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Research article

# Quality assessment of the mango-mandarin (kinnow) squash during storage

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**Abstract**
The aim of this study was to analyze the quality and storage stability of mango and mandarin fruit blend squash. The mango pulp and mandarin juice were mixed together with the addition of sugar to make five different treatments. In those treatments, mango pulp was decreased gradually from 70% to 30% with the alternative increase in mandarin juice concentration from 30% to 70 % among various treatments. Potassium meta-bisulphite (KMS) was added as preservative at the rate 0.1%. Mango-Mandarin squash was subjected to different physico-chemical and sensory analyses during the storage study of 90 days. All the treatments showed a decreasing trend for TSS and pH and increasing trend for total sugars and titratable acidity during storage period. Results showed that mango-mandarin squash contains pH (3.88-3.26), acidity (1.66-1.24 %), total sugars (45.33-42 %) and total soluble solids (47.67- 44.00 °B). The results were further verified by principal component analysis (PCA). The sensory evaluation score showed that treatment T5 (30 % mango pulp, 70 % mandarin juice) was highly acceptable even after 90 days storage period.
**Keywords:** Mango-Mandrin squash, sensory properties, shelf life, physico-chemical analysis.

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## Introduction

Fruits and vegetables are the fundamental and vital elements in the human diet. They make a significant nutritional contribution to human's diet due to their high nutritional value. They are the best source of vitamin A and C, considered as protective foods and are not much expensive. Fruits are not only consumed as fresh, but are also processed in the form of products. With the advances in food science and technology, processing and preservation have ensured maximum utilization of C and D grade fruits, including deformed, de-shaped, underdeveloped for the utilization and converting them into valuable food products. It is also very economical to preserve seasonal fruits to prepare different fruit products when they are in glut season and sold at throw away prices. Fruits can be processed in different ways. Their pulp can be preserved to prepare squash, jams, purees, etc. [1]. It has now become more important for food technologists not only to process the fruits and vegetable into valuable food products, but also to guide the consumers to select these food products according to new concepts of blood group to remain healthy and prevent diseases. These new concepts have already been introduced by Dr Peter and Dr Lam thought to be pioneers in blood group diet studies. These studies are based on the lectins which result in agglutination if unsuitable according to blood group diet. An ultimate diet pyramid based on blood group diet has been developed [2]. This diet pyramid provides information on hidden nutritional potential of fruits to be mixed together or not. While the current concept of a balanced diet and nutrition is based on composition of foods, but does not address the hidden potential of such fruits.

Mango fruit is a very good source of fiber and rich in vitamins like vitamin-A, vitamin-C, vitamin $B_6$, vitamin E, phenolic constituents and carotenoids [3]. It helps to prevent against certain cancers, for the synthesis of iron and also increase the immune system activity in response against many diseases. Mango is a very much relished fruit and contains minerals like iron and phosphorus [4]. Mango fruit is also good for treating the kidney problems [5]. While, citrus fruits contain some bioactive compounds like limonoids, poly methoxy flavones (PMF) and flavones glycosylates (FSs), it is also having preventive properties against cancer and cardiovascular diseases as citrus flavonides could have the ability to moderate the synthesis of cholesterol [6].

The consumption of fruit beverages in the world has increased during the last few decades. With the improvements in processing capacity of food technology, different products like squashes, syrup, cordials, fruit juices and ready-to-serve beverages have been introduced in Pakistan on a commercial scale to a larger extent. The use of different fruits in the industry for the preparation of different products will not only reduce wastage of fruits during handling of fruits but also add nutrition and palatability to maintain health.

The objective of this study was to assess the best possible combination of fruit pulp and fruit juice for overall acceptability and for the preparation of squash through blending in different proportions. At the end the effect of storage time on the quality of mango-mandarin squash was also studied.

