomato Quality, Kenya.

1. INTRODUCTION

Post-harvest management determines quality and quantity losses in fresh produce such as nutritional quality, edibility and calorific value, which determine consumer acceptability and vary with type of produce, production locations and season (WRI, 1998). Such losses occur due to poor handling, storage and preservation of the produce (Willis et al., 1981; Kun-Yang, 2016). Tomato production is highly characterized by seasonality. Consequently, sustainable production requires minimization of losses which occur due to handling during packaging and transportation to curb increasing shortages (Kader, 2005). Rather than increasing the yields to reverse dwindling production trends, it is highly recommended to minimize losses due to low capital investment. However, little has been done to increase the shelf-life and quality of tomato fruits although acceptable food safety standards for tomato consumption are often adhered to (Kader et al., 2004). Consumers are highly subjective to quality characteristics of tomatoes such as the nutritional value, firmness, flavor and even the physical appearance (Kader, 2008; Giovannoni, 2001).

Most consumers prefer to buy tomato fruits with turgid appearance, firmness, shiny and uniform colour with no signs of mechanical injury, decay and shriveling. Empirically, these quality characteristics change at every stage of tomato ripeness from harvesting time to storage and processing depending on such factors as ambient temperatures and handling. Other factors that determine the quality of tomatoes include stage of maturation which readiness of the fruit for harvesting, the stage of ripening and the stage of senescence (FAO, 2008; Beckles, 2012).

In addition, several factors may determine the deterioration of tomato quality. For instance mechanical damages and spoilage account for ~ 16 - 40 percent of total losses in tomatoes (Kitinoja, 2010). Hence it is recommended that fresh market varieties of tomatoes are harvested at mature green state preferably when the purplish colour starts to appear to enhance transport of the produce to distant markets. This allows time for the fruits to slowly ripen, as they are packaged and transported, avoiding the deterioration of quality due to mechanical injuries (Orzolek et al., 2006; Moneruzzaman et al., 2009). In developing countries, postharvest losses during harvesting, packaging and transport of tomatoes to the market have been estimated to be ~ 20-50 percent (Kitinoja & Gorny, 2009). According to Kader et al. (2004), postharvest losses also occur during packaging of tomatoes into materials such as jute bags, woven baskets, wooden boxes and low density perforated plastic buckets. Recommended packaging using these is done with an intention of protecting tomatoes from mechanical damages during compression which may result in crushing tomatoes, avoid contamination and enhance transport (FAO, 1998; Idah et al 2007; Hurst, 2010). Tomato quality can be deteriorated due to poor handling during packaging and transportation. In addition, delayed transportation due to poor road network connecting tomato production areas and causing undulations which in turn causes vibrations and bruising of fruits in most developing countries accounts to ~20 percent of all postharvest losses in tomatoes (Idah et al.,

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2007; Babalola et al., 2008). At this post-harvest stage, care should be taken when handling tomato fruits in order to avoid impact of compression and puncture forces on the produce (Mutari & Debbie, 2011). This study was conducted to assess the influence of knowledge levels on tomato postharvest technologies among smallholder farmers in two counties in Kenya.

2. METHODOLOGY

2.1 Study Area

Research was conducted in three sub counties of Kisii and Nyamira counties, located ~300 km South West of Nairobi, Kenya. The three Sub-counties are Kenyenya and Kisii central sub-counties in Kisii County and Borabu sub-County in Nyamira County (Figure 1).

