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Assessment of post-harvest handling of mango and evaluation of mango jam in major mango producing areas of South Omo Zone, SNNPR, Ethiopia

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A B S T R A C T

The present study aimed to assess the postharvest handling practice, demonstrate and popularize mango jam processing on rural households' levels in major mango growing areas of Debub Ari Woreda, South omo, Southern Ethiopia. Training manual was developed and Practical training on processing, post-harvest handling and utilization of mango jam was given for 12 DAs, 7 Administrators and 161 model Farmers comprising of 72 female farmers and 65 model male farmers and 40 model farmer households were interviewed about the technology and postharvest handling practice in the area in which 28 are females and 12 are male. Postharvest handling practice and sensory perception of mango jam and other relevant data were collected, analysed, interpreted and discussed. Results revealed that, 87.5% of respondent are greater than 25 years old and 40.0% attended various levels (elementary to high school) education. The major transportation method and packaging material used as replied by the respondents are 42.5% (use pack animals: donkey, mule and horse) and 47.5% (use sack), respectively. Pest attack (disease, insect) followed by mechanical damage during harvesting, poor packaging material and damage during transportation were identified as the main causes of mango loss specified by the respondents. Therefore, use of the better adapted and pest/disease-tolerant varieties, improved fruit production and harvesting practice, proper storage and transportation facilities, appropriate postharvest innovations and technologies are required to reduce postharvest loss and extend fruit shelf-life.

Keywords: Postharvest losses, Mango, Postharvest handling, Transportation, Mechanical damage

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Introduction

Mango (*Mangifera indica* L.) is one of the 73 genera of the family Anacardiaceae and order Sapindales (Ahmed and Mohamed, 2015) which is one of the most versatile and widely grown fruit crops of tropical and subtropical regions (Vasugi *et al.*, 2012). Mango is cultivated approximately on 3.7 million hectares worldwide, occupied the 2nd position among the tropical fruit crops (Jahurul *et al.*, 2015) and 5th from fruit crops of the world after citrus, banana, grape and apple (Shi *et al.*, 2015).

Mango is one of the most widely grown among the fruit crops cultivated in Ethiopia preceded only by banana in terms of economic importance (Fita, 2014). A total of 105,379.375 tons of mango is produced from 16,363.48 ha of land (CSA, 2020). It is grown in several parts of the country where the western and eastern Ethiopia are among the major producing belt that accounts >50% of the total mango production in Ethiopia (CSA, 2015).

Mango is known as the king of the fruits due to its excellent flavour, delicious taste and high nutritive values (Ullah *et al.*, 2010) that makes the crop valued for both food and nutritional security especially for developing countries like Ethiopia where the realization of food and nutritional security is still a challenge. The fruit is an excellent source of vitamin A and C and rich in carbohydrates, minerals (potassium and phosphorus), Phenolic compounds and dietary antioxidants (FAO, 2002). Its yellow-orange characteristic color was attributed to the presence of carotenoids (Venkateswarlu and Reddy, 2014). Consumption of fruits like mango was suggested to overcome vitamin A deficiency and dietary carotenoids are considered to be valuable in the prevention of certain cancers and eye diseases (Krinsky and Johnson, 2005).

Processing of fruit is an important step in food preservation of seasonal gluts and for survival in shortage along with availability of different foods throughout the year (Mathooko *et al*., 2013). Mango fruits can be processed into various products: unripe mangoes were processed into powders, pickles, preserves, dessert or chutney while the ripe mangoes can be processed into dried mango chips, mango wine, mango juice, concentrate, jam, jelly, syrup and canned mango (Musyimi, 2016). In order to reduce the post harvests of fruits and to expand the processing industry researches on development of different value added products and applicable technology is necessary (Wiersinga and de Jager, 2007).

