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Improving the Storage Stability and Keeping Quality of Modified Papaya Juices Stored under Refrigeration Conditions

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ABSTRACT

Fresh papaya puree was blended with orange, strawberry, mango and guava to improve the nutritional and quality properties of the mixed juices. The produced juices were evaluated for their nutritional, physicochemical, microbiological and sensory characteristics. The effect of pasteurization (at ~ 65ºC/20 min) and/or chemical preservatives (0.05% potassium sorbate + 0.05% potassium metabisulphite) on the quality and shelf stability of papaya juices was also investigated during cold storage (at ~ 4ºC) for 6 months. The results showed that, the combined action of the thermal treatment and chemical preservatives (T_3) on the quality and shelf stability of papaya juices was better than using either of them alone. During refrigerated storage, the values of moisture, pH, ascorbic acid and total phenolics significantly decreased as the storage time increased. While, the total soluble solids and titratable acidity values significantly increased. Despite this decrease, all juice samples remained satisfactory sources of ascorbic acid and phenolic compounds over the storage period. The sensory quality of papaya juices remained acceptable for up to six months. The total bacterial counts were less than 10^2 cfu/g for all juice samples. Yeasts and moulds were absent during refrigerated storage. Consequently, no potential microbial risk was associated with the storage conditions. As a conclusion, the papaya fruits could be successfully used singly or in combination with orange, strawberry, mango and guava to obtain delicious and healthy nutritious juices. The modified papaya juices (75% papaya + 25% orange/strawberry/mango/guava) had acceptable quality attributes, improved nutritional value, improved shelf stability and microbiological safety.

Keywords: Papaya, orange, strawberry, mango, guava, preservatives, pasteurization.

INTRODUCTION

Nowadays, awareness of consuming healthy food for a healthy life is becoming more and more prevalent. In this respect, fruits and vegetables serve as important sources of a wide variety of vitamins, minerals and dietary fibers essential for human nutrition. They are recommended as important sources of health-promoting phytochemical compounds that may provide desirable health benefits beyond basic nutrition to reduce the risk of chronic diseases. There are many biologically reasonable reasons for this potentially protective association, including the fact that many of the phytochemicals act as antioxidants. Therefore, some people have conferred on fruits and vegetables the status of functional foods (Jongen, 2002; Rosa *et al*., 2010; Slavin and Lloyd, 2012; Gündüz, 2016; Ramya and Patel, 2019 and Murthy and Bapat, 2020).

Fruit juices are becoming more and more popular all over world. They play an important role in promoting health, due to their high content of essential nutrients and bioactive compounds. The current dietary trend toward healthy diets makes juice consumption an important alternative and improves the availability of its nutritive compounds. Fresh juices are highly perishable. Delays between processing and consumption of juices can result in losses of flavor and nutritional quality. Therefore, they should be preserved using an appropriate preservation method unless consumed fresh (Bhardwaj *et al*., 2014; Arend *et al.*, 2017; Dasenaki and Thomaidis, 2019; Guine *et al*., 2020 and Ruxton and Myers, 2021).

Papaya (*Carica papaya*) is a principal horticultural crop of tropical and subtropical regions. It is commonly known for its nutritional, medicinal and neutraceutical properties worldwide. Papaya fruits are delicious and healthy due to their high content of vitamins, minerals, proteolytic enzymes and many other biological active compounds. Papaya fruits are consumed when they ripe and become soft and sweet. They are eaten fresh in fruit salads, blended as juice or processed as jam. The lack of storage facility and perishable nature of papaya fruits can result in severe postharvest losses of this nutritious fruit. Therefore, the processing of papaya into functional foods not only extends its shelf life but also preserves the nutritive value of the fruit (Aravind *et al*., 2013; Devaki *et al*., 2015; Shrivastava and Gowda, 2016; Aly *et al*., 2020; Dwivedi *et al*., 2020; Sharma *et al*., 2020 and Dotto and Abihudi, 2021).

Oranges (*Citrus sinensis*) are among the most popular fruits around the world. The nutrients in oranges offer a range of health benefits.They have been reported as a rich source of vitamin C, fibers, potassium and phytochemicals such as flavonoids. Thus, the consumption of orange could provide significant amounts of bioactive compounds with antioxidant activity (Vanamala *et al*., 2006; Ndife and Abbo, 2009; Ndife *et al*., 2013; Abobatta, 2019 and Pardo *et al*., 2021).

Strawberries (*Fragaria ananassa*) are popular fruits grown in Egypt and many other countries. In the

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Mediterranean diet, strawberries are a common and important fruit because of their high content of essential nutrients and beneficial phytochemicals, which seem to have relevant biological activity in human health. According to their nutrient profile, the strawberries represent a healthy food choice (El-Beltagy *et al*., 2007; Aaby *et al*., 2012; Giampieri *et al*., 2012; Basu *et al*., 2014; Gündüz, 2016 and Putri *et al*., 2020).

Mango (*Mangifera indica*) is one of the most important tropical and subtropical fruits worldwide in terms of production and consumer acceptance. Mango is a highly nutritive fruit and has several health benefits. In addition to its unique color and flavor, it is a good source of carbohydrates, antioxidants including ascorbic acid, carotenoids and polyphenols. Mango can be consumed fresh or processed into juices, nectars, concentrates, jams, jelly, fruit bars, flakes and dried fruits (Khan *et al*., 2008; Djioua *et al*., 2009; Maldonado-Celis *et al*., 2019; Akther *et al*., 2020 and Lebaka *et al*., 2021).

Guava (*Psidium guajava*) is an important fruit crop of the subtropical and tropical regions in the world. It is commercially important because of its flavor and aroma. It has a considerable nutritional importance due to its excellent source of vitamins, antioxidants, fibers and minerals essential for human nutrition and health (Soares *et al*., 2007, Singh and Pal, 2008; Kuchi *et al*., 2014; Yadav *et al*., 2017 and Anand *et al*., 2020).

Therefore, the main objectives of this investigation are to: (1) produce delicious and healthy nutritious juices using papaya puree singly or in combination with orange, strawberry, mango and guava. (2) Evaluate the nutritional and quality properties of the produced juices. (3) Improve the storage stability and keeping quality of the modified papaya juices stored at refrigeration temperature (~ 4ºC) by using pasteurization (~ 65ºC/20 min) and/or chemical preservatives (0.05% potassium sorbate + 0.05% potassium metabisulphite).

MATERIALS AND METHODS

Materials:

Freshly harvested papaya (*Carica papaya*) was obtained from the Horticulture Research Farm, Fac. of Agric. Minia Univ., Minia, Egypt. Orange (*Citrus sinensis*), strawberry (*Fragaria ananassa*), mango (*Mangifera indica*) and guava (*Psidium guajava*) were purchased from the local market (Minia, Egypt). All chemicals used in this study were of analytical grade and purchased from Sigma and El-Naser pharmaceutical chemicals.

Methods:

Preparation of the raw materials for juice processing:

Papaya puree: Fresh papaya fruits were subjected to successive steps of washing, sorting and trimming, then peeled and cut into halves to remove the seeds. Papaya puree was obtained using a food processor, drain with a suitable filter when needed to obtain homogenous puree.

Orange juice: Orange fruits were subjected to successive steps of washing, sorting and trimming, then cut into halves. Orange juice was extracted using a juice extracting machine and filtered to obtain clear juice.

Strawberry puree: Strawberry fruits were subjected to successive steps of washing, sorting and trimming, then blended and screened to obtain homogenous puree.

Mango puree: Mango fruits were subjected to successive steps of washing, sorting and trimming. The fruits were peeled and the stones were removed, then the fleshes of samples were blended and screened through a mesh screen to form homogenous puree.

Guava puree: Guava fruits were washed, sorted, cut into small pieces, blended and screened to remove seeds and obtain homogenous puree.

Processing and storage of papaya juice blends:

Preliminary trials were conducted to prepare papaya juice blends. Papaya puree was mixed (in different proportions) with orange, strawberry, mango and guava. Based on the sensory assessment data, the research on the best sensory samples (75% papaya + 25% orange/strawberry/mango/guava) was completed. The preservation treatments (T_0, T_1, T_2 and T_3) for juice samples were done as follows:

T_0 = Control (without any treatments).

T_1 = Pasteurization at ~ 65ºC / 20 min.

T_2 = 0.05% potassium sorbate (PS) + 0.05% potassium metabisulphite (KMS).

T_3 = Pasteurization at ~ 65ºC / 20 min + 0.05% potassium sorbate (PS) + 0.05% potassium metabisulphite (KMS).

The juice samples were aseptically filled into sterile and clear glass bottles (200 mL), sealed and stored at refrigeration temperature (~ 4ºC) for six months. Evaluation tests for juice samples were carried out at the beginning of experiments (zero time), then every month throughout the storage period. The processing steps of mixed papaya juice preparation and preservation are illustrated in Fig (1).