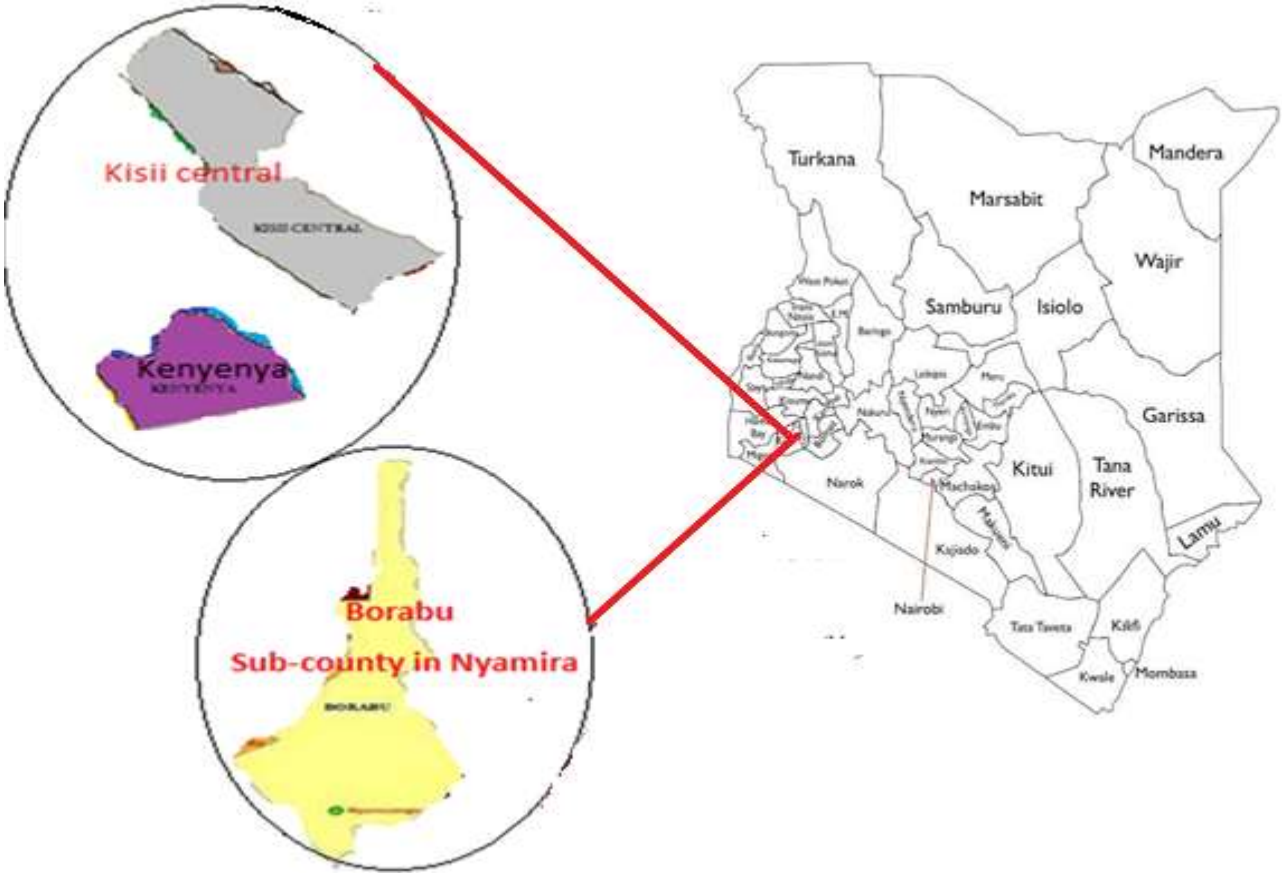

Figure 1: Map of the study areas in Kisii and Nyamira Counties, Kenya

2.1.1 Climate and agro-ecological zones

Kisii and Nyamira counties have an highland equatorial climate which makes them agriculturally potential areas for vegetable production (Nyangwansa et al., 2021). The mean annual temperatures range from 15^0C to 30^0C in Kisii county, while Nyamira County experiences a temperature range of 10.1^0C to 28.7^0C (NCD Plan, 2014-2015; KCID Plan, 2018-2022). The annual average rainfall in the two counties range from ~ 1200 - 2100mm.