Most people enjoy eating ripe and green mangoes. However, high perishability of ripe mangoes, inadequate storage conditions and poor infrastructure for transportation to distant markets make profitable production to remain a challenge to farmers, resulting into income loss. Mango is a seasonal crop; so, the fruits usually ripen at the same time, as a result market prices fall due to oversupply, making it hard to be sold at a good price. Value-addition through food processing would be a good strategy to utilize rejected mango and other unmarketable fruits. It adds value to mango while keeping the cost of production down. It is also important for the products to be competitive in the world market. Fruit preservation will provide availability of mango flavour throughout the year and is important to avoid wastage and increase income. Some of the simplest ways of preserving fruits include drying (mango leather), juicing and making jam or chutneys (Agri Business Week, 2009).

Jam preparation is the best suited technique for preservation of perishable fruits. It is an ancient method for preservation in many parts of the world. Jam is the fruit solid jel made from the pulp of a single fruit or mixed fruits by boiling the fruit pulp with sugar (sucrose), pectin, acid and other ingredients (preservative, colouring, limited amount of fruit peels and flavouring materials). Jams should be in a reasonable thick consistency, firm enough to hold the fruit tissues in position. Jam should contain minimum fruit content of 40% and the expected total soluble solid content should not less than 68% (Featherstone, 2016). Jam is rich in sugar, energy, fibre, life-sustaining vitamins, minerals and amino acids. Jam does not contain any fat and cholesterol. Therefore, jam consumption also lowers the chances of cardiovascular diseases (Levaj *et al*., 2010).

The processed mango products would provide additional source of income, especially during peak season when there is a glut in supply and the price of mangoes is much cheaper. This activity is conducted to assess the post-harvest handling practice in the study area and alleviate the problem of postharvest handling, utilization and storage of mango for a long time by processing mango fruit into mango Jam. Therefore, the demonstration and popularization of mango harvesting material and mango jam are important for improving the nutritional status and additional income of the farmers.

Materials and Methods

Description of the study area

The study was conducted on the major mango-producing rural kebeles of south Ari woreda, (specifically: Alga, Geza, ayikamer, kyisa, bayitsemal, mayitol and shekamer), South Omo Zone, Southern Ethiopia. The Woreda lies between 6.08 to 6.27' N latitude and 36.54 to 36.75' E longitude. The elevation of the areas ranges from 501 to 3500 meter above sea level. The annual average rainfall of the district ranges between 1401 to1600 mm with minimum and maximum annual temperature of 10.1 and 25.0^{o}C.

Site and Farmer Selection: The survey and Demonstration was conducted in major mango growing areas in Debub Ari woreda of South Omo Zone. Debub Ari was selected purposively based on the area allocated for mango growing, number of mango growers, accessibility and engagement in other research projects. Based on the above criteria 7 Kebles (Alga, Geza, Ayikamer, Kayisa, Bayithemal, Mayitol and Shekamer) from the Woreda were selected. Following the site identification, selecting the participating farmers at all sites was done. Selections of the farmers were based primarily on farmer's land covered with mango, production status and willingness to participate in the research.

Sampling methods, data collection and analysis

Total respondent of the survey on post-harvest handling of mango and sensory perception of mango jam were 40 farmers selected from major mango growing Kebeles of debub Ari Woreda (Alga, Geza, Ayikamer, Kayisa, Bayithemal, Mayitol and Shekamer) by simple random sampling, purposively based on their experience in mango production. From the farmers, who were interviewed about the Jam sensory perception, mango harvesting material and post-harvest handling practice in the area, 28 were females and 12 were male farmers. Both qualitative and quantitative data including sex and age of respondents, type of packaging material, transportation method, harvesting practices, percentage of mango fruit loss, causes of mango fruit losses and measures taken by respondents to reduce postharvest losses were collected using the questionnaire and analysed using SPSS statistical software.

