Journal of Food Research; Vol. 5, No. 6; 2016
ISSN 1927-0887 E-ISSN 1927-0895
Published by Canadian Center of Science and Education

Estimation of Shelf Life of Mango Juice Produced Using Small-Scale Processing Techniques

Wezi Mkandawire[1], Tinna Austen Ng'ong'ola-Manani[1], Orpa M Kabambe[2], & Jessica Kampanje-Phiri[2]

[1]Lilongwe University of Agriculture and Natural Resources, Bunda College Campus, Department of Food Science and Technology, Lilongwe, Malawi

[2]Lilongwe University of Agriculture and Natural Resources, Bunda College Campus, Department of Human Ecology, Lilongwe, Malawi

Correspondence: Tinna Austen Ng'ong'ola-Manani, Lilongwe University of Agriculture and Natural Resources, Bunda College Campus, Department of Food Science and Technology, P.O Box 219, Lilongwe, Malawi. Tel: 265-127-7036. E-mail: tinnamanani@yahoo.co.uk

Received: March 22, 2016 Accepted: April 12, 2016 Online Published: October 7, 2016

doi:10.5539/jfr.v5n6p13 URL: http://dx.doi.org/10.5539/jfr.v5n6p13

Abstract

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 80 plastic bottles and stored at 13 ^oC and 30 ^oC. At each temperature, 20 bottles had preservative (0.5 mg/l sodium benzoate) and 20 bottles had no preservative. The juices were analyzed for pH, vitamin C, sensory attributes and microbial load at two week intervals for six weeks. From week 2 to week 6, juices stored at 30 ^oC had lower pH values (3.15 – 2.80 with preservative, 3.60 – 2.6 without preservative) than juices stored at 13 ^oC (4.20 - 3.80 with preservative, 4.15 - 3.70 without preservative) and the differences were significant ($p<0.05$). At 6 weeks, vitamin C loss was highest (79%) in juice without preservative stored at 30 ^oC, followed by juice stored at 30 ^oC with preservative (71.43%). The loss was lowest (26.98%) in juice with preservative stored at 13 ^oC. Significant differences ($p<0.05$) in color were observed at week 6 between juices stored at 13 ^oC (4.5 with preservative and 4.66 without preservative) and 30 ^oC (5.02 with preservative and 7.00 without preservative). Juices stored at 30 ^oC were rated 'bad' from week 2, in smell (5.91 and 6.25) and taste (5.66 and 6.91) while at that time, juices stored at 13 ^oC were rated 'almost similar' to fresh juice in smell (4.25) and taste (4.25 and 4.58). Storage at 13 ^oC with preservative resulted in lowest bacteria (2.04×10^4 CFU/ml) and yeast and mold (1.72×10^4 CFU/ml) counts whilst highest bacteria (2.10×10^8 CFU/ml) and yeast and mold (1.96×10^8 CFU/ml) counts were observed in juices stored at 30 ^oC without preservative. The shelf life was estimated based on taste and smell as 2 weeks and 4 weeks for juices stored at 30 ^oC and 13 ^oC, respectively. Chilling 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

1. Introduction

Mango (*Mangifera indica*) is one of the most popular and valued fruits in tropical countries and many parts of the world (Hassan & Kabir, 2014). In Malawi, mango is a popular seasonal fruit produced throughout the country, although its production favors areas that are hot with minimum rainfall. About 3 to 4 million mangoes are produced annually within the country while some mango varieties are imported into Malawi from other countries like South Africa and Tanzania (Chitedze research station, 1998). 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 (Samson, 1986). In some cases, mature but not fully ripe mangoes are cut into slices and dried (Chitedze research station, 1998). Mangoes play an important role because they provide nutrients beneficial to human health. Fresh mangoes contain 83% water, 36mg/100g vitamin C, 15% carbohydrates (Guiamba, 2016) and other nutrients like vitamins A, B, E, folate and iron (Guiamba, 2016). They are also an excellent source of calcium, phosphorus and pottasium (Guiamba, 2016; Mgaya-Kilima, Remberg, Chove, & Wicklund, 2014).