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Long rains spread between March and June while short rains are distributed between September to November every year. Nevertheless, the two counties hardly experience flooding, due to their location in a high altitude region with an elevation of between 1,500 m and 1,800 m above sea level. Kisii County is moderately hilly with upper midland ecological zone covering ~ 75 percent of the County which is the arable land under crop production (KCID Plan, 2018-2022). Nyamira County is dominated by an highland ecological zone which covers up to 82 percent of the land area and the rest is a lowland ecological zone (Nyamira County Annual Development Plan, 2014-2015). Crop farming dominates the two counties' economic activities. The vegetable crops commonly cultivated in the two counties under small scale land holdings include kales, cabbage, tomatoes and indigenous vegetables mainly for local consumption.

2.2 Research Design

The target population was 1001 smallholder tomato farmers drawn from three subcounties; Kisii central, Kenyenya and Borabu Sub Counties respectively. A sample of 168 small holder farmers which constitute 20 percent of the target population was obtained using Fisher's Formula: $\boldsymbol{Nf = \frac{n}{1+\frac{n}{N}}}$ **;** where: **N,** is the target population, **n**, is the sample and **f,** is the sampling frequency, as recommended by Mugenda & Mugenda (2003). The study employed random sampling for Kenyenya and Kisii Central Sub-counties, while Borabu Sub-County was purposively sampled due its agricultural setup that offers micro-climate for tomato production (Table 1).

Table 1: Proportionate distribution of smallholder farmers

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

A cross-sectional survey design which measures outcome of smallholder farmers' exposure to postharvest handling technologies was used. During piloting, structured questionnaires were randomly administered among 33 (20 % of study sample) tomato farmers who were not part of the sampled population. Data was collected from respondents using structured questionnaires, interview schedules which were administered through multistage sampling techniques while direct observation was used to assess the effects of postharvest handling technologies on tomato quality during packaging and transportation of tomatoes. To ensure the acceptable level of validity, data instruments were given to the supervisors and experts in the School of Agriculture and Natural Resource Management, Kisii University, Kenya, who gave recommendations that were included in the questionnaires as recommended by (Bryman, 2012).

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2.3 Data analysis

The responses on farmer's awareness responses were ranked from least effective to most effective using a five-point Likert scale, in which 1= very low/ least ineffective; 2= low; 3= neutral/ undecided; 4= high/ effective; 5= very high/ most effective. The outcome was then analyzed to reduce social desirability bias and social pressure. The interview schedules consisted of open-ended questions based on tomato postharvest handling technologies. Pearson's correlation coefficient of 0.76 indicated that the responses obtained from smallholder using the structured questionnaires can be considered reliable. Qualitative and quantitative data were analyzed using descriptive statistics and One-way Analysis of variance (ANOVA) which was performed using SPSS Version 19 (IBM Inc.) and the differences considered statistically significant at $p < 0.05$.

3. RESULTS AND DISCUSSION

3.1 Level of Knowledge on Postharvest Technologies among Smallholder Farmers

The mean level of knowledge on tomato postharvest handling technologies was significantly higher ($F_{(2,163)} = 16.0$, $p < 0.05$) among smallholder farmers in Kisii Central subcounty, followed by Kenyenya and Borabu sub counties. However, Tukey's HSD multiple comparisons indicated that there no significance differences in the overall level of knowledge between Kisii Central and Kenyenya sub counties (Table 2).

Table 2: A comparison of overall post-harvest knowledge level among the smallholder farmers' in the three sub counties

Level of Postharvest Knowledge	Sub-County	Mean	Standard Deviation (SD)
Overall level of knowledge	Kisii Central	3.58 [a]	0.800
	Kenyenya	3.34 [b]	0.755
	Borabu	2.81 [c]	0.729

Noted: Tukey's multiple comparisons of means of postharvest knowledge levels at 95% family-wise for the significant differences among the sub county means. The superscripts to the means have ordered the means with highest mean taking the lowest alphabet i.e. a > b > c