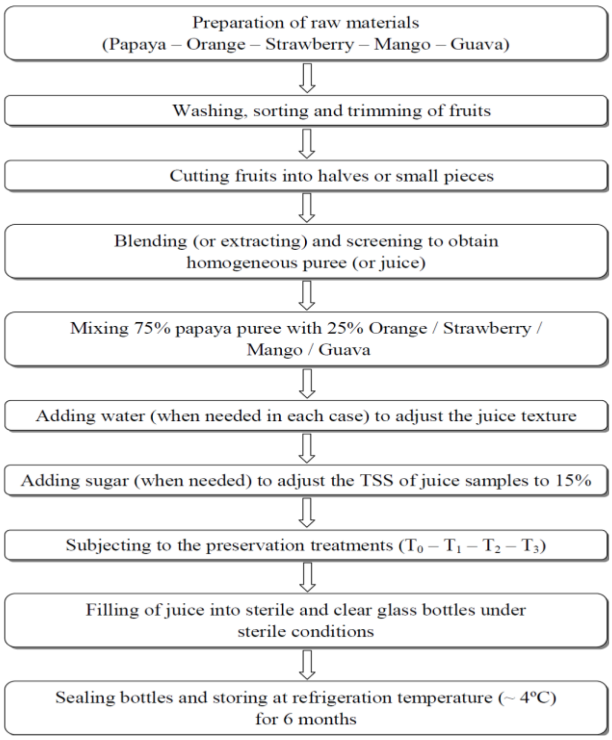

Fig. 1. The processing steps of mixed papaya juices preparation.

Determination of moisture content:

Moisture content of juice samples was determined according to the methods of the AOAC (2000). All determinations were performed in triplicates and the means were reported.

Determination of total soluble solids (TSS):

The total soluble solids were measured (as °Brix) using hand refractometer at room temperature (~ 25ºC) according to AOAC (2000).

Determination of pH and titratable acidity:

The pH of juice samples was determined using a digital pH meter according to the methods of the AOAC (2000). Titratable acidity (as % citric acid) was determined according to Adekunte *et al*. (2010).

Determination of ascorbic acid:

Ascorbic acid was determined by the 2,6-dichlorophenol-indophenol method according to Ranganna (1977). The results were expressed as mg ascorbic acid / 100g sample.

Determination of total phenols:

Estimation of total phenols was carried out according to Musa et al. (2011) using Folin-Ciocalteu reagent. Approximately 10 g sample was homogenized with 100 mL extracting solvent (methanol 50%) for 1 min under high speed. The extracted samples were centrifuged for 15 min at 3000 rpm. The supernatants were collected and passed through Whatman No.1 filter paper. About 0.50 mL sample extract was added with 2 mL distilled water and 2.50 mL diluted Folin-Ciocalteu reagent (0.20 N). The samples (extracts with Folin-Ciocalteu reagent) were left for 5 min before 5 mL of 7.5% (w/v) Na2CO3 was added. The absorbances were taken at 765 nm after 2 hrs. Calibration curve of gallic acid was set up to estimate the activity capacity of samples. The results were expressed as mg of gallic acid equivalents (GAE)/100g of sample.

Microbiological analysis:

The total bacterial count was determined according to Diliello (1982) using nutrient agar media. Yeast and mould count was done using malt extract agar media according to AOAC (2000). The number of bacterial colonies, yeasts and molds were counted, after incubation at 37ºC / 48 hrs for bacteria and 25ºC / 72 hrs for yeasts and molds, and expressed as colony forming units per gram of the sample (CFU/g).

Sensory evaluation:

Sensory evaluation for the color, flavor texture and overall quality were done in order to determine consumer acceptability. A numerical hedonic scale which ranged from 1 to 10 (1 is very bad and 10 for excellent) was used for sensory evaluation (Larmond, 1977).

Statistical analysis:

The statistical analysis was carried out according to Snedecor and Cochran (1982) using the statistical package for social scientist (SPSS) software program. All results are presented as arithmetic means ± SD. Means and standard deviation (SD) were measure by the least significant difference (LSD) and Duncan's multiple range test at 5% significant level.

RESULTS AND DISCUSSION

The moisture content of papaya juice samples during storage:

The moisture contents of control and treated papaya juice samples during cold storage (at ~ 4oC) for six months are presented in Table (1). From which, it could be seen that all preservation treatments and storage intervals both had a significant effect on the moisture content values for most juice samples. The data indicated a gradual inecrease in moisture content up to the third month of storage for all juice samples (except the formula contined 75% papaya + 25% orange). Then there was a gradual decrease up to the end of storage (6 months) for all juice samples. This decrease in moisture content consequently led to an increase in the total solids content. Similar results are reported by Chowdhury et al. (2008) for mixed juice based on wood apple and papaya.

Table 1. Moisture content (%)* of papaya juice samples during cold storage (at ~ 4ºC).

Treatments**	Storage intervals (month)						
	Zero time	1st	2nd	3rd	4th	5th	6th
	100% Papaya juice						
T_0 (Control)	83.74 ± 0.04^{k}	-	-	-	-	-	-
T_1	83.99 ± 0.02^{i}	84.18 ± 0.03^{h}	84.23 ± 0.04^{g}	84.61 ± 0.02^{c}	84.45 ± 0.04^{d}	84.30 ± 0.02^{f}	83.77 ± 0.03^{k}
T_2	84.18 ± 0.03^{h}	84.39 ± 0.03^{e}	84.46 ± 0.02^{d}	84.97 ± 0.02^{a}	84.65 ± 0.02^{c}	84.44 ± 0.02^{d}	83.88 ± 0.03^{j}
T_3	83.91 ± 0.02^{j}	84.15 ± 0.02^{h}	84.32 ± 0.01^{f}	84.74 ± 0.03^{b}	84.45 ± 0.02^{d}	84.43 ± 0.03^{de}	83.68 ± 0.04^{l}
	75% Papaya juice + 25% Orange juice						
T_0 (Control)	86.25 ± 0.05^{d}	-	-	-	-	-	-
T_1	86.09 ± 0.02^{e}	86.02 ± 0.01^{ef}	85.70 ± 0.02^{h}	85.59 ± 0.02^{h}	85.42 ± 0.01^{i}	85.25 ± 0.02^{j}	85.10 ± 0.02^{k}
T_2	86.74 ± 0.03^{a}	86.67 ± 0.02^{ab}	86.47 ± 0.03^{c}	86.35 ± 0.02^{cd}	85.93 ± 0.02^{fg}	85.89 ± 0.02^{fg}	85.85 ± 0.03^{g}
T_3	86.64 ± 0.03^{ab}	86.60 ± 0.02^{b}	86.27 ± 0.04^{d}	86.02 ± 0.03^{ef}	85.87 ± 0.01^{g}	85.72 ± 0.02^{h}	85.68 ± 0.02^{h}
	75% Papaya juice + 25% Strawberry juice						
T_0 (Control)	85.23 ± 0.02^{c}	-	-	-	-	-	-
T_1	85.26 ± 0.02^{c}	85.45 ± 0.03^{bc}	85.72 ± 0.04^{b}	85.97 ± 0.03^{a}	85.63 ± 0.02^{b}	85.42 ± 0.01^{bc}	84.98 ± 0.02^{de}
T_2	85.29 ± 0.03^{c}	85.41 ± 0.01^{bc}	85.67 ± 0.02^{b}	86.05 ± 0.01^{a}	85.67 ± 0.02^{b}	85.20 ± 0.02^{c}	84.99 ± 0.03^{de}
T_3	85.13 ± 0.02^{cd}	85.21 ± 0.02^{c}	85.44 ± 0.02^{bc}	85.71 ± 0.02^{b}	85.42 ± 0.03^{bc}	85.28 ± 0.02^{c}	84.87 ± 0.02^{de}
	75% Papaya juice + 25% Mango juice						
T_0 (Control)	82.59 ± 0.02^{gh}	-	-	-	-	-	-
T_1	82.37 ± 0.01^{i}	82.40 ± 0.03^{i}	82.68 ± 0.03^{fg}	83.35 ± 0.02^{c}	83.09 ± 0.04^{d}	82.62 ± 0.05^{gh}	82.14 ± 0.02^{j}
T_2	82.48 ± 0.03^{hi}	82.64 ± 0.02^{gh}	82.91 ± 0.04^{e}	83.75 ± 0.03^{a}	83.35 ± 0.02^{c}	82.85 ± 0.03^{ef}	82.33 ± 0.03^{i}
T_3	82.30 ± 0.02^{i}	82.34 ± 0.02^{i}	82.76 ± 0.02^{efg}	83.53 ± 0.02^{b}	82.99 ± 0.03^{de}	82.62 ± 0.02^{gh}	82.35 ± 0.02^{i}
	75% Papaya juice + 25% Guava juice						
T_0 (Control)	84.47 ± 0.03^{d}	-	-	-	-	-	-
T_1	84.23 ± 0.02^{efg}	84.38 ± 0.03^{de}	84.73 ± 0.02^{c}	84.82 ± 0.02^{bc}	84.48 ± 0.02^{d}	84.13 ± 0.06^{gh}	83.97 ± 0.04^{h}
T_2	84.42 ± 0.01^{d}	84.46 ± 0.01^{d}	84.95 ± 0.02^{ab}	85.01 ± 0.02^{a}	84.69 ± 0.03^{c}	84.09 ± 0.03^{gh}	84.02 ± 0.02^{h}
T_3	84.14 ± 0.02^{gh}	84.31 ± 0.02^{def}	84.47 ± 0.04^{d}	84.92 ± 0.03^{ab}	84.43 ± 0.04^{d}	84.21 ± 0.02^{fg}	84.03 ± 0.03^{h}

