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Shelf Life Determination of Mango Juice Produce by Small-Scale Processing Techniques in Eastern Hararghe Zone

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Abstract
Mangoes play an important role because they provide nutrients beneficial to human health. Fresh mangoes contain 83% water, 36 mg/100 g vitamin C, 15% carbohydrates (Guiamba, 2016) and other nutrients. The objective of this study was to estimate shelf life of mango juice produced using small-scale processing techniques. Juice was processed and packaged in 40 bottles and stored at (13-16) °C around haramaya and (22-25) °C around FARC. At each temperature, 10 bottles had preservative (0.5 mg/l citric acid) and10 bottles had no preservative was stored. The juices were analyzed for pH, vitamin C, sensory attributes and microbial load at one month intervals up to end. From three month to four month, juices stored at (22-25) °C had lower pH (2.26-2.22), with preservative, (2.98-2.67) without preservative) than juices stored at (13-16) °C (3.12-2.87 with Preservative, 3.32–3.3 without preservative).At month four, vitamin C loss was highest (55.34%) in juice without preservative stored at 22-25 °C, followed by juice stored at with preservative (43.65%). The loss was lowest (26.98%) in juice with preservative stored at 13-16v °C. Juices stored at (22-25) °C were rated 'bad' from week 6, in smell, color and taste while at that time, juices stored at (13-16) °C were rated 'almost similar' to fresh juice in smell (5.75) and taste (5.95 and 5.75). Storage at (13-16) °C with preservative resulted in lowest bacteria (3.3 x 104 CFU/ml) and yeast and mold (3.25 x 106 CFU/ml) counts whilst highest bacteria (2.22 x 107 CFU/ml) and yeast and mold (7.49 x 106 CFU/ml) counts were observed in juices stored at FARC without preservative. The shelf life was estimated based on taste and smell as 3 months and 4 months for juices stored at 30 °C and 13 °C, respectively. Cold temperature combined with use of preservative slowed down rate of vitamin C loss, deterioration of sensory attributes and microbial growth.

Keywords: Mango juice, sensory evaluation, shelf life, small-scale processing, vitamin C

Introduction

Mango (*Mangifera indica*) is one of the most popular and valued fruits in tropical countries and many parts of the world (Jahurul, M.H.A., *et al.* 2015) [1]. Mangoes are utilized in a number of ways including being eaten fresh whilst green or when ripe or they can also be eaten as desserts, canned or used for making juice, jams and other preserves (Panda, H., 2010) [20]. In some cases, mature but not fully ripe mangoes are cut into slices and dried (Mahayothee, B., *et al*. 2007) [13]. Mangoes play an important role because they provide nutrients beneficial to human health. Fresh mangoes contain 83% water, 36 mg/100 g vitamin C, 15% carbohydrates and other nutrients like vitamins A, B, E, folate and iron (Masibo, M. and He, Q., 2008) [17]. They are also an excellent source of calcium, phosphorus and potassium (Guiamba, 2016; Mgaya-Kilima, Remberg, Chove, & Wicklund, 2014) [4, 15] Vitamin C is one of the major nutrients in mango juices in which its content can be up to 48 mg/100 ml (Falade, Babalola, Akinyemi, & Ogunlade, 2004) [3]. Vitamin C is an essential nutrient required for prevention of scurvy and maintenance of healthy skin, gums and blood vessels (Lee & Kader, 2000) [10]. Masamba & Mndalira (2013) [16] reported similar results whereby juices with preservatives stored at 10 ºC retained more vitamin C than juices with preservative but stored at room temperature. In addition, vitamin C has many biological functions including being an antioxidant with potential of reducing some forms of cancer (Lee & Kader, 2000) [10] and preventing many degenerative diseases (Mkandawire, W., *et al.*) [18].

However, vitamin C is most sensitive to destruction when commodity is subjected to adverse handling and storage conditions (Lee & Kader, 2000) [10]. Vitamin C decomposes rapidly in high temperatures and in the presence of oxygen and light (Mkandawire, W., *et al.*) [18]. Other factors that enhance vitamin C losses are extended storage, relative humidity, processing methods and cooking procedures (Lee & Kader, 2000) [10]. Because of vitamin C's instability, its contentis used to indicate the presence of other nutrients and is considered as an indicator vitamin in food processing (Lund *et al.,* 2000; Guiamba, 2016) [12, 4].