This could have been be due presence of many higher learning institutions and middle level colleges such as agricultural universities, a national polytechnic and farmers training centres (FTCs) in Kisii Central subcounty which serve to enlighten the farmers on several aspects of tomato farming. The knowledge levels on postharvest handling and packaging technologies were measured using different parameters which are indicated in the appendix.
Smallholder farmers in Kisii and Nyamira Counties had high level of knowledge on both tomato postharvest packaging technologies (3.49 ± 1.210) and choice of appropriate means of transport (3.48 ±1.229). These farmers had however moderate knowledge levels on timing of

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harvest to obtain best quality of tomatoes, proper harvesting methods, precooling of tomato fruits after harvesting, cleaning or disinfecting tomato fruits, sorting and grading of tomatoes and storage of tomato fruits (Figure 1). The overall mean of knowledge levels (3.24 ± 0.822) indicated that smallholder farmers had moderate level of knowledge on tomato postharvest handling technologies.

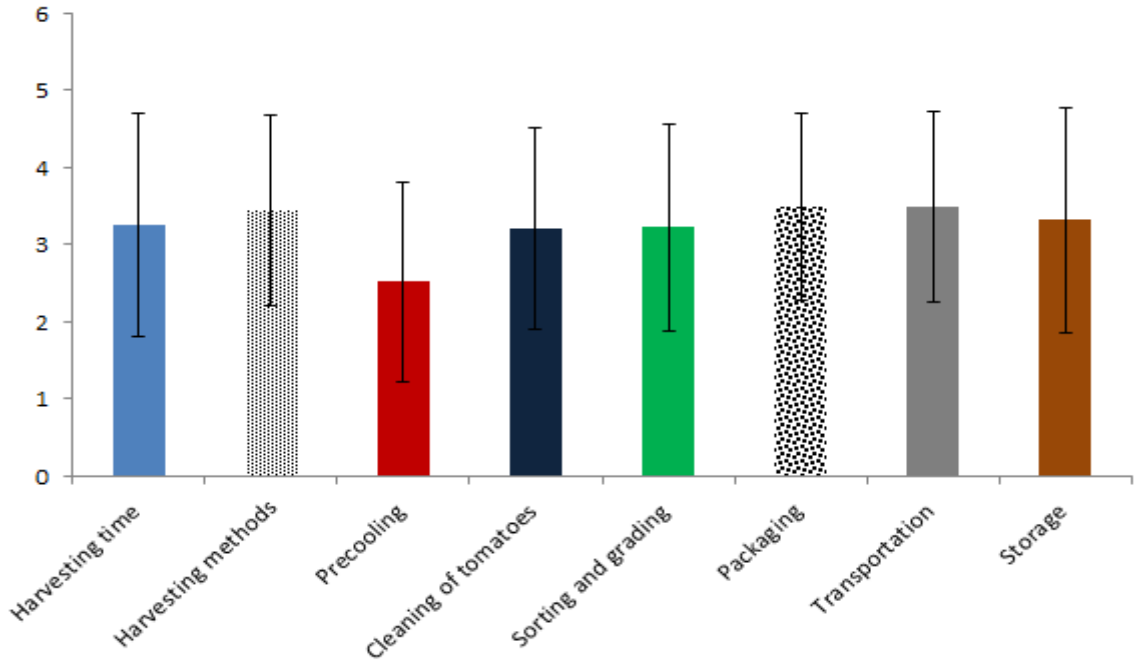

Figure 2: Knowledge levels on postharvest handling technologies

Noted: Interpretation key for the means of knowledge level: 1.00 - 1.44 , indicates "very low", 1.45 - 2.44 "low" , 2.45 - 3.44 "moderate", 3.45 - 4.44 "high" whereas 4.45 - 5.00 indicates "very high".