*** Means of three determinations ± SD, values within the same column and row followed by the same letter are not significantly different ($P \leq 0.05$).**
**** T_1 = Pasteurization at ~ 65ºC/20 min.** **** T_2 = 0.05% potassium sorbate + 0.05% potassium metabisulphite.**
**** T_3 = Pasteurization at ~ 65ºC/20 min + 0.05% potassium sorbate + 0.05% potassium metabisulphite.**

The total soluble solids of papaya juice samples during storage:

The total soluble solids (TSS) as an indicator for the sugar content is an important factor in the production of fruit juice. In this respect, the TSS (as °Brix) values of control and treated papaya juice samples during cold storage (at ~ 4ºC) for six months are presented in Table (2). From which, it could be seen that the storage intervals had a significant effect on the TSS values for all juice samples. While in most juice samples, the preservation treatments did not affect the TSS values significantly. The data indicated a gradual increase in TSS values during storage for all juice samples. This increase could be due to hydrolysis of polysaccharides and solubilization of pulp constituents during storage. For example, the TSS values of 100% papaya juice were significantly increased from 15 °Brix at zero time and reached 16.1, 15.9 and 15.8 °Brix for T_1 (pasteurization at ~ 65ºC/20 min), T_2 (0.05% potassium sorbate + 0.05% potassium metabisulphite) and T_3 (pasteurization at ~ 65ºC/20 min + 0.05% potassium sorbate + 0.05% potassium metabisulphite), respectively at the end of the storage period. The highest increase percent was observed in T_1 (7.33%) followed by T_2 (6.0%), while T_3 recorded the lowest increase percent (5.33%). This could be due to the combined action of the thermal treatment and chemical preservatives. The TSS values for the rest of the juice samples (75% papaya + 25% orange, 75% papaya + 25% strawberry, 75% papaya + 25% mango and 75% papaya + 25% guava) presented in Table (2) followed the similar pattern as 100% papaya juice samples.

Similar observations were found by Ayub *et al.* (2010) for strawberry juice; Khan *et al.* (2012) for mango-sea buckthorn blended juice; Singh *et al.* (2014) for aonla-mango blended beverages; Rohila *et al.* (2017) for bael-guava nectar and crush; Yadav *et al.* (2017) for guava pulp and Zakaria *et al.* (2017) for black mulberry pulpy juice.

Table 2. Total soluble solids (as °Brix)* of papaya juice samples during cold storage (at ~ 4ºC).

Treatments**	Storage intervals (month)						
	Zero time	1st	2nd	3rd	4th	5th	6th
	100% Papaya juice						
T_0 (Control)	15 ± 0.2^{g}	-	-	-	-	-	-
T_1	15 ± 0.2^{g}	15.1 ± 0.2^{fg}	15.3 ± 0.2^{efg}	15.5 ± 0.2^{cde}	15.7 ± 0.2^{bcd}	16.1 ± 0.2^{a}	16.1 ± 0.2^{a}
T_2	15 ± 0.2^{g}	15.1 ± 0.2^{fg}	15.4 ± 0.2^{def}	15.4 ± 0.2^{def}	15.5 ± 0.2^{cde}	15.6 ± 0.2^{bcde}	15.9 ± 0.2^{ab}
T_3	15 ± 0.2^{g}	15.1 ± 0.2^{fg}	15.3 ± 0.2^{efg}	15.3 ± 0.2^{efg}	15.5 ± 0.2^{cde}	15.5 ± 0.2^{cde}	15.8 ± 0.2^{abc}
	75% Papaya juice + 25% Orange juice						
T_0 (Control)	15 ± 0.2^{g}	-	-	-	-	-	-
T_1	15 ± 0.2^{g}	15.1 ± 0.2^{fg}	15.2 ± 0.2^{efg}	15.4 ± 0.2^{cdef}	15.5 ± 0.2^{bcde}	15.7 ± 0.2^{abc}	16.0 ± 0.2^{a}
T_2	15 ± 0.2^{g}	15 ± 0.2^{g}	15.1 ± 0.2^{fg}	15.4 ± 0.2^{cdef}	15.5 ± 0.2^{bcde}	15.6 ± 0.2^{bcd}	15.8 ± 0.2^{ab}
T_3	15 ± 0.2^{g}	15 ± 0.2^{g}	15.1 ± 0.2^{fg}	15.3 ± 0.2^{defg}	15.3 ± 0.2^{defg}	15.5 ± 0.2^{bcde}	15.5 ± 0.2^{bcde}
	75% Papaya juice + 25% Strawberry juice						
T_0 (Control)	15 ± 0.2^{e}	-	-	-	-	-	-
T_1	15 ± 0.2^{e}	15.1 ± 0.1^{de}	15.2 ± 0.2^{cde}	15.4 ± 0.2^{abcd}	15.5 ± 0.2^{abc}	15.5 ± 0.2^{abc}	15.7 ± 0.2^{a}
T_2	15 ± 0.2^{e}	15 ± 0.1^{e}	15.1 ± 0.2^{de}	15.4 ± 0.2^{abcd}	15.5 ± 0.2^{abc}	15.6 ± 0.2^{ab}	15.6 ± 0.2^{ab}
T_3	15 ± 0.2^{e}	15 ± 0.1^{e}	15.1 ± 0.2^{de}	15.2 ± 0.2^{cde}	15.3 ± 0.2^{bcde}	15.3 ± 0.2^{bcde}	15.5 ± 0.2^{abc}
	75% Papaya juice + 25% Mango juice						
T_0 (Control)	15 ± 0.2^{e}	-	-	-	-	-	-
T_1	15 ± 0.2^{e}	15.1 ± 0.2^{e}	15.3 ± 0.2^{cde}	15.5 ± 0.2^{bcd}	15.7 ± 0.2^{b}	16.1 ± 0.2^{a}	16.3 ± 0.2^{a}
T_2	15 ± 0.2^{e}	15.1 ± 0.2^{e}	15.3 ± 0.2^{cde}	15.4 ± 0.2^{cde}	15.5 ± 0.2^{bcd}	15.6 ± 0.2^{bc}	15.8 ± 0.2^{b}
T_3	15 ± 0.2^{e}	15.1 ± 0.2^{e}	15.2 ± 0.2^{de}	15.3 ± 0.2^{cde}	15.3 ± 0.2^{cde}	15.5 ± 0.2^{bcd}	15.5 ± 0.2^{bcd}
	75% Papaya juice + 25% Guava juice						
T_0 (Control)	15 ± 0.2^{g}	-	-	-	-	-	-
T_1	15 ± 0.2^{g}	15.1 ± 0.2^{g}	15.3 ± 0.2^{efg}	15.6 ± 0.2^{cde}	15.8 ± 0.2^{bcd}	16.1 ± 0.2^{ab}	16.2 ± 0.2^{a}
T_2	15 ± 0.2^{g}	15.1 ± 0.2^{g}	15.3 ± 0.2^{efg}	15.4 ± 0.2^{efg}	15.7 ± 0.2^{cd}	15.9 ± 0.2^{abc}	15.9 ± 0.2^{abc}
T_3	$15 \pm 0.2g$	15.1 ± 0.2^{g}	15.2 ± 0.2^{fg}	15.3 ± 0.2^{efg}	15.5 ± 0.2^{def}	15.5 ± 0.2^{def}	15.6 ± 0.2^{cde}

*** Means of three determinations ± SD, values within the same column and row followed by the same letter are not significantly different ($P \leq 0.05$).**
**** T_1 = Pasteurization at ~ 65ºC/20 min.** **** T_2 = 0.05% potassium sorbate + 0.05% potassium metabisulphite.**
**** T_3 = Pasteurization at ~ 65ºC/20 min + 0.05% potassium sorbate + 0.05% potassium metabisulphite.**

The pH and titratable acidity values of papaya juice samples during storage:

The pH value has a great importance for maintaining the quality and shelf stability of juices, as it affects their flavor and manufacturing requirements. The pH and titratable acidity values of papaya juice samples during cold storage (at ~ 4ºC) for six months are shown in Tables (3 and 4). The results showed that the pH values were significantly decreased during storage for all juice samples. The pH values of 100% papaya juice were significantly decreased from 4.71, 4.72 and 4.73 at zero time and reached 3.61, 3.96 and 4.30 for T_1 (pasteurization at ~ 65ºC/20 min), T_2 (0.05% potassium sorbate + 0.05% potassium metabisulphite) and T_3 (pasteurization at ~ 65ºC/20 min + 0.05% potassium sorbate + 0.05% potassium metabisulphite), respectively at the end of the storage period. The highest decrease percent was observed in T_1 (23.35%) followed by T_2 (16.10%), while T_3 recorded the lowest decrease percent (9.09%). This could be due to the combined action of the thermal treatment and chemical preservatives. The pH values for the rest of the juice samples presented in Table (3) followed the similar pattern as 100% papaya juice samples. Similar results are reported by Hussain *et al.* (2008) for apricot and apple juices; Mehmood *et al.* (2008) for apple juice and Zakaria *et al.* (2017) for black mulberry pulpy juice.