Post-harvest changes associated with ripening and senescence and the effects of postharvest handling techniques make mangoes highly perishable. Therefore, a great proportion of mangoes are wasted during their season (Falade *et al*., 2004) [3] due to spoilage when the mangoes are kept for a long time without processing. To prevent wastage of the seasonal fruit when it is in abundance, small scale processing techniques, pulp extractor and recipes for formulation of mango juices were developed, transferred and promoted to small-scale processors and the technologies were adopted (Chitedze research station, 1998) [2]. In Malawi, the small-scale processing techniques of mango juice for commercial purposes were promoted by various governmental and nongovernmental organizations. However, the shelf life of the juices produced using these techniques was not established.

Shelf life of a food is the period of time under defined conditions of storage, after manufacture or packaging, during which a food product will remain safe and suitable for use (Man, 2002). During this time period, a food product should retain its sensory, chemical, physical, functional, microbiological and nutritional characteristics in optimal conditions in such a way that it is acceptable for a consumer (Man, 2002; New Zealand Government, 2014) [19]. Within the shelf life period, a product is expected to comply with any label declaration of nutritional information when stored according to recommended conditions (Man, 2002). The shelf life of any given product will depend on a number of factors such as its composition, processing methods, packaging and storage conditions (Man, 2002). Shelf life of any product can be determined by monitoring physical, chemical, microbiological and sensory changes occurring to the food during storage whereby measurable deterioration characteristics may be chosen (Institute of Food Science and Technology, 1993). Because the shelf-life of the juices produced using small-scale techniques was not yet established, problems exist during marketing because of labeling requirements and consumer safety considerations. Therefore, this study aimed at determining the shelf life of mango juice produced using small-scale processing techniques.

Materials and Methods

Description of Area

The experiment was conducted Fadis and Haramaya woredas. The fruit sample was collected from Fadis, Babille. The study area found at about 523 km from Addis Ababa to eastern and located at 9.31 latitude and 42.12 longitude and situated at 1917 meters above sea level. The area experiences annual average rainfall of 700 mm for the lower kola to nearly 1200 mm for the higher elevation, as average temperature 27 °C-35 °C. Juice mixer, digital balance, sieve, bottle (jar), thermometer was materials used as well as sugar and citric acid were chemical used.

Preparation of the Mango Juice

Mangoes which were fully ripe (based on yellowness and softness) and free from rot were selected and were cleaned and peeled, then pulp was extracted using a juice mixer and the pulp as well as peel was weighed. The pulp was mixed with water in the ratio of 1 part pulp to 2 parts water and the mixture was stirred for 5 minutes. The mixture was then sieved and weighed again. The mixture was then heated for 10 minutes at 65, followed by addition of white table sugar in the ratio of 90 g sugar per 1 liter juice mixture. Then the mixture was cooled below 15 °C by placing in the container of the juice in a water bath containing chilled water. After cooling, the juice was divided into half and preservative (citric, 0.5 mg/l) was added to one portion the left was without preservatives. The juice was packed into 250 mL bottles. The bottles were treated by dipping in hot water at 60 for 15 minutes prior to packing. Finally, 80 bottles containing the juice were divided in half was stored at room temperature under two location which was (22-25) and (13-16) Fadis research center and Haramaya university laboratory respectively.

The juice was packaged in 40 bottles of 250 ml each. Half of the bottles were stored in Haramaya at chilling temperature of (13-16) and the remaining was stored at FARC at average room temperature of (22-25). At each storage temperature, 20 bottles contained a preservative (citric acid 0.5 mg/l) and the other 20 bottles did not have the preservative.

Fig 1: Bottled mango

Experimental design and statistical analysis

The experiment was arranged to analysis under simple descriptive statistical, Storage temperature is factors. The treatment was prepared under two storage room temperature (Haramaya and FARC) storage place.