Sensory analysis of the mango jam

A total of 40 untrained panelists were randomly chosen from a group of farmers in seven different kebeles. Sensory evaluation was conducted using a five point hedonic scale to know acceptance of the jam in different sensory aspect (Bekele *et al.*, 2020). The panellists were selected solely on the basis of interest, time available and lack of allergies to food ingredients used in the study. On every occasion, the panellists were provided with the randomly coded white plates containing different samples. The assessors were asked to provide their response for different parameters like appearance, colour, flavour, consistency and overall acceptability. The 5-point hedonic scale was used as 5: like extremely, 4: like moderately, 3: Nether like or dislike, 2: dislike moderately and 1 dislike extremely.

Technology demonstrated and recipe making of mango technology: The demonstration was undertaken to popularize mango harvesting material and mango Jam using the local mango variety. The mango jam was prepared. Then, the product was packed in glass bottle and stored at room temperature until used for sensory perception. Finally, the sensory perception was tested by selected mango producer.

Training and Participants: Training manual was developed and practical training on processing, postharvest handling and utilization of mango jam was imparted to 12 development agents, 7 Administrators and 161 model farmers comprising of 72 female and 65 male farmers.

Promotion: Promotional materials such as brochures and jam preparation guidelines were prepared and distributed to farmers for promoting awareness about mango utilization and postharvest handling.

Results and Discussion

Socio-demographic characteristics of the study area

Among 40 mango farmers interviewed, their gender, age and educational levels were quantified (Table 1). In gender category, 12 (30.0%) of respondents were males and rest of them were females. Among the age groups, the maximum of 17 (42.5%) members were 25-35 years of age followed by 35–45 years and >45 years of age, and the minimum of 5 (12.5%) farmers belong to <25 years of age. The level of education varies among the gender and age categories, 24 of them were illiterates, 16 of them were in various levels (elementary to high school) education. About 40.0% of literate respondents have awareness on the influence of improper harvesting and handling practices on the quality of mango fruits. Similar observation was made by Olayemi *et al.* (2012) who stated that peoples on secondary educational levels can easily understand the postharvest handling practices more than peoples on primary educational levels. Babalola (2011) also reported that education enables to understand the effect of handling practices on the postharvest loss of the produces and leads to better handling practices than illiterate.

Tables 1. Demographic characteristics of sampled respondents.

Socio-demographic characteristics of mango fruit producers		Frequency	Percentage
sex	Male	12	30.0
	Female	28	70.0
Age	<25	5	12.5
	25–35	17	42.5
	35–45	11	27.5
	>45	7	17.5
Educational level	Literate	16	40.0
	Illiterate	24	60.0

Mango fruit transportation method used

Transportation is an essential process during the postharvest supply chain of any fresh produce (Al-Dairi *et al.*, 2021). However, transportation could cause postharvest losses leading to high economic losses (Cherono and Workneh, 2018) if it is not probably managed. About 30.0% of the growers transport their produce by trucks but these vehicles do not have ventilation facility. In addition, 42.5% and 22.5% of the growers transport their produce by pack animals (donkey, mule and Horse) and by the farmers themselves to the nearby village market, respectively. All transportation methods predispose fruits to heat build-up and mechanical damage. Also, during loading and unloading, the fruit was exposed to mechanical and physiological injuries. During transport, fruits and vegetables exposed to rough handling and transported over bad road conditions resulted in damage and mechanical injuries which could increase the losses over the supply chain (Mutari and Debbie, 2011).

Table 2. Fruit transportation methods and packaging materials used.

Transportation method	Number of respondent	Percentage	Packaging material	Number of respondent	Percentage
Car	12	30.0	Basket	15	37.5
Human	9	22.5	Sack	19	47.5
On animal back	17	42.5	Plastic bath	6	15.0

Mango fruit packaging materials used

Packaging is also one of the important aspects to consider in addressing postharvest losses in fruits and vegetables. It is enclosing food produce or product to protect it from mechanical injuries, tampering and contamination from physical, chemical and biological sources (Prasad and Kochhar, 2014). About 47.5, 37.5 and 15.0% respondents reported sack, basket and plastic bath as their mango packaging materials, respectively. They also tightly packed mango fruit, with low gas exchange between commodities in a packaging material without grading fruits based on ripening stage. This practice facilitates ripening process and contributes in shortening fruit shelf-life. Hence, the existing packaging material and practice need to be improved to reduce fruit postharvest losses. Similarly, Seid *et al.* (2013) reported sack as the major fruit packaging material in South Wollo zone, Ethiopia.