Vitamin C is one of the major nutrients in mango juices in which its content can be up to 48mg/100ml (Falade, Babalola, Akinyemi, & Ogunlade, 2004). Vitamin C is an essential nutrient required for prevention of scurvy and maintenance of healthy skin, gums and blood vessels (Lee & Kader, 2000). In addition, vitamin C has many biological functions including being an antioxidant with potential of reducing some forms of cancer (Lee & Kader, 2000) and preventing many degenerative diseases (Lund, Collins, & Dimon, 2000). However, vitamin C is most sensitive to destruction when commodity is subjected to adverse handling and storage conditions (Lee & Kader, 2000). Vitamin C decomposes rapidly in high temperatures and in the presence of oxygen and light (Jung,Williams, & Pillar, 1995; Mgaya-Kilima et al., 2014). Other factors that enhance vitamin C losses are extended storage, relative humidity, processing methods and cooking procedures (Lee & Kader, 2000). Because of vitamin C's instability, it's content is used to indicate the presence of other nutrients and is considered as an indicator vitamin in food processing (Lund *et al.,* 2000; Guiamba, 2016).

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) 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). 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; NewZealand Government, 2014). 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.

2. Materials and Methods

2.1 Preparation of the Mango Juice

Mango juice was produced in the laboratory. A recipe from Chitedze research station was adopted because the research station was involved in training most of the small-scale processors. Mangoes which were fully ripe (based on yellowness and softness) and free from rot were selected. The mangoes were cleaned and peeled. The pulp was extracted using a pulp extractor (Chitedze research station prototype pulp extractor, Lilongwe, Malawi) and the pulp 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 ^{O}C, followed by addition of white table sugar in the ratio of 90 g sugar per 1 liter juice mixture. The mixture was cooled to 45 ^{o}C by placing the container of the juice in a water bath containing chilled water. At this point, the juice was divided into half and preservative (sodium benzoate, 0.5 mg/l; Glassworld, South Africa) was added to one portion. The juice was packed into 250 mL bottles. The bottles were treated by dipping in hot water at 60 ^{O}C for 15 minutes prior to packing. Finally, 80 bottles containing the juice were pasteurized at 65 ^{O}C for 20 minutes (Chitedze research station, 1998).

2.2 Sample Storage

The juice was packaged in 80 bottles of 250 ml each. Half of the bottles were stored at chilling temperature of 13 ^{O}C and the remaining was stored at a high temperature of 30 ^{O}C for accelerated shelf life testing. At each storage temperature, 20 bottles contained a preservative (sodium benzoate, 0.5 mg/l) and the other 20 bottles did not have the preservative.

2.3 Data Collection

The juice was monitored on pH, vitamin C, sensory and microbiological changes. Data collection started soon after preparation of the samples and later on at 2 weeks intervals for 6 weeks. A total of 16 bottles were collected for analysis each week. Four bottles were collected from each category (i.e stored at 13 ^{o}C with and without preservative and at 30 ^{o}C with and without preservative).

2.3.1 Determination of pH and Vitamin C Content

AOAC (1984) 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) method.

2.3.2 Sensory Evaluation

2.3.2.1 Panelist Selection and Training

A descriptive sensory panel was used to carry out the sensory evaluation. Twelve panelists (6 males and 6 females) were recruited among Food Science and Nutrition students. 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) was conducted. Panelists were exposed to fruit juices to be tested during descriptive analysis sessions. Three training sessions were held in one week and each session lasted one hour.

During training, fresh mango juice and juice with different storage times were presented to the panelists with the aim of generating terms to be used to describe the sensory changes. Through consensus, the terms (sensory attributes) selected to evaluate sensory changes were color, viscosity, smell and taste. The meanings of the terms were as follows:

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

A consensus was reached to compare freshly made juice with stored juice. An 8-point scale was used to rate the intensity of changes of the sensory attributes. On the scale, 1 referred to ‘extremely better than fresh juice’, 4 = ‘same as fresh juice’, 7 = ‘extremely bad than fresh juice’ for smell, taste and color attributes. For viscosity, 1= ‘extremely thicker than fresh juice’, 4 = ‘same as fresh juice’, and 7 = ‘extremely thinner than fresh juice’.