## Materials and Methods

### Procurement of raw material

Fresh Mango fruits (*Mangifera indica*) chaunsa variety and mandarin fruits (*Citrus sinensis*) were taken from the local fruit market of Sargodha, Pakistan. Fruits which were used for the preparation of squash were free of damage, diseases and insect attack, and with no sign of fermentation, etc.

### Preparation of mango pulp and mandarin juice

The fruits were washed with tap water to remove any adhering foreign material. Mango peel was removed manually with the help of steel knife. Fleshy part of mango fruit was cut into small pieces and the pulp was extracted by adding a measured amount of water (50% weight of mango fruit) to facilitate pulping operation. Fruit pulp was passed through a fine mesh (0.3mm) to remove any hair or pieces of peel.

The mandarin juice was extracted by using lab type electric juice extraction machine. The extracted juice was passed through the same fine mesh (0.3 mm). Then the mandarin juice was pasteurized at 92 $^{o}$C temperature for 40 seconds to inactivate enzymes as described by Uelgen and Oezilgen [7]. Finally the mango pulp and mandarin juice were filled in pre-sterilized air tight PET bottles for further use and processing for making mango-mandarin squash. The flow sheet of mango-mandarin squash is given in Fig. 1 and different treatments are given in Table 1.

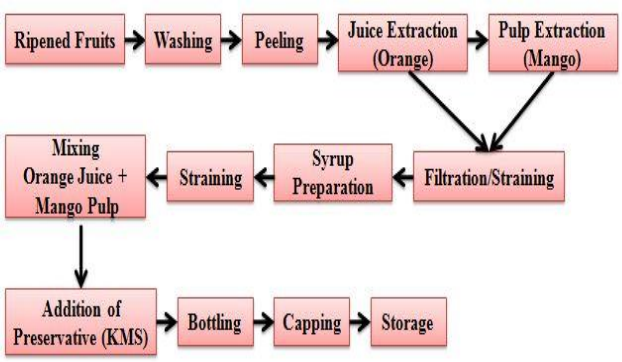


**Fig. 1** Flow sheet of mango-mandarin squash preparation.

### Preparation of mango-mandarin squash

Mango-mandarin squash was prepared according to the formulations as given in the Table 1. The addition of potassium metabisulphite (KMS) as a preservative was done by dissolving the KMS in little quantity of water separately before addition to the squash. No flavor was added in the treatments, but the color was added in the proportion 1:3 ratio of orange red and Lime yellow in the ratio of 1g/l of prepared squash samples. Immediately after thorough mixing, squash was filled into sterilized air tight PET bottles, keeping the head space of almost 1 inch. The squash was stored at room temperature at the laboratory shelf. Squash was used by diluting it in 1:5 ratio, i.e. one part of squash in five parts of chilled water. The squash was offered for sensory evaluation to a panel of 20 semi trained judges comprising faculty members and 2$^{nd}$ year M Phil students.

### Determination of pH

The pH of the mango-mandarin squash was measured using a pH meter (Hanna Model 8520, Italy).

### Determination of titrable acidity (TA)

Titratable acidity (%) of the mango-mandarin squash samples were determined as stated by AOAC [8-10]. Titration was done against 0.1N NaOH solution by using phenolphthalein as indicator. Five ml of the sample was placed in an Erlenmeyer flask which was then added with a drop of phenolphthalein indicator. The solution was titrated with 0.1N NaOH solution until the faint pink color appeared. The volume of NaOH was converted to g citric acid per 100mL of juice and titratable acidity was finally calculated by using the equation given below:

$$\text{TA (\%)} = \frac{V \times 0.1\,N\ NaOH \times 0.064 \times 100}{m}$$

where as "V" is the volume of titer NaOH, and "m" is the volume of the sample (mL).

### Determination of total soluble solids (TSS)

Total soluble solids were measured by hand-refractrometer and corrected to the equivalent reading at 20 $^{0}$C as stated in AOAC [11-15].