Data Collection

The juice was monitored on PH, vitamin C, sensory and microbiological changes. Data collection was started soon after preparation of the samples and later on at three weeks intervals for 4 (four) month. Three (3) bottles were collected from each category (i.e. stored at 13 °C with and without preservative and at 30 °C with and without preservative).

Determination of pH and Vitamin C

AOAC (1984) [22] methods were used to determine PH. The pH was measured using a PH meter (WTW PH 525, D. Jurgens and Co., Bremen, Germany) fitted with a glass electrode (WTW SenTix 97T). Vitamin C was determined and monitored using an AOAC (1984) [22] method.

Sensory Evaluation
Untrained Panelist selection was based on interest, availability, health and ability to discriminate four tastes (sweet, sour, salty and bitter). Panelists were trained before the testing sessions in order to develop a common understanding of terminologies and procedure during sensory evaluation. Consensus training as explained by Lawless and Heymann (1998) [9] was conducted.

Color: Uniform orange color generally accepted for mango pulp and juice. Deterioration was indicated by change from orange to brownish
Viscosity: Referred to the thickness or thinness of the juice after agitation
Smell: Smell associated with fresh mango juice
Taste: Taste associated with fresh mango juice

Visual quality was examined in accordance with the sensory evaluation standards (Ma *et al*., 2010), untrained panelist were scored on a scale of 9 points (1-9). In which 1. Like extremely, 2. Like very much 3. Like moderately, 4. Like slightly, 5. Dislike slightly, 6. Neither like nor dislike, 7. Dislike moderately, 8. Dislike very much, 9. Dislike extremely with this regarded every one month of stored period mangoes were tested by panelist and gave score as above rating scale.

Microbial Analysis
From each sample, appropriate serial dilutions were made aseptically using sterile saline solution. The dilutions were used for enumeration of total bacteria on Nutrient Agar (Merck, Gauteng, South Africa). Pour plate technique was used and the plates were incubated at 30 °C for 48 h. Yeasts and molds were enumerated on Malt Extract Agar (Merck) using spread plate technique and the plates were incubated at 25 °C for 3-5 days.

Results and Discussion

Table 1: Changes in pH during storage

Storage time (Month)	Haramaya 13 °C with preservatives	Haramaya 13 °C without preservatives	Fadis 25 °C with preservatives	Fadis 25 °C without preservatives
0	3.82	3.82	3.82	3.82
1	3.67	3.91	3.22	3.45
2	3.54	3.68	2.82	3.12
3	3.32	3.12	2.26	2.98
4	3.3	2.87	2.22	2.67

Changes in PH during Storage
The juices became acidic with increasing storage time, at four (4) month the pH was recorded lower for juices stored at FARC under average room temperature of (22-25) °C than juices stored at Haramaya districts of (13-16) °C (Table 1). The increase in acidity could be dueto increase in organic acids following the temperature increased. In this case, the increase in acidity could be due to the activities of yeasts and bacteria whose load increased with increase in storage time.