Plastic crates, which are stackable, stable, easy to clean and reuse has been shown to reduce damage of perishable crops from an average of 30.0% to less than 10.0% (Kitnoja, 2010). Hence, the postharvest constraints mentioned by the respondents could be alleviated by demonstrating and promoting use of plastic crates with appropriate transportation methods.

Causes of mango fruit postharvest loss at the farmer level

As shown in Table 3, 40.0, 22.5, 15.0, 10.0, 7.5 and 5% of the producers were lost their produce due to pest attack (disease, insect), mechanical damage during harvesting, poor packaging material and damage during transportation, marketing problem and poor storage condition. According to the respondents, the largest loss occurred due to pest attack followed by mechanical damage. The fruit loss during harvesting (picking) are dropping of fruits on the ground from tall varieties of mango, harvesting stick injury, harvesting fruit by kicking with stone, high temperature, sun burning in temporary field storages and harvesting immature fruits together. Most of the varieties being grown by farmers are tall and there is no improved harvesting technology as a result long sticks and stones are used to kick matured fruit from tall trees and fruits detached and dropped to the ground and harvested in to a container and this creates fruit injury that leads to fast postharvest decay. Moreover, harvesting should be made when the temperature drops but harvesting is practiced normally during the day time when there is high temperature, low relative humidity and high sun shine that brought and wilting. Moreover, there is no cool temporary field storage for pre cooling. Our findings similar to the report by Ali *et al.* (2019) who reported that pest attack (disease, insect) and mechanical damage during harvesting had significant effect on post-harvest loss of mangoes.

Table 3. Major causes of postharvest loss and percentage of respondents at producer's level.

Causes of postharvest loss	Frequency	Percentage
Pest attack (disease, insect)	16	40.0
Mechanical damage during harvesting	9	22.5
Damage during transportation	4	10.0
Poor packaging material	6	15.0
Poor storage condition	2	5.0
Marketing problem	3	7.5

Sensory evaluation of mango jam

The processed local variety mango jam was subjected to hedonic testing and the mean scores of appearance, colour, flavour, Consistency and overall acceptability results clearly shown in Table 2. The mean scores of sensory acceptability of mango jam made from local variety remained above 4 in the scale of 5-point hedonic scale which shows acceptability levels above like moderately and near to like extremely. This can lead to the conclusion that local mango jam had highly acceptable sensory quality. The observed acceptance score is very supportive evidence for marketing prospects of mango jam for better income generation than the more perishable raw fruit. Also, processing could contribute to the reduction of postharvest losses of mango.

Table 4. Sensory evaluation of mango Jam.

Processed mango product	Sensory perception				
	Taste	Flavour	Appearance	Consistency	Overall acceptability
Jam	4.3	4.2	4.6	4.2	4.3

Conclusion

Minimizing postharvest losses of fruit and vegetable is a very effective way of fighting poverty, ensuring food security and maintaining the quality of produce. In many developing countries, major causes of fresh fruit and vegetable loss are the pest/disease attack, lack of infrastructure (poor harvesting, transportation, storage and processing (technologies) while fruit and vegetable losses in developed countries occur largely at consumer stage. Use of the better adapted and pest/disease-tolerant varieties, appropriate post-harvest innovations and technologies is necessary to reduce post-harvest losses. Along with post-harvest technologies, coordination and management of post-harvest stages successfully have an important role in reduction of post-harvest losses.

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Conflict of interest

The authors declare that they have no conflict of interest.

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