2.3.2.2 Sensory Evaluation of the Juices

Sensory evaluation was conducted in a well-lit and well ventilated room. The room temperature was around 25 ^{o}C and samples were presented at room temperature. Each sample was served in a transparent glass and was coded a three-digit random number. To avoid bias, the samples were presented in random order to the panelists. The panelists were asked to refrain from smoking, snacking or chewing gum 20 minutes before the sensory evaluation session. Panelists were asked to sensory evaluate the juice at each testing time. Potable water was provided to the panelists to rinse their palate before and between tasting samples. Panelists rated the intensity in differences between the stored juices and the freshly made juice according to the 8-point scale presented above.

2.4 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 ^{o}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 ^{o}C for 3–5 days.

2.5 Data Analysis

Two-way analysis of variance (ANOVA) at p=0.05 was performed in SPSS 12.0 (SPSS Inc., Chicago, Ill., USA). The factors were storage time and treatment (use of preservatives and storage temperature). The ANOVA was conducted to find out the influence of storage time, temperature and preservative on sensory attributes, microbial load, pH and vitamin C content of the samples. Means were separated using least significance difference (LSD) test.

3. Results and Discussion

3.1 Changes in pH during Storage

The juices became acidic with increasing storage time. At week 4, the pH was lower for juices stored at 30 ^{o}C than juices stored at 13 °C (Table 1). The increase in acidity could be due to increase in organic acids. Organic acids are natural compounds in fruits and vegetables and they originate from biochemical processes or from the activities of microorganisms (Salinas-Hernandez, González-Aguilar, & Tiznado-Hernández, 2015). 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. Organic acids can also be produced by non-enzymatic browning reactions (Falade et al., 2004).

Table 1. Changes in pH during storage

Storage Time (weeks)	30 °C with preservative	30 °C without preservative	13 °C with preservative	13 °C without preservative
0	4.30±0.07a	4.30±0.07a	4.30±0.07a	4.30±0.07a
2	3.15±0.07a	3.60a	4.20±0.57b	4.15±0.07b
4	2.90±0.09a	2.90±0.09a	3.80b	3.90b
6	2.80±0.09a	2.60±0.09a	3.80±0.07b	3.70±0.07b

Means in the same row with different letters are significantly different (p<0.05)

3.2 Vitamin C Content during Storage

Vitamin C content soon after extracting the pulp was 42 mg/100g and just after juice processing the content was 39.34 mg/100g. The results indicated that there were significant differences ($p < 0.05$) in vitamin C contents among the juices during storage. Change in vitamin C content was dependent on temperature and presence or absence of preservative (Figure 1). By the end of week 2, loss of vitamin C was higher in juices stored at 30 °C i.e. contents were 24.49 mg/100g in juice without preservative and 31.79 mg/100g in juice with preservative. In juices stored at 13 °C, the vitamin C contents were 33.10 mg/100g in juice without preservative and 39.21 mg/100g in juice with preservative. The percent vitamin C losses at 6 weeks were 79 % at 30 ℃ without preservative, 71.43 % at 30 ℃ with preservative, 26.98 % at 13 ℃ with preservative and 64.30 % at 13 ℃ without preservative.

The higher vitamin C losses at 30 °C than 13 °C (Figure 1) were probably due to the instability of vitamin C at 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). In addition, this study showed that losses were higher in juices without preservative than in juices with preservative. According to Jung et al. (1995), preservatives contain sorbates which prevent vitamin C loss. The effect of preservative in vitamin C retention was more pronounced in juices stored at 13 °C than in juices stored at 30 °C. The results showed that a combination of cold storage and addition of preservative retains more vitamin C during storage. Masamba & Mndalira (2013) reported similar results whereby juices with preservatives stored at 10 °C retained more vitamin C than juices with preservative but stored at room temperature.

