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Research Article

Postharvest Utilization and Physic-Chemical Properties of Mango (*Mangifera Indica*) Jam as Influenced by Different Storage Temperature and Storage Periods

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ABSTRACT

Mango (*Mangifera indica*) is one of the most important tropical and sub-tropical fruit in the world. In Ethiopia most of the mango postharvest handling system is traditional techniques, thus which cause enormous injuries to the fruit. Such fruit is generally discarded by users due to unfitness of intended quality. These huge quantities of postharvest loss cause impact on individuals in economical and nutritional aspect. Therefore efficient utilization of low quality mango fruits with standardization procedure to produce mango jam has a vital role to attain the goal of this study. The experimental design were arranged in CRD with triplications of three storage temperatures (room, refrigeration and incubator); and three storage periods for (30, 60 and 90) days. The data obtained was analyzed by SAS version 9.2 and means were compared by Duncan's Multiple Range Test. The TSS in the mango jams prepared from marketable and unmarketable mangoes were ranged from 65.54-68.33 °Brix. The ranged values of acidity, pH, ash, moisture, total sugar, reducing sugar and non-reducing sugar content in the jam prepared from marketable mango were 0.47%-0.57%, 3.05%-3.36%, 0.29%-0.53%, 30.91%-34.38%, 57.95%-69.09%, 26.97%-35.53% and 22.39%-42.29% respectively whereas the range values for the product prepared from unmarketable mango were 0.34%-0.73%, 2.79%-3.93%, 0.29%-0.44%, 30.96%-34.41%, 56.46%-71.62%, 20.68%-24.84% and 31.62%-50.94% respectively.

Keywords: Utilization; Mango type; Jam; Physic-chemical properties; Storage conditions

INTRODUCTION

Mango (*Mangifera indica L.*) is one of the most important tropical and sub-tropical fruits. It is originated in India, Assam-Burma region; and has been cultivated for more than 4000 years [1]. It is thought to have been introduced to East Africa by the Persians in the 10th century A.D and the crop started growing in West Africa in the 16th century A.D [2]. The global production of mango is estimated as 42 million tons per year. The annual mango production in Africa is 13.6 million tons [3]. In Ethiopia, mango is produced mainly in Harari region, west and east Oromia, SNNPR and Amhara [4]. Mango is the second most important fruit crop in Ethiopia, after banana. It constituted 16.01% of 92,362.36 hectare of land under fruit crops and 14.76% of 679,742.83 tons of produced fruit [5]. Arba Minch Zuria Woreda is one of the Gamo Zone Sub-administrative of the Southern of Ethiopia and is known for its high potential in tropical fruit production. The production of mango at Arba Minch Zuria Woreda is 126,800 quintals with total area coverage of 634 hectares. It is estimated that 8,096 tons of the fruit is discarded as waste.

Huge quantities of mangoes are wasted due to various reasons. One of the major causes of huge wastage of this fruit is inappropriate harvesting techniques and post-harvest handling of the fruit. Most of the mango growers use traditional techniques of beating the mango plants for harvesting which cause enormous injuries to the fruit. These injuries may not be immediately visible at the time of harvest but are significantly visible after some days of storage. The postharvest handling of the fruit is equally defective which promotes fruit spoilage. Moreover, number of diseases, which either infect the fruit in the field or during storage make the fruit unfit for fresh market. It is generally observed in the mango production areas that farmers and traders sort out huge quantities of unmarketable fruit which is discarded in the nearby fields or which remain piled up in the community land. This fruit rots and the fermenting smell spreads around the area.

It causes environmental pollution and serves as a source for spread of many fungal diseases to the fresh fruits. Such fruit is generally, discarded because either part of the fruit has started rotting due to inappropriate post-harvest handling storage or the fruit is infected, with some visible diseases or it is under sized or color development is not proper. In fact, healthier portion of such fruit forms a substantial proportion of the discarded lot but such portion also gets wasted with the rotten part once the farmers or traders discard

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it. These are huge wastages and besides causing great financial losses, cause food and nutritional losses as well.