Access to information creates awareness of post-harvest technologies among smallholder farmers which contributes to reduction of post-harvest losses (Obayelu et al., 2017). According to Nyagwansa et al. (2021), there are various advisory channels for disseminating agricultural information which increases the knowledge levels among the small holder farmers. However, farmers attitudes and perceptions towards extension services, which is the main advisory channel in Kenya, may hinder adoption of post-harvest technologies among the small holder tomato farmers. Therefore, extension services need to keep up with the changing technologies in order to meet the knowledge needs of smallholder tomato farmers (Muturi, 1999).
majority of smallholder farmers 31 (58.5 percent) in Kisii Central and 30 (53.6 percent) in Kenyenya Sub-Counties get access to extension services on tomato postharvest handling technologies, while in Borabu Sub-County majority of smallholder farmers 44 (77.2 percent) did not get access to these services (Table 3).

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Table 3: Responses of small holder farmers access to extension services on tomato postharvest handling technologies

County	Sub-County	Frequencies/ %	Yes	No	Total
Kisii	Kisii Central	Count	31	22	53
		percent	58.5	41.5	100
	Kenyenya	Count	30	26	56
		percent	53.6	46.4	100
Nyamira	Borabu	Count	13	44	57
		percent	22.8	77.2	100
Total			**-`**	**92**	**166**

These findings indicate that most households require extension services only when they are necessary. This corroborates with the findings of Ochola *et al.* (2014), who reported that extension agents are mainly motivated by the households having high chances of technology uptake, which increases their frequency of visits to these households. Furthermore, the findings suggests that extension services exhibit a positive influence on the level of knowledge among smallholder tomato farmers and this explains why there was remarkably low level of post-harvest losses among the smallholder farmers in Kisii Central sub county compared to Borabu and Kenyenya Sub-Couties. By enhancing the level of knowledge among the smallholder tomato farmers, access to extension services serves as a crucial determinant for adoption of postharvest handling technologies.

A total of 74 smallholder farmers indicated that they get access to extension services. Majority of these respondents (33.8 percent) sampled from Kisii Central sub county indicated to have obtained extension services through forums organized by local leaders. This is in contrast with Kenyenya and Borabu sub-counties where majority of the farmers accessed extension services directly through extension agent from Ministry of Agriculture, without involving the local leadership. Consequently, few number of small holder farmers, accounting for 35.1 and 9.5 percent in Kenyenya and Borabu sub counties got access to extension services. The study found that local leadership played a pivotal role in mobilizing small holder farmers to form working groups which enhances information dissemination through on farm and field demonstrations.

It is imperative to understand that apart from extension officers, several other agents, such as trained farmers and agro-processors also recommend techniques for reducing post harvest losses in tomatoes. They assess whether the technology suits the farmers' present needs than imposing predetermined technology and its accompanying practices and principles. Sometimes, several agents work in collaboration to design and evaluate the potential post-harvest technologies to be adopted by small holder farmers (NALEP1, 2011). However, the influence of extension officers to farmers uptake of new technology is motivated by farmers confidence levels and the frequent visits made by extension officers to the farms. Extension services have led to an overall improved postharvest handling of tomatoes as well as packaging (Yuan, 2010). It increases the knowledge levels among smallholder farmers which increases their capacity to reduce tomato post-harvest losses. Therefore, there is need for both

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private sectors and public sectors to be involved in disseminating agricultural information for the benefit of smallholder farmers in the two counties.

4. CONCLUSIONS

The current study concludes that the smallholder farmers domiciled in Kisii and Nyamira regions of Kenya have moderate level of knowledge on tomato postharvest handling technologies which significantly affected the quality of tomatoes. The mean levels of knowledge on tomato postharvest handling and packaging technologies were significantly higher in Kisii County due to a large number of Farmer Training Centers (FTCs), which disseminated the knowledge on postharvest technologies. Additionally, the modes of packaging and transport were significantly higher than other post-harvest technologies, while precooling was not well articulated by the farmers. Nevertheless was conducted was unable to capture seasonal variations of tomato postharvest losses during storage, packaging and transportation and did not collect information from other advisory channels, which could further limit the generalizations made from the study.

The study recommends the involvement of other advisory channels in training smallholder farmers to improve their awareness on postharvest handling technologies to reduce tomato postharvest losses.

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