Nevertheless, all treatments resulted in vitamin C contents which were far lower than the recommended nutrient intake (RNI) for vitamin C. The lowest RNI for vitamin C is 25 mg/day in children between 0 – 6 months and RNI increases with age and is highest in lactating mothers, 70 mg/day (Food and Agriculture Organization, 2001).

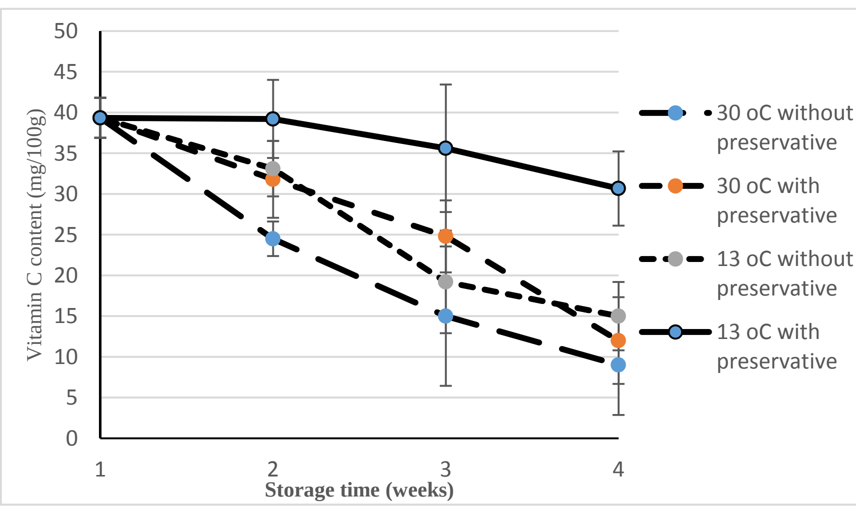

Figure 1. Changes in Vitamin C content (mean ± standard deviation) in the juices during storage

3.3 Sensory Evaluation

In shelf life studies, it is important to evaluate the behaviors of all attributes that confer quality to the product such as texture, taste, appearance, smell and color during storage so as to assess the changes and to check if products keep acceptable levels over time (Granato, Masson, & de Freitas, 2010). It was observed that prolonged storage (6 weeks) resulted in significant differences in all sensory attributes between fresh and stored juices. In general, juices stored at 30 ^{o}C had significantly higher means than refrigerated juices because higher temperatures accelerated the rate of deterioration hence rapid changes in sensory characteristics. Thus, increase in storage temperature resulted in rapid changes in all the quality attributes namely, color, viscosity, smell and taste. In addition, the juices without sodium benzoate had higher means than those with preservative.

3.3.1 Color

Color of the juices at both temperatures, and with and without preservative was rated 4.0 on the 2nd and 4th weeks. However, on the 6th week, the color of juices stored at 30 ^{o}C with preservative changed slightly while that of juices without preservative changed to brownish and the colors were rated 5.02 and 7.00, respectively (Table 2). The brown color could be due to Maillard reactions which lead to formation of a wide variety of end-products including organic acids, furans, furanose, ketones, and pyrroles. These contribute to color change and off flavor in juices (Falade et al., 2004). 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).

Table 2. Mean scores for sensory attributes of mango fruit juices stored at different temperatures

Storage time (weeks)	30 ^{O}C with preservative	30 ^{O}C without preservative	13 ^{O}C with preservative	13 ^{O}C without preservative
Color				
2	4.83±2.12a	4.06±1.78a	4.05±1.66a	4.01±1.30a
4	4.75±1.76a	4.08±1.94a	4.33±1.83a	4.23±1.58a
6	5.02±1.76a	7.00±0.06b	4.50±0.01c	4.66±0.89c
Viscosity				
2	4.00±1.27a	5.25±1.35b	4.05±1.95a	4.16±1.19a
4	5.33±1.37c	6.83±1.19b	4.25±1.28a	4.43±1.05a
6	6.51±1.28a	7.90±0.62c	4.75±1.05b	4.75±1.08b
Smell				
2	5.91±1.88a	6.25±1.91b	4.25±1.54c	4.25±1.23c
4	6.50±1.38a	7.58±1.31b	4.75±1.38c	5.66±1.07d
6	7.98±0.67a	7.00±1.21a	5.41±1.14b	7.07±0.88a
Taste				
2	5.66±0.98a	6.91±0.31b	4.25±1.40c	4.58±1.37c
4	6.66±1.61a	7.58±0.62b	4.91±0.99c	5.83±0.93d
6	7.86±1.88a	7.24±0.53a	7.03±1.27a	7.98±0.64a