The results presented in Table (4) showed that the storage intervals had a significant effect on the titratable acidity (as % citric acid) values for all juice samples. While in most samples, the preservation treatments did not affect the titratable acidity significantly. Papaya juice samples differed in titratable acidity values according to the mixed fruits. The values ranged from 0.19% (for 100% papaya juice) to 0.24% (for 75% papaya + 25% strawberry juice) at zero time of storage. These values were significantly increased during storage for all juice samples. This increment in acidity coud be due to the formation of acids by sugars, breakdown of polysaccharides and oxidation of reducing sugars, pectin hydrolysis or degradation of ascorbic acid. Similar results are reported by Baghaei *et al*. (2008) for orange-cantaloupe seed beverage; Hussain *et al*. (2008) for apricot and apple juices; Mehmood *et al*. (2008) for apple juice; Ayub *et al*. (2010) for strawberry juice; Bal *et al*. (2014) for guava nectar; Yadav *et al*. (2017) for guava pulp and Zakaria *et al*. (2017) for black mulberry pulpy juice.

Table 3. The pH values* of papaya juice samples during cold storage (at ~ 4ºC).

Treatments**	Storage intervals (month)						
	Zero time	1st	2nd	3rd	4th	5th	6th
	100% Papaya juice						
T_0 (Control)	4.71 ± 0.02^{ab}	-	-	-	-	-	-
T_1	4.71 ± 0.02^{ab}	4.64 ± 0.02^{d}	4.50 ± 0.02^{g}	4.42 ± 0.02^{h}	4.14 ± 0.02^{l}	3.90 ± 0.02^{n}	3.61 ± 0.02^{o}
T_2	4.72 ± 0.02^{a}	4.67 ± 0.02^{c}	4.60 ± 0.02^{e}	4.54 ± 0.02^{f}	4.37 ± 0.01^{i}	4.18 ± 0.02^{k}	3.96 ± 0.02^{m}
T_3	4.73 ± 0.02^{a}	4.70 ± 0.02^{abc}	4.68 ± 0.03^{bc}	4.62 ± 0.02^{de}	4.50 ± 0.03^{g}	4.40 ± 0.02^{h}	4.30 ± 0.02^{g}
	75% Papaya juice + 25% Orange juice						
T_0 (Control)	4.48 ± 0.03^{b}	-	-	-	-	-	-
T_1	4.53 ± 0.02^{a}	4.43 ± 0.02^{cd}	4.31 ± 0.02^{fg}	4.23 ± 0.02^{h}	4.05 ± 0.02^{j}	3.47 ± 0.02^{n}	3.64 ± 0.02^{m}
T_2	4.49 ± 0.02^{b}	4.41 ± 0.02^{d}	4.35 ± 0.02^{e}	4.29 ± 0.02^{g}	4.11 ± 0.02^{i}	3.91 ± 0.02^{k}	3.75 ± 0.02^{l}
T_3	4.50 ± 0.03^{ab}	4.50 ± 0.03^{ab}	4.45 ± 0.03^{c}	4.40 ± 0.03^{d}	4.30 ± 0.03^{g}	4.10 ± 0.03^{i}	3.90 ± 0.03^{k}
	75% Papaya juice + 25% Strawberry juice						
T_0 (Control)	4.40 ± 0.03^{b}	-	-	-	-	-	-
T_1	4.43 ± 0.02^{a}	4.39 ± 0.02^{bc}	4.30 ± 0.02^{e}	4.21 ± 0.02^{g}	3.95 ± 0.02^{j}	3.42 ± 0.02^{o}	3.56 ± 0.02^{n}
T_2	4.39 ± 0.02^{bc}	4.36 ± 0.02^{cd}	4.25 ± 0.02^{f}	4.19 ± 0.02^{g}	3.98 ± 0.02^{i}	3.79 ± 0.02^{l}	3.67 ± 0.02^{m}
T_3	4.39 ± 0.03^{bc}	4.34 ± 0.03^{d}	4.27 ± 0.03^{f}	4.20 ± 0.03^{g}	4.12 ± 0.03^{h}	4.02 ± 0.03^{i}	3.83 ± 0.03^{k}
	75% Papaya juice + 25% Mango juice						
T_0 (Control)	4.58 ± 0.01^{a}	-	-	-	-	-	-
T_1	4.56 ± 0.02^{ab}	4.50 ± 0.02^{e}	4.43 ± 0.02^{f}	4.30 ± 0.02^{i}	4.01 ± 0.02^{k}	3.45 ± 0.02^{o}	3.66 ± 0.02^{n}
T_2	4.55 ± 0.02^{abc}	4.51 ± 0.01^{de}	4.42 ± 0.02^{f}	4.36 ± 0.02^{g}	4.15 ± 0.02^{j}	3.93 ± 0.02^{l}	3.82 ± 0.02^{m}
T_3	4.56 ± 0.03^{ab}	4.54 ± 0.02^{bcd}	4.50 ± 0.03^{e}	4.42 ± 0.03^{f}	4.33 ± 0.03^{h}	4.13 ± 0.01^{j}	3.94 ± 0.03^{l}
	75% Papaya juice + 25% Guava juice						
T_0 (Control)	4.65 ± 0.01^{a}	-	-	-	-	-	-
T_1	4.64 ± 0.01^{ab}	4.60 ± 0.02^{cd}	4.52 ± 0.02^{fg}	4.44 ± 0.02^{i}	4.10 ± 0.02^{m}	3.89 ± 0.02^{n}	3.52 ± 0.02^{o}
T_2	4.63 ± 0.01^{abc}	4.57 ± 0.02^{de}	4.53 ± 0.02^{fg}	4.47 ± 0.02^{h}	4.23 ± 0.01^{l}	4.11 ± 0.02^{m}	3.88 ± 0.02^{n}
T_3	4.61 ± 0.01^{bc}	4.60 ± 0.02^{cd}	4.55 ± 0.03^{ef}	4.51 ± 0.02^{g}	4.40 ± 0.03^{j}	4.34 ± 0.02^{k}	4.21 ± 0.02^{l}

*** Means of three determinations ± SD, values within the same column and row followed by the same letter are not significantly different ($P \leq 0.05$).**
**** T_1 = Pasteurization at ~ 65ºC/20 min. ** T_2 = 0.05% potassium sorbate + 0.05% potassium metabisulphite.**
**** T_3 = Pasteurization at ~ 65ºC/20 min + 0.05% potassium sorbate + 0.05% potassium metabisulphite.**

Table 4. Titratable acidity (as % citric acid)* of papaya juice samples during cold storage (at ~ 4ºC).