Utilization of such unmarketable mango fruits for developing value added products can be of a great interest. In Ethiopia non availability of required commercial infrastructure for processing sectors is presently a great problem. One cannot think of using such huge wastages at commercial level without required infrastructures. In view of such constraints it is felt necessary to standardize procedure for making products from such wastage at home scale level, which will be simple and could be popularized at small scale levels.

This will provide an opportunity to the farmer's to utilize such wastages gainfully and also improve the nutritional status. Standardization of the processing techniques for product development of unmarketable mango could also attract the potential entrepreneur to start small scale fruit processing units in rural areas, which could be a great contribution for economic boost and sustainable agriculture. Among various products which could be developed from the unmarketable mangoes are mango jams and squash. The present study was undertaken to develop a suitable mango jam having good quality and consumer acceptability. Jam is a fruit product that contains fruit pulp from whole fruit or more kinds of fruit boiled with sufficient quantity of sugars, acid at low pH (2.5-3.2) to produce a tissue with firm and thick consistency with or without addition of water [6]. Jam is very popular fruit product and has great demand by the consumers. Utilizing culled and unmarketable mangoes for development of such product will not only be beneficial for farmers but will be good for consumer of fruit products also. Allot is made to develop products of high consumer acceptance. The detailed procedures and results are discussed in the respective chapters of this discretion. Food preservation has an important role in the conservation and better utilization of fruits in order to avoid the glut and utilize the surplus during the off-season. It is necessary to employ modern methods to extend storage life for better distribution and also processing techniques to preserve them for utilization in the off season in both large and small scale [7]. Arba Minch is a sub-tropical area, and is known for production of many fruits such as mango, avocado, banana etc. Mango is one of perishable climacteric fruit and most farmers in the area harvest the fruits in a traditional manner by beating the branches of the trees, with a long hand stick.

This makes the beginning of postharvest deterioration. Improper post-harvest handling methods also lead to deteriorations of the fruit. Substantial quantities of mango fruits are sorted because of defects, mechanical damages, and pest damages, bruised and partially spoiled fruits and are discarded as unmarketable by the farmers and traders in the production area. Thus a substantiated quantity of fruit becomes unmarketable. Huge quantities of fruits are segregated as unmarketable fruit. Once the fruit is being graded for packing, the traders genuinely expect that packing such fruit will causes additional spoilage and as such discard such fruit. Such huge quantities of waste not only result in economic and food losses, but also cause environment pollutions. Unmarketable fruit not only results in wastage of food and nutrition but also causes a great environmental pollution and a heavy financial loss to the growers and traders. As such there is an urgent need to address this problem. Therefore this study was expected to efficiently utilize the substantial quantities of unmarketable mangoes in the research area and to compare its physico-chemical properties under different storage conditions.

METHODOLOGY

Material collection

Mango fruits were collected from Chano Mile kebele in Arba Minch district. Both marketable and unmarketable mangoes were selected on basic criteria's for marketable and unmarketable fruits as reflected here. Marketable mangoes: healthy mangoes at proper stage of maturity without any blemishes, defects, having proper size, color, and shape and without any hygienically injuries were selected for procurement. Unmarketable mangoes: mangoes discarded by traders (growers) due to their inferior qualities which included heavily injured fruits, infected with diseases, under developed color and size, partially rotten and other such factors. Such fruit was being discarded by farmers or traders during grading of mangoes for dispatches of fresh fruit to market.

Mango pulp preparation

Fruits of both the lots of marketable and unmarketable mango fruits were washed thoroughly in tap water to remove the foreign materials and to reduce the microbial load. The bruised portion of the unmarketable mangoes separated with the stainless steel knife and the healthier part of the fruit were peeled and sliced into pieces. The flesh portion of both marketable and unmarketable mango was separately autoclaved at 10 psi for 15 min separately. Autoclaved mango slices from both marketable and unmarketable mango were pulped separately using Juice extractor model JX-909 (Lumnix-juice maker) to converting the slices into pulp in a blender, then packed, labeled and stored in refrigerator for further use. Both the marketable and unmarketable lots were kept separate and details of stone; rotten portion etc. had recorded to work out the per cent age pulp yield from marketable and unmarketable fruits.