### Determination of total sugars (TS)

Total sugar (TS) was measured using standard methods as described in AOAC [16-18].

### Sensory characteristics

The mango-mandarin squashes were evaluated organoleptically by a panel of twenty judges for color, flavor, taste and overall acceptability as described by other researchers [19-21]. Judges were provided with a sensory evaluation form.

### Statistical analysis

For statistical analysis, a completely randomized design was used with a factorial experiment design and significant differences between mean values were determined by least significant difference

**Table 1** Different formulations used for the preparation of mango-mandarin squashes.

| Treatments | Mango pulp (ml) | Mandarin juice (ml) | Sugar (kg) | Water (ml) | Citric acid (g) | KMS (g) |
|---|---|---|---|---|---|---|
| $T_1$ | 700 | 300 | 1.75 | 500 | 17 | 3 |
| $T_2$ | 600 | 400 | 1.75 | 500 | 17 | 3 |
| $T_3$ | 500 | 500 | 1.75 | 500 | 17 | 3 |
| $T_4$ | 400 | 600 | 1.75 | 500 | 17 | 3 |
| $T_5$ | 300 | 700 | 1.75 | 500 | 17 | 3 |

(LSD) pairwise comparison test at a significance level of $P < 0.05$. Statistix 9.0 software (Analytical Software, Tallahassee, FL, USA) was used for statistical analyses. Principal component analysis (PCA) was used to analyze the correlation between mango-mandarin squash samples (different formulations of mango pulp and mandarin juice) and storage period (0, 30, 60 and 90 days) using Minitab statistical software (Version 16.0, Minitab Inc., Enterprise Drive State College, PA).

## Results and Discussion

### Effect of treatments and storage period on pH and titratable acidity

The results regarding pH are given in Table 1S. The highest pH was observed in the samples of $T_4$ (3.88) while the minimum was observed in the samples of $T_2$ (3.38). The results showed that the pH of the treatments was significantly affected during storage time of mango-mandarin squash. Treatments showed a decreasing trend during storage (Fig. 2). The pH of mango-mandarin squash during storage time ranged between 3.88-3.26. The pH of squash normally adjusted to 3.7 with citric acid [22]. The results regarding the decrease in pH during storage time are in accordance with the earlier reports [23-25].

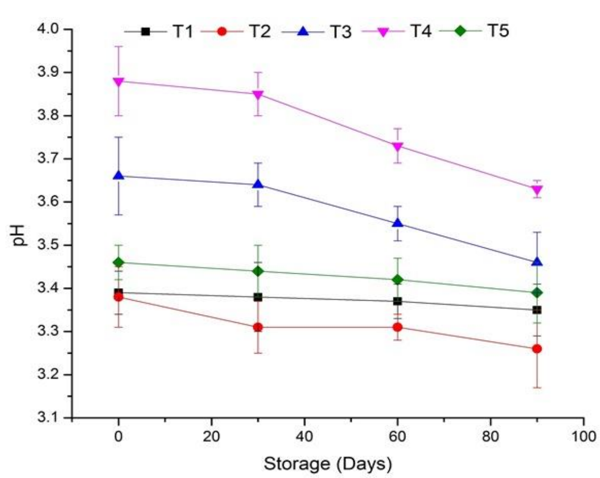


**Fig. 2** Effect of treatments and storage period on the pH of mango-mandarin squash.

The results regarding titratable acidity are presented in Table 1S. The highest titratable acidity value was observed in the samples of $T_4$ (1.61) while the minimum was observed in the samples of $T_3$ (1.24). The results showed that treatment effects were highly significantly during storage time of mango-mandarin squash. Treatments showed an increasing trend during storage (Fig. 3). The acidity of mango-mandarin squash during storage time ranged between 1.66-1.24. The results regarding the increase in acidity during storage time are in accordance with the earlier findings [24-27]. The increase in acidity might be attributed due to the increase in the concentration of powerless ionized acid and their salts during storage. Another reason for the rise in acidity might be due to the acid formation, reducing sugars oxidation and polysaccharide degradation or by the breakdown of uronic acid and pectin substances [24, 28]. The acidity of the fruit samples also tends to increase due to the addition of chemical preservatives [23].