Treatments**	Storage intervals (month)						
	Zero time	1st	2nd	3rd	4th	5th	6th
	100% Papaya juice						
T_0 (Control)	0.19 ± 0.02^{f}	-	-	-	-	-	-
T_1	0.19 ± 0.02^{f}	0.20 ± 0.01^{ef}	0.22 ± 0.02^{cdef}	0.23 ± 0.02^{bcde}	0.24 ± 0.02^{abcd}	0.26 ± 0.02^{ab}	0.27 ± 0.02^{a}
T_2	0.19 ± 0.02^{f}	0.19 ± 0.01^{f}	0.20 ± 0.02^{ef}	0.22 ± 0.02^{cdef}	0.23 ± 0.02^{bcde}	0.24 ± 0.02^{abcd}	0.25 ± 0.02^{abc}
T_3	0.19 ± 0.02^{f}	0.19 ± 0.01^{f}	0.20 ± 0.02^{ef}	0.21 ± 0.02^{def}	0.23 ± 0.02^{bcde}	0.24 ± 0.02^{abcd}	0.25 ± 0.02^{abc}
	75% Papaya juice + 25% Orange juice						
T_0 (Control)	0.23 ± 0.02^{c}	-	-	-	-	-	-
T_1	0.23 ± 0.02^{c}	0.24 ± 0.01^{bc}	0.25 ± 0.02^{abc}	0.25 ± 0.02^{abc}	0.27 ± 0.02^{ab}	0.28 ± 0.02^{a}	0.28 ± 0.03^{a}
T_2	0.23 ± 0.02^{c}	0.23 ± 0.02^{c}	0.24 ± 0.02^{bc}	0.25 ± 0.02^{abc}	0.25 ± 0.02^{abc}	0.27 ± 0.02^{ab}	0.27 ± 0.02^{ab}
T_3	0.23 ± 0.02^{c}	0.23 ± 0.01^{c}	0.23 ± 0.02^{c}	0.24 ± 0.02^{bc}	0.24 ± 0.02^{bc}	0.25 ± 0.02^{abc}	0.26 ± 0.02^{abc}
	75% Papaya juice + 25% Strawberry juice						
T_0 (Control)	0.24 ± 0.02^{c}	-	-	-	-	-	-
T_1	0.24 ± 0.02^{c}	0.24 ± 0.02^{c}	0.25 ± 0.02^{bc}	0.26 ± 0.02^{abc}	0.26 ± 0.02^{abc}	0.27 ± 0.02^{abc}	0.29 ± 0.02^{a}
T_2	0.24 ± 0.02^{c}	0.24 ± 0.01^{c}	0.25 ± 0.02^{bc}	0.26 ± 0.02^{abc}	0.27 ± 0.02^{abc}	0.27 ± 0.02^{abc}	0.28 ± 0.02^{ab}
T_3	0.24 ± 0.02^{c}	0.24 ± 0.01^{c}	0.24 ± 0.02^{c}	0.25 ± 0.02^{bc}	0.26 ± 0.02^{abc}	0.27 ± 0.02^{abc}	0.27 ± 0.02^{abc}
	75% Papaya juice + 25% Mango juice						
T_0 (Control)	0.22 ± 0.01^{e}	-	-	-	-	-	-
T_1	0.22 ± 0.01^{e}	0.22 ± 0.01^{e}	0.23 ± 0.01^{de}	0.24 ± 0.01^{cd}	0.24 ± 0.01^{cd}	0.25 ± 0.01^{bc}	0.27 ± 0.01^{a}
T_2	0.22 ± 0.01^{e}	0.22 ± 0.01^{e}	0.23 ± 0.01^{de}	0.23 ± 0.01^{de}	0.24 ± 0.01^{cd}	0.25 ± 0.01^{bc}	0.26 ± 0.01^{ab}
T_3	0.22 ± 0.01^{e}	0.22 ± 0.01^{e}	0.22 ± 0.01^{e}	0.23 ± 0.01^{de}	0.23 ± 0.01^{cd}	0.24 ± 0.01^{cd}	0.25 ± 0.01^{bc}
	75% Papaya juice + 25% Guava juice						
T_0 (Control)	0.21 ± 0.01^{e}	-	-	-	-	-	-
T_1	0.21 ± 0.01^{e}	0.21 ± 0.01^{e}	0.22 ± 0.01^{de}	0.23 ± 0.01^{cd}	0.24 ± 0.0^{bc}	0.24 ± 0.01^{bc}	0.25 ± 0.01^{a}
T_2	0.21 ± 0.01^{e}	0.21 ± 0.01^{e}	0.22 ± 0.01^{de}	0.22 ± 0.01^{de}	0.23 ± 0.01^{cd}	0.24 ± 0.01^{bc}	0.25 ± 0.02^{a}
T_3	0.21 ± 0.01^{e}	0.21 ± 0.01^{e}	0.21 ± 0.01^{e}	0.22 ± 0.01^{de}	0.23 ± 0.01^{cd}	0.24 ± 0.01^{bc}	0.24 ± 0.01^{bc}

*** Means of three determinations ± SD, values within the same column and row followed by the same letter are not significantly different ($P \leq 0.05$).**
**** T_1 = Pasteurization at ~ 65ºC/20 min. ** T_2 = 0.05% potassium sorbate + 0.05% potassium metabisulphite.**
**** T_3 = Pasteurization at ~ 65ºC/20 min + 0.05% potassium sorbate + 0.05% potassium metabisulphite.**

Ascorbic acid content of papaya juice samples during storage:

Ascorbic acid is an important nutrient in fresh fruits and vegetables. It is water-soluble vitamin and more sensitive to heat, oxygen, light and considered to be highly subjected to losses during processing and storage. Consequently, the retention of ascorbic acid is used as an indicator of the potential preservation of all other nutrients. In this respect, ascorbic acid contents of control and treated papaya juice samples during cold storage (at ~ 4ºC) for six months are presented in Table (5). From which, it could be seen that the control papaya juice samples (T_0 without any treatments) differed in ascorbic acid content according to the mixed fruits (orange, strawberry, mango and guava). The values ranged from 27.66 mg/100g (for 75% papaya + 25% mango juice) to 34.47 mg/100g (for 100% papaya juice) at zero time of storage. This could be due to the high content of ascorbic acid in papaya fruits compared to the other mixed fruits. The results also showed that all preservation treatments and storage intervals both had a significant effect on ascorbic acid values for all juice samples ($LSD_{0.05}$ = 0.10 – 0.37). The data indicated a gradual decrease in ascorbic acid values during storage for all juice samples. This decrease could be due to the oxidation of ascorbic acid into dehydro-ascorbic acid depending on the applied preservation treatments and storage conditions. Despite this decrease, all juice samples remained satisfactory sources of ascorbic acid over the storage period of six months. For example, the ascorbic acid values of 100% papaya juice samples were significantly decreased ($LSD_{0.05}$ = 0.37) from 30.05, 34.33 and 31.42 mg/100g (as such basis) at zero time and reached 20.90, 29.07 and 26.94 mg/100g for T_1 (pasteurization at ~ 65ºC/20 min), T_2 (0.05% potassium sorbate + 0.05% potassium metabisulphite) and T_3 (pasteurization at ~ 65ºC/20 min + 0.05% potassium sorbate + 0.05% potassium metabisulphite), respectively at the end of the storage period. The highest decrease percent was observed in T_1 (30.45%) followed by T_2 (15.32%), while T_3 recorded the lowest decrease percent (15.21%). This could be due to the combined action of the thermal treatment and chemical preservatives that have protected the vitamin from loss during storage. As shown in the same Table (5), the ascorbic acid values for the rest of the juice samples (75% papaya + 25% orange, 75% papaya + 25% strawberry, 75% papaya + 25% mango and 75% papaya + 25% guava) followed the similar pattern as 100% papaya juice samples. These results are in a good agreement with those reported by Hussain *et al.* (2008) for apricot and apple juices; Mehmood *et al.* (2008) for apple juice; Ayub *et al.* (2010) for strawberry juice; Khan *et al.* (2012) for mango-sea buckthorn blended juice; Mandal and Nath (2013) for aonla squash; Singh *et al.* (2014) for aonla-mango blended beverages; Muzaffar *et al.* (2017) for pomegranate juice; Rohila *et al.* (2017) for bael-guava nectar and crush and Yadav *et al.* (2017) for guava pulp.

Table 5. Ascorbic acid (mg/100g)* of papaya juice samples during cold storage (at ~ 4ºC).