Mango jam preparation

Following steps were used for preparation of mango jam. Weight quantity of fruit pulp used taken and boiled. Two third of sugar was added to the boiling pulp and heating continued with continuous stirring of the product to ensure that the sugar is dissolved properly. Continued boiling and stirring until the weight of the pulp was reduced to about half of the initial weight. Citric acid was dissolved in a small quantity of water and added to the product. Add the remaining one third of sugar and continued boiling. While continuing cooking the temperature was raised to about 104 to 105°C and TSS of 68.5 °Brix was attained. The end point was assessed by noting TSS and by drop test. TSS was recorded by Abbe refractor meter. The drop test was conducted by taking a spoon full of hot mixture, cool it slightly and drop it in glass of water. If the drop falls in a single peace until it reaches the bottom, the end point has reached. If it disperses there it needs more boiling. The heating was stopped and the time troth at surface was removed. The product was cooled to 82°C and filled into free sterilized jars. The jars were closed after allowing heat vaporized from the product to come out of jar. Lid of the jar was closed properly leaving no chance for any gaseous exchange.

The jar was cooled room temperature by immersing in normal cool potable water. The jars were dried and labeled. Products were analyzed for various quality parameters and sensory evaluation. Product was stored at three different storage temperatures that is room temperature low temperature and 37°C. Preliminary trials for preparation of jam using fruit pulp to sugar in the ratio of 1:1 kg, 1:0.75 kg, 1:1.25 kg were conducted and evaluated by sensory panelists using nine-point hedonic scale methods. The top ranked

mango jam products both from marketable and unmarketable mango fruits were selected for further studies. This was done with an objective to find an appropriate ratio of fruit pulp and sugar to develop a product of consumer acceptance. The best ranking ratio for jam prepared from marketable and unmarketable fruit were then prepared using the same ratio and procedure. The storage study was conducted for three months at three different storage temperatures. Jam formulation for both marketable and unmarketable mango was made as the mixing of one litter pulp, one-kilogram sugar, 10 g of citric acid, 5 g of pectin and 2.5 g of sodium benzoate. Understanding above the formula the pulp yield made from marketable mango was recorded was 815.07 g whereas in case of unmarketable mango fruit the amount of pulp yield recorded was 667.98 g. The pulp yield difference from marketable and unmarketable was recorded as 147.09 g.

Experimental design

The trial was laid out in completely randomized design with three replications in 2*3*3 factorial experimental combinations. The treatments were two types of mango (marketable and unmarketable), three types of storage condition (room temperature, refrigeration and incubator) and three different storage periods (30, 60 and 90) days. Mango jam stored at room temperature at first day was considered as a control.

RESULTS AND DISCUSSION

Chemical composition of mango jam

Chemical composition of mango jam prepared from the marketable and unmarketable mangoes were presented below Table 1. The TSS in the fruit jam prepared from marketable and unmarketable fruits were ranged from 65.23-68.21 and 65.93-68.33 °Brix respectively. The ranged values of acidity, pH, ash, moisture, total sugar, reducing sugar and non-reducing sugar content in the jam prepared from marketable mango were 0.47%-0.57%, 3.05%-3.36%, 0.29%-0.53%, 30.91%-34.38%, 57.95%-69.09%, 26.97%-35.53%, 22.39%-42.29% respectively whereas the corresponding range values for the product prepared from unmarketable fruit were 0.34%-0.73%, 2.79%-3.93%, 0.29%-0.44%, 30.5%-34.11%, 56.46%-71.62%, 20.68%-24.84% and 31.62%-50.94% respectively.

Table 1: Effect of storage temperature and time on ash and moisture content of mango jam (mg/100 g).