Means with different letters within a row, are s significantly different ($p<0.05$). Intensity based on a scale of 1 to 8 (1 = extremely better than fresh juice, 7 = extremely worse than fresh juice for color, smell and taste attributes and 1 = extremely thicker than fresh juice, 7 = extremely thinner than fresh juice for viscosity).

3.3.2 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. From week 2 to week 6, there were no significant differences in the juices stored at 13 ^{o}C both with and without preservative (Table 2). However, there were significant differences ($p<0.05$) among the juices stored at 30 ^{o}C from the 2nd week to the 6th week (Table 2). The juice stored at 30 ℃ without preservative was rated 5.25 and with preservative was rated 4.00 at week 2. By the 4th week, the viscosity of the juices stored at 30 ^{o}C was thinner than the viscosity of the juices stored at 13 ^{o}C. At week 6, the juices stored at 30 ℃ without preservative were extremely thinner than the fresh juice (7.90). The use of preservative slowed down the rate of deterioration of the thickness of the juice. Mango juices consist of a dispersing phase in which sugars, acids, soluble pectins, proteins and salts dissolve and a dispersed phase made up of particles of different sizes and volume which come from the tissues of the mango. This structure contributes to the viscosity of the juice, and with increased storage time and high temperatures, the structure is affected hence the thickness reduces (Jimenez & Duran, 1999).

3.3.3 Smell

Juice stored for 2 weeks at 13 ℃ smelled similar to fresh juice (Table 2) while the juice stored at 30 ^{o}C without preservative smelled badly (6.25) compared to the juice with preservative stored at the same temperature (5.91). Deterioration in smell was perceived at week 2 in juices stored at 30 ^{o}C while in juices stored at 13 ^{o}C, deterioration was noticed from week 4 (Table 2). The deterioration in smell could be due to non-enzymatic reactions which lead to production of off-flavors (Jimenez & Duran, 1999).

3.3.4 Taste

The taste of juices stored at 30 ℃ with preservative was slightly bad at week 2, was bad at week 4 and at week 6, the taste of the juice was extremely bad (Table 2). While the taste of juice at 30 ℃ without preservative was bad at week 2 and extremely bad at week 4. On the other hand, the juices at 13 ℃ were all still similar to fresh juice at week 2 but at week 4, the juice without preservative was bad and at week 6, all juices were extremely bad. The deterioration could be due to non-enzymatic reactions in which sugars are used up, releasing a variety of end products such as organic acids and off-flavors, leading to reduction in sweetness of juice (Jimenez & Duran, 1999). In addition, the panelists indicated that the juice had a taste similar to that of alcohol probably because of by-products released into the juices due to activities of microorganisms such as yeasts.

These results agree with other studies which indicate that temperature is an important factor during storage of fruit juices. Higher temperatures result in accelerated deterioration of sensory parameters such as color, viscosity, smell and taste. In addition, this study shows that deterioration of attributes like color and viscosity may take long (in this study, 4 to 6 weeks) when in fact smell and taste may have already deteriorated (2 weeks). Deterioration was rapid in taste and smell in all treatments at both temperatures. This underscores the importance of using sensory analysis alongside other tests during shelf life studies in which the shelf life of a product maybe overestimated if only physicochemical and microbiological analyses are used.