Treatments**	Storage intervals (month)						
	Zero time	1st	2nd	3rd	4th	5th	6th
	100% Papaya juice						
T_0 (Control)	34.47 ± 0.11^{a}	-	-	-	-	-	-
T_1	30.05 ± 0.08^{g}	28.17 ± 0.04^{l}	27.29 ± 0.10^{m}	25.21 ± 0.10^{o}	23.70 ± 0.10^{p}	22.82 ± 0.10^{q}	20.90 ± 0.12^{r}
T_2	34.33 ± 0.09^{a}	33.57 ± 0.06^{b}	32.22 ± 0.08^{c}	31.43 ± 0.14^{d}	30.01 ± 0.07^{g}	29.52 ± 0.08^{i}	29.07 ± 0.08^{j}
T_3	31.42 ± 0.07^{d}	31.16 ± 0.08^{e}	30.82 ± 0.11^{f}	29.67 ± 0.10^{h}	28.56 ± 0.10^{k}	27.07 ± 0.12^{n}	26.94 ± 0.13^{n}
	75% Papaya juice + 25% Orange juice						
T_0 (Control)	28.24 ± 0.16^{a}	-	-	-	-	-	-
T_1	25.16 ± 0.12^{i}	24.86 ± 0.07^{j}	23.77 ± 0.06^{n}	22.97 ± 0.06^{p}	21.14 ± 0.06^{q}	20.93 ± 0.04^{r}	18.30 ± 0.05^{s}
T_2	28.11 ± 0.09^{b}	27.87 ± 0.05^{c}	27.02 ± 0.10^{d}	26.22 ± 0.10^{g}	25.17 ± 0.10^{i}	24.53 ± 0.10^{k}	24.12 ± 0.10^{l}
T_3	26.63 ± 0.10^{e}	26.45 ± 0.07^{f}	25.79 ± 0.07^{h}	25.26 ± 0.08^{i}	24.04 ± 0.05^{lm}	23.91 ± 0.07^{m}	23.37 ± 0.09^{o}
	75% Papaya juice + 25% Strawberry juice						
T_0 (Control)	31.72 ± 0.15^{a}	-	-	-	-	-	-
T_1	28.37 ± 0.07^{g}	26.43 ± 0.05^{k}	25.53 ± 0.04^{m}	23.41 ± 0.06^{n}	21.90 ± 0.05^{o}	21.10 ± 0.08^{p}	20.16 ± 0.05^{q}
T_2	31.70 ± 0.11^{a}	31.34 ± 0.07^{b}	30.51 ± 0.05^{c}	29.65 ± 0.05^{e}	28.36 ± 0.04^{g}	27.35 ± 0.06^{i}	26.88 ± 0.07^{j}
T_3	29.81 ± 0.12^{d}	29.68 ± 0.05^{e}	29.27 ± 0.06^{f}	28.20 ± 0.04^{h}	27.32 ± 0.04^{i}	26.92 ± 0.04^{j}	26.12 ± 0.03^{l}
	75% Papaya juice + 25% Mango juice						
T_0 (Control)	27.66 ± 0.17^{a}	-	-	-	-	-	-
T_1	25.35 ± 0.10^{h}	24.79 ± 0.05^{j}	23.65 ± 0.04^{n}	22.88 ± 0.05^{p}	21.18 ± 0.07^{q}	20.90 ± 0.05^{r}	18.10 ± 0.05^{s}
T_2	27.54 ± 0.12^{b}	27.08 ± 0.03^{c}	26.33 ± 0.09^{e}	26.00 ± 0.04^{f}	25.10 ± 0.05^{i}	24.03 ± 0.10^{l}	23.82 ± 0.10^{m}
T_3	26.51 ± 0.10^{d}	26.33 ± 0.04^{e}	25.70 ± 0.05^{g}	25.12 ± 0.08^{i}	24.10 ± 0.05^{k}	23.83 ± 0.06^{m}	23.19 ± 0.07^{o}
	75% Papaya juice + 25% Guava juice						
T_0 (Control)	31.08 ± 0.13^{a}	-	-	-	-	-	-
T_1	28.71 ± 0.09^{h}	26.80 ± 0.04^{k}	25.94 ± 0.05^{o}	23.82 ± 0.07^{q}	22.30 ± 0.05^{r}	21.52 ± 0.04^{s}	20.64 ± 0.05^{t}
T_2	30.89 ± 0.11^{b}	30.43 ± 0.05^{c}	29.57 ± 0.06^{d}	28.74 ± 0.04^{gh}	27.16 ± 0.04^{j}	26.67 ± 0.05^{l}	26.29 ± 0.06^{n}
T_3	29.31 ± 0.04^{e}	29.12 ± 0.04^{f}	28.82 ± 0.04^{g}	27.70 ± 0.03^{i}	26.60 ± 0.06^{m}	26.27 ± 0.05^{n}	25.83 ± 0.03^{p}

*** Means of three determinations ± SD (as such basis), values within the same column and row followed by the same letter are not significantly different ($P \leq 0.05$).**

**** T_1 = Pasteurization at ~ 65ºC/20 min.** **** T_2 = 0.05% potassium sorbate + 0.05% potassium metabisulphite.**

**** T_3 = Pasteurization at ~ 65ºC/20 min + 0.05% potassium sorbate + 0.05% potassium metabisulphite.**

Total phenols content of papaya juice samples during storage:

Phenolic compounds provide antioxidant potential and health-promoting properties and contribute to the flavor and color attributes of fruits and vegetables. In this respect, the total phenols values of control and treated papaya juice samples during cold storage (at ~ 4ºC) for six months are presented in Table (6). From which, it could be seen that the control papaya juice samples (T_0 without any treatments) differed in total phenols content according to the type of mixed fruits (orange, strawberry, mango and guava). The values ranged from 25.61 mg/100g (for 75% papaya + 25% strawberry juice) to 31.75 mg/100g (for 100% papaya juice) at zero time of storage. This could be due to the high content of total phenols in papaya fruits compared to the other mixed fruits. The results also showed that all preservation treatments and storage intervals both had a significant effect on the total phenols values for all juice samples ($LSD_{0.05}$ = 0.09 – 0.24). The data indicated a gradual decrease in total phenols values during storage for all juice samples. This decrease could be due to the nature of phenolic compounds as they are highly volatile and easily oxidized. Despite this decrease, all juice samples remained satisfactory sources of phenolic compounds over the storage period of six months. For example, the total phenols values of 100% papaya juice samples were significantly decreased ($LSD_{0.05}$ = 0.09) from 31.27, 31.32 and 31.56 mg/100g (as such basis) at zero time and reached 26.82, 27.85 and 28.47 mg/100g for T_1 (pasteurization at ~ 65ºC/20 min), T_2 (0.05% potassium sorbate + 0.05% potassium metabisulphite) and T_3 (pasteurization at ~ 65ºC/20 min + 0.05% potassium sorbate + 0.05% potassium metabisulphite), respectively at the end of the storage period. The highest decrease percent was observed in T_1 (14.23%) followed by T_2 (11.08%), while T_3 recorded the lowest decrease percent (9.79%). This could be due to the combined action of the thermal treatment and chemical preservatives that have protected the phenolic compounds from degredation during storage. As shown in the same Table (6), the total phenols values for the rest of the juice samples (75% papaya + 25% orange, 75% papaya + 25% strawberry, 75% papaya + 25% mango and 75% papaya + 25% guava) followed the similar pattern as 100% papaya juice samples. These results are in a good agreement with those reported by Sharma *et al.* (2012) for guava-jamun ready-to-serve drink and squash; Karpagavalli and Amutha (2015) for pomegranate squash; Muzaffar *et al.* (2017) for pomegranate juice and Rohila *et al.* (2017) for bael-guava nectar and crush.

Table 6. Total phenols (mg GAE/100g)* of papaya juice samples during cold storage (at ~ 4ºC).

Treatments**	Storage intervals (month)						
	Zero time	1st	2nd	3rd	4th	5th	6th
				100% Papaya juice			
T_0 (Control)	31.75 ± 0.08a	-	-	-	-	-	-
T_1	31.27 ± 0.06cd	31.16 ± 0.05e	30.62 ± 0.04g	29.28 ± 0.05i	28.17 ± 0.05n	27.94 ± 0.05o	26.82 ± 0.06q
T_2	31.32 ± 0.08c	31.20 ± 0.06de	30.60 ± 0.05g	29.37 ± 0.04i	28.80 ± 0.05k	28.37 ± 0.04m	27.85 ± 0.08p
T_3	31.56 ± 0.07b	31.36 ± 0.07c	30.76 ± 0.06f	29.81 ± 0.05h	29.32 ± 0.06i	28.93 ± 0.06j	28.47 ± 0.07l
				75% Papaya juice + 25% Orange juice			
T_0 (Control)	28.08 ± 0.06a	-	-	-	-	-	-
T_1	27.84 ± 0.09c	27.55 ± 0.06e	27.07 ± 0.05g	26.30 ± 0.05j	25.13 ± 0.07n	24.15 ± 0.07q	23.78 ± 0.08r
T_2	27.93 ± 0.06bc	27.68 ± 0.05d	27.15 ± 0.06g	26.43 ± 0.04i	25.58 ± 0.05l	24.91 ± 0.05o	24.65 ± 0.04p
T_3	27.95 ± 0.07b	27.74 ± 0.04d	27.29 ± 0.04f	26.87 ± 0.05h	26.02 ± 0.06k	25.95 ± 0.06k	25.31 ± 0.05m
				75% Papaya juice + 25% Strawberry juice			
T_0 (Control)	25.61 ± 0.08a	-	-	-	-	-	-
T_1	25.11 ± 0.08cd	24.92 ± 0.06de	24.30 ± 0.05g	23.57 ± 0.06hi	22.60 ± 0.05k	22.06 ± 0.06l	21.48 ± 0.07m
T_2	25.26 ± 0.05bc	25.03 ± 0.04de	24.48 ± 0.06fg	23.76 ± 0.04h	23.09 ± 0.04j	22.96 ± 0.06j	22.39 ± 0.05k
T_3	25.47 ± 0.04b	25.21 ± 0.05c	24.72 ± 0.04ef	24.23 ± 0.05g	23.58 ± 0.05hi	23.37 ± 0.05i	23.08 ± 0.06j
				75% Papaya juice + 25% Mango juice			
T_0 (Control)	31.05 ± 0.07a	-	-	-	-	-	-
T_1	30.67 ± 0.06cd	30.41 ± 0.04e	29.87 ± 0.06g	29.03 ± 0.04i	27.82 ± 0.05l	26.73 ± 0.04n	26.17 ± 0.07o
T_2	30.85 ± 0.05bc	30.64 ± 0.06d	30.21 ± 0.04f	29.46 ± 0.06h	28.61 ± 0.04j	27.89 ± 0.06l	27.31 ± 0.04m
T_3	30.91 ± 0.07ab	30.76 ± 0.05bcd	30.57 ± 0.05de	29.71 ± 0.05g	28.84 ± 0.04i	28.26 ± 0.05k	27.96 ± 0.05l
				75% Papaya juice + 25% Guava juice			
T_0 (Control)	31.17 ± 0.07a	-	-	-	-	-	-
T_1	30.78 ± 0.06d	30.52 ± 0.04f	29.87 ± 0.05j	29.22 ± 0.05l	28.14 ± 0.06o	27.23 ± 0.05p	26.19 ± 0.06q
T_2	30.90 ± 0.04bc	30.69 ± 0.05e	30.12 ± 0.06h	29.88 ± 0.06ij	29.64 ± 0.04k	28.36 ± 0.05n	27.22 ± 0.04p
T_3	30.97 ± 0.05b	30.83 ± 0.04cd	30.34 ± 0.04g	30.06 ± 0.04h	29.95 ± 0.04i	28.82 ± 0.06m	28.09 ± 0.04o