### Effect of treatments and storage period on the total soluble solids (TSS)

The results regarding TSS are presented in Table 1S. The highest TSS value was observed in the samples of $T_3$ (46.00), whereas, the minimum value was observed in the samples of $T_2$ and $T_4$ (44.00). The results showed that treatments showed significant effect on TSS during storage time of mango-mandarin squash. Treatments showed an increasing trend during storage time (Fig. 4). The TSS of mango-mandarin squash during storage time ranged between 47.67-44.00. The squashes having high value of TSS indicated that they have more sugar contents than those having lower value. Hussain et al. [29] observed that mango squash exhibited TSS values 53.74 to 44.66. Warth, noted that the time at which fruit was harvested actually determine the quality attribute of the pulp [30].

### Effect of treatments and storage period on the total sugars (TS)

The results regarding TS are given in Table 1S. The highest TS was observed in the samples of $T_3$ (45.33), whereas, the minimum value was observed

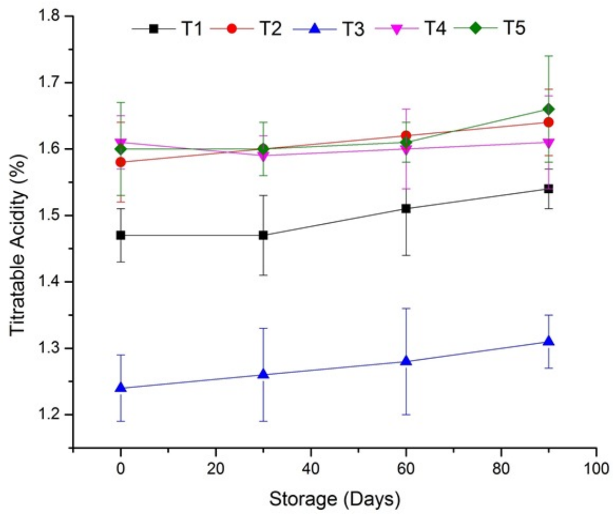


**Fig 3** Effect of treatments and storage period on titratable acidity of mango-mandarin squash.

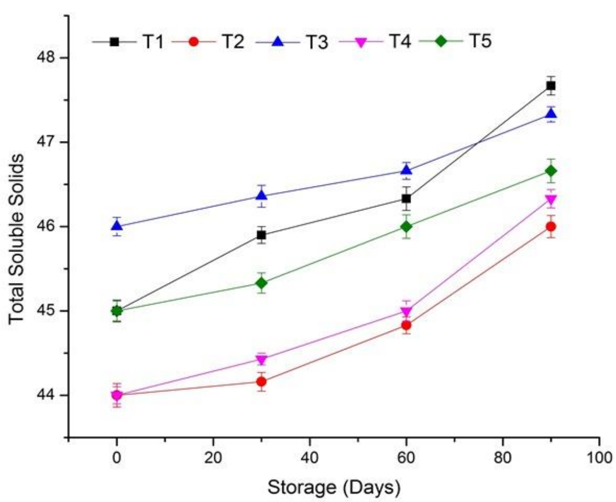


**Fig 4** Effect of treatments and storage period on total soluble solids of mango-mandarin squash.

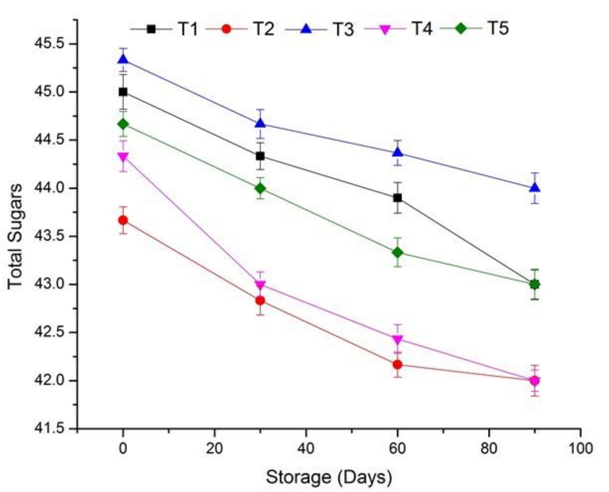


**Fig 5** Effect of treatments and storage period on total sugars of mango-mandarin squash.

in the samples of $T_2$ (43.66). The results showed that treatments showed highly significant effects during storage time of mango-mandarin squash. Treatments showed decreasing trend during storage time (Fig. 5). The TS of mango-mandarin squash during storage time ranged between 45.33-42. These results are in accordance with Krishnakumar et al. [31] who noted that total sugars decreased after storage at ambient temperature. Decrease in total sugars might be due to breakdown of total sugars into reducing and other sugars. Similar findings were reported by Safdar et