3.4 Microbial Analysis

Microorganisms constitute a major mechanism by which many foods especially fresh ones lose their quality. 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 in the juice from week 0 to week 6. There were significant differences ($p<0.05$) 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 ^{o}C than in juices without preservative and stored at 30 ^{o}C. 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). The initial mean population was approximately 12 cfu/ml and after 6 weeks, the mean populations were highest, 2.10×10^{8} cfu/ml, in juices stored at 30 ^{o}C without preservative and lowest, 2.04×10^{4} cfu/ml, in juices stored at 13 ^{o}C 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 week. Total aerobic counts are used as indicators of quality and counts $>10^4$ cfu/ml can provide useful information about the general quality and remaining shelf life of the cooked food in question. When total aerobic counts are used to indicate quality, counts of 10^4 cfu/ml indicate upper limit of acceptability (Center for Food Safety, 2014).

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

	Bacterial count (CFU/ml)			
Storage time(weeks)	30 ^{o}C with preservative	30 ^{o}C without preservative	13 ^{o}C without preservative	13 ^{o}C with preservative
0	1.20×10^{1}a	1.20×10^{1}a	1.20×10^{1}a	1.20×10^{1}a
2	1.52×10^{2} a	2.04×10^{3}b	1.37×10^{2}a	1.10×10^{1}c
4	1.93×10^{4} a	2.17×10^{5}b	1.98×10^{4}a	1.70×10^{2}c
6	2.06×10^{6} a	2.10×10^{8}b	2.19×10^{5}c	2.04×10^{4}d

Means with different letters within a row, are significantly different ($p<0.05$)

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). It is suggested that spoilage occurs when yeast and mold count reaches 10^5 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). The initial mean population of yeast and molds was 1.4×10^2 cfu/ml (Table 4). At week 6, the mean population was highest, 1.96

$\times 10^8$ cfu/ml, in juices stored at 30 °C without preservative and lowest, 1.71 $\times 10^4$ cfu/ml, in juices stored at 13 °C with preservative. By week 4, all juices, except the chilled with preservative, had yeast counts $>10^5$ cfu/ml indicating some degree of spoilage.

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

	Yeasts and molds count (CFU/ml)			
Storage time (weeks)	30 °C with preservative	30 °C without preservative	13 °C with preservative	13 °C without preservative
0	1.4×10^2a	1.4×10^2a	1.4×10^2a	1.4×10^2a
2	1.71×10^4a	8.90×10^5b	2.75×10^2c	2.75×10^3d
4	1.50×10^6a	2.13×10^8b	3.50×10^3c	2.15×10^5d
6	1.50×10^7a	1.96×10^8b	1.72×10^4c	2.12×10^6d

Means with different letters within a row, are significantly different ($p<0.05$)

4. 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 vitamin C loss. A combination of cold storage and use of preservative resulted in highest vitamin C retention during storage. Smell and taste deteriorated faster than viscosity and color. Even though microbial counts implied deterioration by week 4 in both juices stored at 30 °C and in juice stored at 13 °C without preservative, but panelists perceived deterioration in sensory parameters earlier. Therefore, based on deterioration of taste, the shelf life were estimated to be 2 weeks and 4 weeks for juices stored at 30 °C and 13 °C, 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.

References

Association of Official Analytical Chemists (AOAC). (1984). *Official Methods of the Association of Official Analytical Chemists.* Virginia, USA.

Centre for Food Safety. (2014). Microbiological Guidelines for Food (For ready-to-eat food in general and specific food items). Revised. Food and Environmental Hygiene Department. http://www.cfs.gov.hk/english/food_leg/files/food_leg_Microbiological_Guidelines_for_Food_e.pdf Last accessed: July 2016.

Chitedze research station. (1998). *Recipes for fruit juice production.* Chitedze, Lilongwe, Malawi.

David, P. C., & Norah, H. (1998). *Fruits in Africa.* Aspen publishers, UK

Falade, K. O., Babalola, S. O., Akinyemi, S. O. S., & Ogunlade, A. A. (2004). Degradation of quality attributes of sweetened Julie and Ogbomoso mango juices during storage. *European Food Research Technology, 218*, 456-459. http://dx.doi.org/10.1007/s00217-004-0878-5

Food and Agriculture Organization of the United States. (2001). Human vitamins and mineral requirements. Report of a joint FAO/WHO expert consultation, Bangkok, Thailand. Food and Nutrition Division. Rome, Italy.