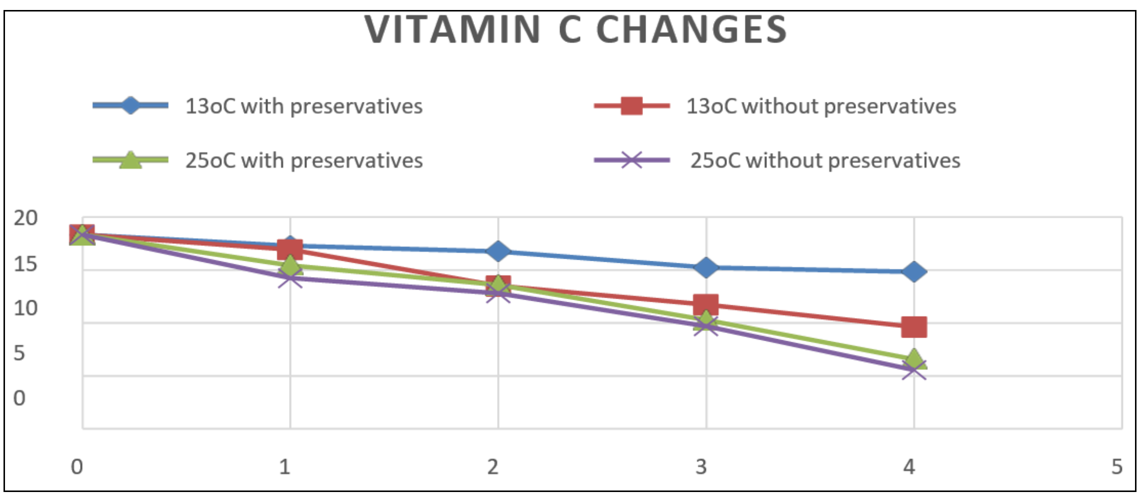

Fig 2: Changes in vitamin C

Vitamin C Content during Storage
Vitamin C content soon after extracting the pulp was 17.04 mg/100g and just after juice processing the content was 16.34 mg/100g. As we observed from graph Change in vitamin C content was dependent on temperature and presence or absence of preservative (Figure 2). By the end of four (4) month, loss of vitamin C was higher in juices stored at (22-25) i.e. contents were 5.5 mg/100 g in juice without preservative and 6.56mg/100g in juice with Preservative. In juices stored at (13-16) °C, the vitamin C contents were 9.63 mg/100 g in juice without preservative and 14.82 mg/100g in juice with preservative.
The higher vitamin C losses at (22-25) °C than (13-16) °C (Figure 2) were due to store under high temperatures. These results agree with other studies in which increased temperature and storage time were associated with increased vitamin C losses (Mgaya-Kilima *et al*., 2014; Falade *et al*., 2004) [15, 3].

Sensory Evaluation

Table 2: Average scores for sensory attributes of juices stored at the ends four month

Sensory parameters	Haramaya 13 °C With preservatives	Haramaya 13 °C without preservatives	Fadis 25 °C with preservatives	Fadis 25 °C without preservatives
Taste	4.2	7.1	5.6	7.45
Color	3.3	6.65	4.5	6.1
Smell	4.7	7.4	5.8	7.3
Viscosity	4.1	4.85	5.66	6.85
Overall acceptance	4	6	5	6.5

It was observed that prolonged storage (four month) resulted differences in all sensory attributes between fresh and stored juices. In general, juices stored at high had higher means than low temperature. Thus, increase in storage temperature resulted in rapid changes in all the quality attributes namely, color, viscosity, smell and taste.

Color: Color of the juices at both temperatures, and with and without preservative was rated 4.0 on the 1st and 2nd month. However, on the 3rdthe color of juices stored at (22-25) ºC with preservative changed slightly and while that of juices without preservative changed to brownish and the colors were rated 3.3 and 6.65 respectively (Table 2). These contribute to color change and off flavor in juices (Falade *et al*., 2004) [3]. The products of non-enzymatic browning are due to the reactions of sugars, amino acids and ascorbic acid and are present in mango juice (Falade *et al*., 2004) [3].

Viscosity: Viscosity refers to the texture of a product. Products can be thick or thin depending on the nature of the product. Mango juices are thick soon after processing but become thin after storing the juice for some time. The first two month, there were no changes in the juices stored at Haramaya both with and without preservative. The use of preservative slowed down the rate of deterioration of the thickness of the juice.

Smell: Juice stored for 4 month at 13 ºC smelled similar to fresh juice at (Table 2) while the juice stored at Fadis 25 ºC without preservative smelled badly compared to the juice with preservative stored at the same temperature. Deterioration in smell was perceived at one month in juices stored at Fadis 25 ºC while in juices stored at 13 ºC, deterioration was noticed from two month (Table 2). The deterioration in smell could be due to non-enzymatic reactions which lead to production of off-flavors (Jimenez & Duran, 1999) [6].

Taste: The taste of juices stored at Fadis 25 ºC with preservative was slightly bad at week 5, the taste of the juice was extremely bad after week 7 (Table 2). While the taste of juice at Fadis 25 ºC without preservative was bad at week 7 and extremely bad at two month. On the other hand, the juices at 13 ºC were all still similar to fresh juice but the juice without preservative was bad and all juices were extremely bad.

Microbial Analysis

Microbial activities result in production of by-products, which can influence changes in sensory quality of juices during storage. Table 3 indicates the number of bacteria present inthe juice from week 0 to month 4.