*** Means of three determinations ± SD (as such basis), values within the same column and row followed by the same letter are not significantly different (P ≤ 0.05).**

**** T_1 = Pasteurization at ~ 65ºC/20 min.** **** T_2 = 0.05% potassium sorbate + 0.05% potassium metabisulphite.**

**** T_3 = Pasteurization at ~ 65ºC/20 min + 0.05% potassium sorbate + 0.05% potassium metabisulphite.**

Microbiological analysis of papaya juice samples during storage:

Fruit juices contain a microbial load representative of the organisms normally found on fruits during harvest plus contaminants added post-harvest (during transport, storage and processing). Many microorganisms can use the fruit juices as substrate and cause spoilage, producing off flavors and discoloration. If the contaminating microorganisms are pathogens, they can also cause human diseases. Under favorable conditions, the toxigenic fungi can produce mycotoxin in fruit juice. Using thermal treatments and chemical preservatives will rid juices from pathogens and other heat-sensitive microbes. Therefore, they will substantially reduce the microbial load and extend the shelf-life (Tournas *et al.*, 2006; Amirpour *et al.*, 2016 and Almeida *et al.*, 2018).

The microbiological analysis (total bacterial, yeast and mould counts) of papaya juice samples during cold storage (at ~ 4ºC) for six months are shown in Tables (7 and 8). The results showed that the total bacterial counts slowly increased throughout the storage period, but still lower than the critical microbial limit for fruit juices. The total bacterial count was less than 10^2 cfu/g for all preserved juice samples. This indicated that the applied preservation treatments and storage conditions were efficient and post contamination did not occurred. The preserved papaya juice samples achieved a shelf life up to 6 months below the microbial load limit (10^6 cfu/ml).

Table 7. Total bacterial count (CFU/g)* of papaya juice samples during cold storage (at ~ 4ºC).

Treatments**	Storage intervals (month)						
	Zero time	1st	2nd	3rd	4th	5th	6th
				100% Papaya juice			

T_0 (Control)	130 ± 8	-	-	-	-	-	-
T_1	< 100	< 100	< 100	< 100	< 100	< 100	< 100
T_2	< 100	< 100	< 100	< 100	< 100	< 100	< 100
T_3	< 100	< 100	< 100	< 100	< 100	< 100	< 100
	75% Papaya juice + 25% Orange juice						
T_0 (Control)	110 ± 7	-	-	-	-	-	-
T_1	< 100	< 100	< 100	< 100	< 100	< 100	< 100
T_2	< 100	< 100	< 100	< 100	< 100	< 100	< 100
T_3	< 100	< 100	< 100	< 100	< 100	< 100	< 100
	75% Papaya juice + 25% Strawberry juice						
T_0 (Control)	145 ± 6	-	-	-	-	-	-
T_1	< 100	< 100	< 100	< 100	< 100	< 100	< 100
T_2	< 100	< 100	< 100	< 100	< 100	< 100	< 100
T_3	< 100	< 100	< 100	< 100	< 100	< 100	< 100
	75% Papaya juice + 25% Mango juice						
T_0 (Control)	130 ± 5	-	-	-	-	-	-
T_1	< 100	< 100	< 100	< 100	< 100	< 100	< 100
T_2	< 100	< 100	< 100	< 100	< 100	< 100	< 100
T_3	< 100	< 100	< 100	< 100	< 100	< 100	< 100
	75% Papaya juice + 25% Guava juice						
T_0 (Control)	140 ± 3	-	-	-	-	-	-
T_1	< 100	< 100	< 100	< 100	< 100	< 100	< 100
T_2	< 100	< 100	< 100	< 100	< 100	< 100	< 100
T_3	< 100	< 100	< 100	< 100	< 100	< 100	< 100

*** Means of three determinations ± SD.**
**** T_1 = Pasteurization at ~ 65ºC/20 min.**
**** T_2 = 0.05% potassium sorbate + 0.05% potassium metabisulphite.**
**** T_3 = Pasteurization at ~ 65ºC/20 min + 0.05% potassium sorbate + 0.05% potassium metabisulphite.**

Table 8. Yeast and mould counts (CFU/g)* of papaya juice samples during cold storage (at ~ 4ºC).

Treatments**	Storage intervals (month)						
	Zero time	1st	2nd	3rd	4th	5th	6th
	100% Papaya juice						
T_0 (Control)	20 ± 3	-	-	-	-	-	-
T_1	Nil	Nil	Nil	Nil	Nil	Nil	Nil
T_2	Nil	Nil	Nil	Nil	Nil	Nil	Nil
T_3	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	75% Papaya juice + 25% Orange juice						
T_0 (Control)	10 ± 2	-	-	-	-	-	-
T_1	Nil	Nil	Nil	Nil	Nil	Nil	Nil
T_2	Nil	Nil	Nil	Nil	Nil	Nil	Nil
T_3	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	75% Papaya juice + 25% Strawberry juice						
T_0 (Control)	20 ± 5	-	-	-	-	-	-
T_1	Nil	Nil	Nil	Nil	Nil	Nil	Nil
T_2	Nil	Nil	Nil	Nil	Nil	Nil	Nil
T_3	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	75% Papaya juice + 25% Mango juice						
T_0 (Control)	20 ± 2	-	-	-	-	-	-
T_1	Nil	Nil	Nil	Nil	Nil	Nil	Nil
T_2	Nil	Nil	Nil	Nil	Nil	Nil	Nil
T_3	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	75% Papaya juice + 25% Guava juice						
T_0 (Control)	20 ± 4	-	-	-	-	-	-
T_1	Nil	Nil	Nil	Nil	Nil	Nil	Nil
T_2	Nil	Nil	Nil	Nil	Nil	Nil	Nil
T_3	Nil	Nil	Nil	Nil	Nil	Nil	Nil

*** Means of three determinations ± SD.**
**** T_1 = Pasteurization at ~ 65ºC/20 min.**
**** T_2 = 0.05% potassium sorbate + 0.05% potassium metabisulphite.**
**** T_3 = Pasteurization at ~ 65ºC/20 min + 0.05% potassium sorbate + 0.05% potassium metabisulphite.**

Yeasts and moulds were absent (Nil) during refrigerated storage for all preserved juice samples. Consequently, no potential microbial risk was associated with the storage conditions. The data of control juice samples (T_0 without any treatments) at zero time were included in the tables (7 and 8) for comparison with the preserved juice samples (T_1 – T_2 – T_3). But they were spoiled in less than a week therefore their storage experiments were not completed. Similar results are reported by Vasavada and Heperkan, (2002); Tournas *et al*. (2006); Baghaei *et al*. (2008) for orange-cantaloupe seed beverage; Mehmood *et al*. (2008) for apple juice; Hossain *et al*. (2011) for tomato juice; Chia *et al*. (2012) for pineapple juices; Sakhale *et al*. (2012) for kesar mango pulp and Almeida *et al*. (2018) for cashew, guava, mango and pineapple juices. They reported that yeasts and moulds are considered as the main contaminant of fruit juices. The juices produced from healthy fruits have yeast loads between 10^3 to 10^5 cfu/ml. The limit of microbial shelf life for juice is 10^6 cfu/ml.

Sensory characteristics of papaya juice samples during storage:

Sensory characteristics (color, flavor, texture and overall quality) of papaya juice samples during cold storage (at ~ 4ºC) for six months are shown in Tables (9 – 12). The results showed that the preservation treatments and storage intervals did not affect the sensory quality significantly up to the third month of storage for all juice samples. Then the sensory assessment values began to decrease. This decrease was significantly in some juice samples, but the values remained above the acceptable level. In the case of treatment T_1 (pasteurization at ~ 65ºC/20 min), the color scores decreased from 95% at zero time and reached 80% at the end of storage. There were no significant changes in the sensory quality for T_2 (0.05% potassium sorbate + 0.05% potassium metabisulphite) and T_3 (pasteurization at ~ 65ºC/20 min + 0.05% potassium sorbate + 0.05% potassium metabisulphite) during storage for all juice samples. Their color scores (85 – 90%) evaluated better than T_1 (80%) at the end of storage.