al. [32] during a study on Sudanese mango jam. According to Sindumathi and Amutha [33] observed that primary total sugar contents of coconut based jam were 52.20 g/100g which decreased to 51.60 g/100g during storage at ambient temperature. Breakdown of total sugar into simple sugar would have decreased the quantum of total sugar.

**Effect of treatments and storage period on the sensory characteristics**

The results regarding sensory characteristics are presented in Fig. 6. The sensory evaluation score showed that treatment $T_5$ was highly acceptable as tested by the sensory panel even after 90 days storage. The maximum score for color was observed in the samples of $T_5$ (8.06), whereas, the minimum score was observed in the samples of $T_1$ (6.22). The treatments showed a decreasing trend for color during storage. The score for color of mango-mandarin squash during storage ranged between 8.06-6.06. The color of fruit pulp tends to decrease periodically [34, 35]. It was noted from storage study results that fruit pulp without chemical preservative had better flavor than the one which is chemically preserved. Gliemmo et al. [36] stated that oxygen promotes carotenoid degradation by oxidation, and cause the development of off-flavors and off-color, due to the reduction of the oxygen in the headspace.

Flavor is the blend of taste and smell perceptions, it is judged when the food is in the mouth. The overall flavor impression is the result of the tastes perceived by the taste buds in the mouth and the aromatic compounds detected in the nose [37]. The maximum score for flavor was found in the samples of $T_5$ (8.16), whereas, the minimum score was observed in the samples of $T_1$ (6.14). The treatments showed a decreasing trend during storage. The score for the flavor of mango-mandarin squash during storage ranged between 8.16-6.04. The results are in accordance with the Hussain et al. [29] who studied the influence of storage and cultivars on overall acceptability and quality of mango squash and also observed that the quality parameters like color and