Granato, D., Masson, M. L., & de Freitas, R. J. S. (2010). Stability studies and shelf life estimation of a soy-based dessert. *Ciência e Tecnologia de Alimentos, Campinas, 30*(3), 797-807. http://dx.doi.org/10.1590/S0101-20612010000300036

Guiamba, I. (2016). *Nutritional value and quality of processed mango fruits* (Doctoral thesis, Chalmers University of Science and Technology, Goteborg, Sweden). Retrieved from http://publications.lib.chalmers.se/records/fulltext/230195/230195.pdf

Hassan, M. M., & Kabir, M. S. (2014). Study on shelf life of non-preservative containing mango drinks produced in Dhaka, Bangladesh. *Stamford Journal of Microbiology, 4*, 24-27.

Henney, J. E., Taylor, C. L., & Boon, C. S. (eds). (2010). *Strategies to reduce sodium intake in the United States*. Washington (DC): National Academies Press, USA. http://dx.doi.org/10.17226/12818

Institute of Food Science and Technology (Great Britain). (1993). *Shelf life of foods: Guidelines for its determination and prediction*. London: Institute of Food Science & Technology UK.

Jimenez, K., & Duran, C. (1999). *Principles of food chemistry* (2nd ed.). University of Guelph, Canada.

Jung, H. J., Williams, A. S. & Pillar, T. (1995). *Human beings and Preservation of food.* Macmillan publishers, U.S.A.

Lawless, H. T., & H. Heymann. (1998). Pp. 341-378 in Sensory evaluation of food: principles and practices. Chap. 10. Chapman & Hall, New York, NY.

Lee, S. K. C., & Kader, A. A. (2000). Pre-harvest and postharvest factors influencing vitamin C content of horticultural crops. *Postharvest Biology and Technology, 20*, 207-220. http://dx.doi.org/10.1016/S0925-5214(00)00133-2

Lund, B. M., Collins, P., & Dimon, Z. (2000). *The microbial safety and quality of foods*. Aspen Publishers Ltd, Maryland.

Man, D. (2002). Food Industry Briefing Aeries: *Shelf life.* Blackwell Science Ltd, London, U K. http://dx.doi.org/10.1002/9780470995068

Masamba, K. G., & Mndalira, K. (2013). Vitamin C stability in pineapple, guava and baobab juices under different storage conditions using different levels of sodium benzoate and metabisulphite. *African Journal of Biotechnology, 12*(2), 186-191. http://dx.doi.org/10.5897/AJB10.501

Mgaya-Kilima, B., Remberg, S. F., Chove, B. E., & Wicklund, T. (2014).Influence of storage temperature and time on the physicochemical and bioactive properties of roselle-fruit juice blends in plastic bottle. *Food Science & Nutrition, 2*(2), 181-191. http://dx.doi.org/10.1002/fsn3.97

NewZealand Government. (2014). Guidance document. How to determine shelf life of food. Ministry for Primary Industries, NewZealand. https//www.mp.govt.nz/document-vault/3414 Last accessed 2 March 2016.

Praphailong, W., & Fleet, G. H. (1997). The effect of pH, sodium chloride, sucrose, sorbate and benzoate on the growth of food spoilage yeasts. *Food Microbiology, 14*, 459-468. http://dx.doi.org/10.1006/fmic.1997.0106

Salinas-Hernandez, R. M., González-Aguilar, G. A., & Tiznado-Hernández, M. E. (2015). Utilization of physicochemical variables developed from changes in sensory attributes and consumer acceptability to predict the shelf life of fresh-cut mango fruit. *Journal of Food Science and Technology, 52*(1), 63 -77. http://dx.doi.org/10.1007/s13197-013-0992-0

Samson, J. A. (1986). Tropical fruits, 2nd edn. Longman Scientific & Technical, New York, U. S. A. 216-234.