Table 3: Total aerobic bacteria counts in mango juice during storage

	Bacterial Count (CFU/ml)			
Storage time (Month)	13 °C with preservatives	13 °C without preservatives	25 °C with preservatives	25 °C without preservatives
0	3.82*103	3.82*103	3.82*103	3.82*103
1	4.3*103	3.91*104	3.22*104	3.45*104
2	5.4*103	3.68*104	2.82*105	3.12*106
3	6.32*103	3.12*107	2.26*106	2.98*107
4	3.3*104	2.87*108	2.22*107	3.69*108

There were differences in bacteria counts in juices with and without preservative at the two temperatures. The results indicate lower microbial load in juices with preservative and stored at 13 ºC than in juices without preservative and stored at 25 ºC. The results agree with the fact that preservatives play an important role in preventing microbial growth by slowing down the rate of multiplication of the microbes (Henney, Taylor, & Boon, 2010) [5].

The initial mean population was approximately 3.82*103 cfu/ml and after month 4, the mean populations were highest, 3.69*108 cfu/ml, in juices stored at fadis at 25 ºC without preservative and lowest, 2.04 ×104 cfu/ml, in juices stored at 13 ºC with preservative. However, the quality of all the juices, except the chilled juice containing preservative, could be considered unsatisfactory by the end of the forth month. Total aerobic counts are used as indicators of quality and counts >104 cfu/ml can provide useful information about the general quality and remaining shelf life of the juice in question. When total aerobic counts are used to indicate quality, counts of 104 cfu/ml indicate upper limit of acceptability (Center for Food Safety, 2014).

Table 4: Yeasts and molds count in mango juice during storage

Storage time (month)	Yeasts and molds count (C FU/ml			
	13 °C with preservatives	**13 °C without preservatives**	**25 °C with preservatives**	**25 °C without preservatives**
0	3.625*103	2.3*104	1.467*104	2.497*103
1	4.3*103	7.05*104	2.825*104	4.2*104
2	1.23*104	2.99*105	2.94*105	1.64*106
3	3.05*105	4.11*105	9.943*105	2.78*107
4	3.25*106	3.66*107	7.49*106	2.72*107

Spoilage in fruits and fruit juices is mostly caused by yeasts contamination mainly due to low acidity. Foods that have low acidity can be spoiled by yeasts because yeasts are most tolerant to acidic conditions being able to grow at pH as low as 2.5 (Praphailong & Fleet, 1997) [12]. It is suggested that spoilage occurs when yeast and mold count reaches 105 cfu/ml. At this limit, color, viscosity, smell and taste of the food are affected by the microorganisms in which case spoilage would have occurred (David & Norah, 1998) [2]. The initial mean population of yeast and molds was 1.4 x 102 cfu/ml (Table 4). At week 6, the mean population was highest, 1.96×108 cfu/ml, in juices stored at (22-25) ºC without preservative and lowest, 1.71 ×104 cfu/ml, in juices stored at (13-16) ºC with preservative. By week 4, all juices, except the chilled with preservative, had yeast counts >105 cfu/ml indicating some degree of spoilage.

Fig 3: Mold and yeast variation, and Colony forming unit of bacterial and fungal cells

Conclusion

These results confirm that temperature and preservatives have significant effects on quality of juice during storage. At higher temperature and without preservative, the juices promoted a faster microbial growth, deteriorated faster in sensory attributes and had a higher rate of quantitative and qualitative loss. A combination of cold storage and use of preservative resulted in highest vitamin C retention during storage. Therefore, based on deterioration of taste, the shelf life were estimated to be two (2) month and four (4) month for juices stored at FARC (22-25) ºC and Haramaya (13-16) ºC respectively. The study underscored the importance of using sensory analysis, particularly attributes like taste and smell, alongside instrumental and microbial analyses in shelf life studies.

Recommendation

Therefore, based on laboratory result and sensory test the upper limit of the prepared mangoes juice was to be 2.5 month and 4 month for at 25 ºC and 13 ºC, respectively. So that any small scale processor can use the processing mango fruit under recommended temperature with listed preservative to extend the shelf life of the juice.

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