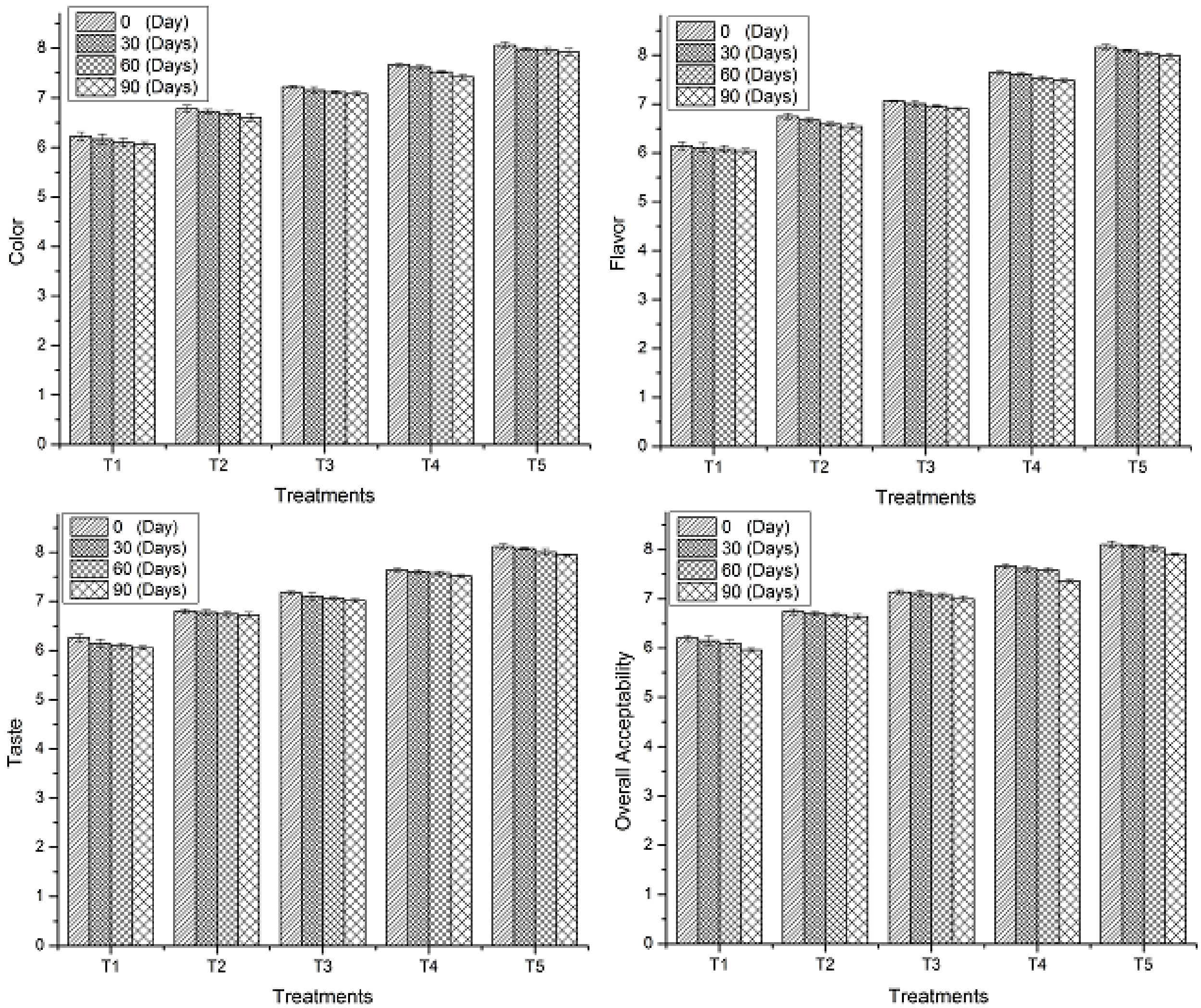


**Fig 6** Effect of treatments and storage period on the sensory characteristics of mango-mandarin squash.

flavor decreased during storage. Flavor decreased as the time proceeded. Previous studies give evidence that the fruit samples show significant effect on the sensory attributes of mango pulp by the addition of the chemical preservatives [38].

The maximum score for taste was observed in the samples of $T_5$ (8.12), whereas, the minimum score was observed in the sample of $T_1$ (6.26). The treatments showed a decreasing trend for a taste during storage. The score for taste of mango-mandarin squash during storage ranged between 8.12-6.06. The maximum score for overall acceptability was observed in the samples of $T_5$ (8.10), whereas the minimum score was observed in the sample of $T_1$ (6.20). The treatments showed a decreasing trend during storage. The score for overall acceptability of mango-mandarin squash during storage ranged between 8.10-5.96. According to Picouet et al. [39] and Larmond [19] , the overall acceptability of chemically preserved fruit beverages depended on what sort of chemical treatment were applied to them.