Storage periods	Mango types	Ash			Moisture content		
		Refr	RT	Inc	Refr	RT	Inc
First day	MM	0.32	0.33	0.32	34.41	34.41	34.41
	UMM	0.32	0.32	0.32	34.36	34.36	34.36
30 days	MM	0.34	0.38	0.41	32.8	33.24	32.91
	UMM	0.29	0.34	0.37	33.17	32.79	33.11
60 days	MM	0.3	0.46	0.49	32.62	32.66	32.31
	UMM	0.29	0.32	0.41	32.4	31.6	32.59
90 days	MM	0.29	0.51	0.53	32.3	31.02	30.97
	UMM	0.3	0.3	0.44	31.54	31.33	30.96
CV%		-	6.52	-	2.82	-	
LSD			NS		0.7562		

Note: MM: marketable mango; UMM: unmarketable mango; CV: coefficient of variation and LSD: least significant difference NS: not significant.

TSS

Total soluble solid of the jam prepared from marketable and unmarketable mangoes ranged from 65.54-68.21 °Brix and from 65.54-68.33 °Brix respectively as presented in Table 1. It was observed that during storage the total soluble solid increased in both the products. The maximum increase in total soluble solid observed in the product stored at incubator temperature, followed by increase in room temperature, whereas the refrigerated stored jams had least increase in total soluble solid. With increase in the storage period the amount of total soluble solid content is slightly increased in jam prepared from both marketable and unmarketable mango. This was probably due to the conversion of polysaccharides into sugar during storage period. These results are similar to the result of who reported that the total soluble solid at 67 °Brix in mango jam for good shelf life also reported that the recommended total soluble solid of 68 °Brix to retard the microbial growth in sapodilla jam. Similar finding was also reported by that the total soluble solid content of mango (Gulb-Eltour) jam 68 °Brix followed by mango (Malgoba) 66 °Brix and mango (Abusamaka) jam 64 °Brix.

TA

Titrable acidity of mango jam expressed as percentage citric acid is reflected in Table 1. The initial acidity of the jam prepared from marketable and unmarketable mango was 0.47% and 0.45% respectively. When expressed as percentage citric acid an erratic fluctuation in percentage acidity of both the product was observed during storage studies. Table 1 deficit that no particular trend is observed for acidity of jam during storage. The present studies show a similar trend in the studies of who reported that the TA content of mango (Abusamaka) jam which contains TA content of 0.67 mg and mango (Malgoba) jam contains acidity of 0.51 mg stored for 90 days low temperature.

pH

Jam prepared from marketable and unmarketable mangoes had the pH value of 3.35-3.36 and 2.79-3.93 respectably and presented in Table 1. Various researches also report that for a good setting of jam the pH of 3.0-3.4 is appropriate. In the present studies also, it is observed that the setting of jam was appropriate at this pH. During storage the pH of jam prepared from marketable mangoes ranged from 3.05-3.36; whereas in the jam prepared from unmarketable fruit the pH during storage ranged from 2.79-3.93. There was an increase in the pH values of both products during storage.

Total ash

The ash content of the mango jam prepared from marketable and unmarketable mango fruit was presented in Table 1. The initial ash content of 0.33% was recorded in the jam prepared from marketable mangoes; whereas the corresponding values for the jam prepared from unmarketable mangoes was 0.32%. Ash content of jam prepared from marketable mangoes ranged from 0.29%-0.53% during storage; whereas in the jam prepared from unmarketable mangoes the ash content ranged from 0.29%-0.44%. The ash content in jam prepared from unmarketable mango was lower than the ash content in the product prepared from marketable mangoes. The reduction of ash content could be due to the utilization of minerals by microorganisms for their growth.