## Principal component analysis (PCA)

PCA was used to analyze the data in order to make a correlation between mango-mandarin squash samples and quality parameters during storage. The score plots made from PCA of mango-mandarin squash samples during storage are shown in Fig. 7a and the distribution of quality parameters defined by the first and second PCA dimensions is presented in Fig. 7b. The sum of principal components PC1 and PC2 contributed to 74.6% of variance among mango-mandarin squash samples. The first principal component (PC1) accounted for 44.2% of the total variation and the second principle component (PC2) contributed to 30.4% of the total variation. PC1 was positively correlated with pH, total soluble solids and total sugars, and negatively with titratable acidity.

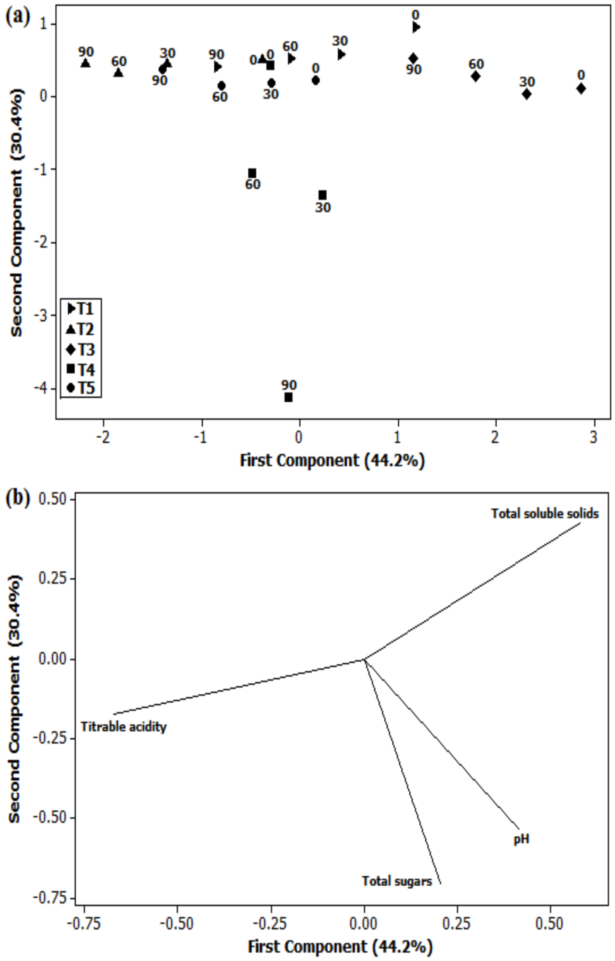


**Fig 7** Principle component analysis (PCA) of mango-mandarin squash samples (a) the location of different treatments and storage periods (b) the location of quality parameters.

## Conclusions

A rich in taste and delicious mango-mandarin squash was prepared which can be used in our daily life due to long shelf life of about six months and above. The present study observed that people mostly liked the mango-mandarin squash, which contained more percentage of mandarin juice ($T_5$: 30 % mandarin juice with 70 % mango pulp) as compare to other samples $T_1$, $T_2$, $T_3$ and $T_4$ which contained less amount of mandarin juice. This squash was prepared from selected fruits available at one time in the market, but on an industrial scale, the fruit pulp of early and late season are mixed to obtain a uniform quality product. Because, before the processing of fruit squashes, some factors like harvesting yields, seasonal changes and maturation must be taken into account for the production of better quality product because these factors also significantly affect the taste profile of the final product. The production of squashes saves the seasonal fruits which are valuable and precious for health and diet by making them useful to people almost for the whole year. Good developments have been made in the manufacturing of fruit squashes by the use of food science and technology. Advances and research should be done for further improvement and betterment of the value added products by utilizing the seasonal fruits like mango and mandarin.

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