Moisture content

Moisture content of the mango jam ranged from 30.96-34.41%. Initially a moisture content of 34.41% was observed in the jam prepared from marketable mangoes, whereas the moisture content of jam prepared from unmarketable mangoes was 34.36%. During storage at three different temperatures the moisture of jam prepared from marketable mango ranged from 34.41%-30.97%, the lowest was recorded at storage period of 90 days under incubator temperature. However, the moisture content of jam prepared from unmarketable mangoes ranged from 34.36%-30.96% during storage period. This could be due to absorption of moisture by blended sugar during long storage period. Studies of earlier reports also show similar ranges of moisture content in apple jam. The moisture content in present studies was found in range from 30.96%-34.41% which is similar result with the moisture of 27% and 34% jam prepared from apple variety reported by Moisture content in any food commodity plays key role in deciding its shelf life [8]. Usually high sugar content makes the moisture unavailable for the growth of microorganisms.

Total sugar

The jam prepared from marketable mango at initial day for all treatments under room temperature and incubator recorded maximum total sugar content of 66.78%; whereas jam prepared from unmarketable mango was recorded 66.77% at initial day under all storage conditions. The minimum total sugar content of 60.28% was recorded in jam prepared from marketable mango under refrigerator at 90 days; whereas in jam prepared from unmarketable mango was 61.34% under room temperature at 90 days. Total sugar in mango jam prepared from marketable and unmarketable mangoes ranged from 60.28%-66.78%. Studies of earlier reports also shows similar ranges of total sugar in mango jam ranged from 53.01%-68%.

Reducing sugar

The reducing sugar content of the jam prepared from marketable and unmarketable mangoes. The maximum reducing sugar content of 34.86% was recorded in jam prepared from unmarketable mango after 90 days under incubator, whereas it was maximum 34.77% in jam prepared from marketable mangoes after 90 days under incubator temperature. The reducing sugar of the mango jam prepared from both marketable and unmarketable was in the range of 31.67%-34.86%. Also reported reducing sugars content of mango jam ranged from 22%-40.0%. Therefore, the present findings were in line with earlier reports. During storage period the reducing sugar content is increased. This could be due to the inversion of sucrose into reducing sugar due to acid hydrolysis and inversion of non-reducing sugar in to reducing sugar. The inversion of non-reducing sugar may be due to presence of acids such as citric acid during storage period. Similar opinions were reported by during studies on Sudan's mango jam.

Non-reducing sugar

Non-reducing sugar content of the jam prepared from marketable and unmarketable mango. The initial non-reducing sugar percentage of jam prepared from marketable and unmarketable mangoes was 35.03% and 35.12% respectively. The minimum non-reducing sugar content of 26.15% was recorded in jam prepared from marketable mango jam after 90 days storage under refrigerated conditions, whereas minimum non-reducing sugar in the jam prepared from unmarketable mango was 26.48% after 90 days under room temperature. The non-reducing sugar of the mango jam prepared from both marketable and unmarketable was in the range of 26.15%-35.12%. Non-reducing sugar content decreased during increasing storage period. This could be due to inversion of non-reducing sugar to reducing sugar in the presence of citric acids.

CONCLUSION

From the results obtained in this study the following points can be concluded: The jam prepared from unmarketable mango has similar results to jam prepared from marketable mango. When compared with jam prepared from marketable mango there was no significant differences between the two jams in the preliminary test of sensory attributes. The jam prepared has been well accepted however some improvement can be made to make it more attractive to consumers. It is an opportunity for exploring the possibility of producing other value-added food products in order to preserve the fruit during off seasons and also to reduce post-harvest losses. The taste and flavor some of the attributes that can be improved to make it more acceptable. Because of its highly perishable in nature, to preserve the unmarketable mango for longer period should be promoted through production of many other value-added food products such as jelly, juice, squash, candy bar, mango chips, fruit preserves all these can be processed by simple techniques so as to reduce postharvest losses and can be sold in domestic as well as external market to increase income. Government through extension workers and NGOs should promote the utilization of such lots into value added products to generate income for farmers, traders, small scale business owners and enterprises in order to increase farmer's income and improve their livelihood. A regular training of the small-scale farmers and entrepreneurs and other stakeholders on how to procedures of processing operation on utilizing such unmarketable mango by simple technologies and its advantages in order to allow them have a full knowledge of the technology that will always strengthen their economic status by creating employment for them.

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COMPETING INTERESTS

The authors declare that they have no competing interests.

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