It is evident from Tables (9 – 12) that the sensory assessment values for flavor (Table 10), texture (Table 11) and overall quality (Table 12) had the same trend as color values (Table 9). The results of control juice samples (T_0 without any treatments) at zero time were included in the tables for comparison with the preserved juice samples. But they were spoiled in less than a week therefore their storage experiments were not completed.

It is obviously observed from Tables (9 – 12) that all papaya juice blends (100% papaya, 75% papaya + 25% orange, 75% papaya + 25% strawberry, 75% papaya + 25% mango and 75% papaya + 25% guava) had excellent sensory assessment values in terms of color, flavor, texture and overall quality. These values remained above the acceptable level up to the end of storage (6 months) for all juice samples.

Similar results are reported by Mehmood *et al*. (2008) for apple juice; Ayub *et al*. (2010) for strawberry juice; Hossain *et al*. (2011) for tomato juice; Sakhale *et al*. (2012) for kesar mango pulp; Rohila *et al*. (2017) for bael-guava nectar and crush and Zakaria *et al*. (2017) for black mulberry pulpy juice.

Table 9. Sensory characteristics (color)* of papaya juice samples during cold storage (at ~ 4ºC).

Treatments**	Storage intervals (month)						
	Zero time	1st	2nd	3rd	4th	5th	6th
	100% Papaya juice						
T_0 (Control)	9.5 ± 0.5^{a}	-	-	-	-	-	-
T_1	9.5 ± 0.5^{a}	9.5 ± 0.5^{a}	9.5 ± 0.5^{a}	9.0 ± 0.5^{ab}	8.5 ± 0.5^{bc}	8.5 ± 0.5^{bc}	8.0 ± 0.5^{c}
T_2	9.5 ± 0.5^{a}	9.5 ± 0.5^{a}	9.5 ± 0.5^{a}	9.5 ± 0.5^{a}	9.0 ± 0.5^{ab}	8.5 ± 0.5^{bc}	8.5 ± 0.5^{bc}
T_3	9.5 ± 0.5^{a}	9.5 ± 0.5^{a}	9.5 ± 0.5^{a}	9.5 ± 0.5^{a}	9.0 ± 0.5^{ab}	9.0 ± 0.5^{ab}	9.0 ± 0.5^{ab}
	75% Papaya juice + 25% Orange juice						
T_0 (Control)	9.5 ± 0.5^{a}	-	-	-	-	-	-
T_1	9.5 ± 0.5^{a}	9.5 ± 0.5^{a}	9.5 ± 0.5^{a}	9.0 ± 0.5^{ab}	8.5 ± 0.5^{bc}	8.5 ± 0.5^{bc}	8.0 ± 0.5^{c}
T_2	9.5 ± 0.5^{a}	9.5 ± 0.5^{a}	9.5 ± 0.5^{a}	9.5 ± 0.5^{a}	9.0 ± 0.5^{ab}	8.5 ± 0.5^{bc}	8.5 ± 0.5^{bc}
T_3	9.5 ± 0.5^{a}	9.5 ± 0.5^{a}	9.5 ± 0.5^{a}	9.5 ± 0.5^{a}	9.0 ± 0.5^{ab}	9.0 ± 0.5^{ab}	9.0 ± 0.5^{ab}
	75% Papaya juice + 25% Strawberry juice						
T_0 (Control)	9.0 ± 0.5^{a}	-	-	-	-	-	-
T_1	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.0 ± 0.5^{b}	8.0 ± 0.5^{b}	8.0 ± 0.5^{b}
T_2	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.5 ± 0.5^{ab}	8.5 ± 0.5^{ab}
T_3	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.5 ± 0.5^{ab}
	75% Papaya juice + 25% Mango juice						
T_0 (Control)	9.5 ± 0.5^{a}	-	-	-	-	-	-
T_1	9.5 ± 0.5^{a}	9.5 ± 0.5^{a}	9.5 ± 0.5^{a}	9.0 ± 0.5^{ab}	8.5 ± 0.5^{bc}	8.5 ± 0.5^{bc}	8.0 ± 0.5^{c}
T_2	9.5 ± 0.5^{a}	9.5 ± 0.5^{a}	9.5 ± 0.5^{a}	9.5 ± 0.5^{a}	9.0 ± 0.5^{ab}	8.5 ± 0.5^{bc}	8.5 ± 0.5^{bc}
T_3	9.5 ± 0.5^{a}	9.5 ± 0.5^{a}	9.5 ± 0.5^{a}	9.5 ± 0.5^{a}	9.0 ± 0.5^{ab}	9.0 ± 0.5^{ab}	9.0 ± 0.5^{ab}
	75% Papaya juice + 25% Guava juice						
T_0 (Control)	9.0 ± 0.5^{a}	-	-	-	-	-	-
T_1	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.0 ± 0.5^{bc}	7.5 ± 0.5^{cd}	7.0 ± 0.5^{d}
T_2	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.0 ± 0.5^{bc}	8.0 ± 0.5^{bc}
T_3	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.5 ± 0.5^{ab}	8.0 ± 0.5^{bc}

*** Means of ten determinations ± SD, values within the same column and row followed by the same letter are not significantly different ($P \leq 0.05$).**
**** T_1 = Pasteurization at ~ 65ºC/20 min.** **** T_2 = 0.05% potassium sorbate + 0.05% potassium metabisulphite.**
**** T_3 = Pasteurization at ~ 65ºC/20 min + 0.05% potassium sorbate + 0.05% potassium metabisulphite.**

Table 10. Sensory characteristics (flavor)* of papaya juice samples during cold storage (at ~ 4ºC).

Treatments**	Storage intervals (month)						
	Zero time	1st	2nd	3rd	4th	5th	6th
	100% Papaya juice						
T_0 (Control)	8.5 ± 0.5^{a}	-	-	-	-	-	-
T_1	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.0 ± 0.5^{ab}	8.0 ± 0.5^{ab}	7.0 ± 0.5^{c}	7.0 ± 0.5^{c}	7.0 ± 0.5^{c}
T_2	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.0 ± 0.5^{ab}	8.0 ± 0.5^{ab}	8.0 ± 0.5^{ab}	7.5 ± 0.5^{bc}
T_3	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.0 ± 0.5^{ab}	8.0 ± 0.5^{ab}	7.5 ± 0.5^{bc}
	75% Papaya juice + 25% Orange juice						
T_0 (Control)	9.0 ± 0.5^{a}	-	-	-	-	-	-
T_1	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.0 ± 0.5^{b}	8.0 ± 0.5^{b}	7.0 ± 0.5^{c}
T_2	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.5 ± 0.5^{ab}	8.0 ± 0.5^{b}
T_3	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.5 ± 0.5^{ab}	8.0 ± 0.5^{b}
	75% Papaya juice + 25% Strawberry juice						
T_0 (Control)	9.0 ± 0.5^{a}	-	-	-	-	-	-
T_1	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.0 ± 0.5^{bc}	8.0 ± 0.5^{bc}	7.0 ± 0.5^{d}
T_2	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.0 ± 0.5^{bc}	7.5 ± 0.5^{cd}
T_3	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.5 ± 0.5^{ab}	7.5 ± 0.5^{cd}
	75% Papaya juice + 25% Mango juice						
T_0 (Control)	9.0 ± 0.5^{a}	-	-	-	-	-	-
T_1	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.0 ± 0.5^{b}	8.0 ± 0.5^{b}	7.0 ± 0.5^{c}
T_2	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.5 ± 0.5^{ab}	8.0 ± 0.5^{b}
T_3	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.5 ± 0.5^{ab}	8.0 ± 0.5^{b}
	75% Papaya juice + 25% Guava juice						
T_0 (Control)	8.5 ± 0.5^{a}	-	-	-	-	-	-
T_1	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.0 ± 0.5^{ab}	8.0 ± 0.5^{ab}	7.0 ± 0.5^{c}	7.0 ± 0.5^{c}	7.0 ± 0.5^{c}
T_2	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.0 ± 0.5^{ab}	8.0 ± 0.5^{ab}	8.0 ± 0.5^{ab}	7.5 ± 0.5^{bc}
T_3	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.0 ± 0.5^{ab}	8.0 ± 0.5^{ab}	7.5 ± 0.5^{bc}

*** Means of ten determinations ± SD, values within the same column and row followed by the same letter are not significantly different ($P \leq 0.05$).**
**** T_1 = Pasteurization at ~ 65ºC/20 min.** **** T_2 = 0.05% potassium sorbate + 0.05% potassium metabisulphite.**
**** T_3 = Pasteurization at ~ 65ºC/20 min + 0.05% potassium sorbate + 0.05% potassium metabisulphite.**

Table 11. Sensory characteristics (texture)* of papaya juice samples during cold storage (at ~ 4ºC).

Treatments**	Storage intervals (month)						
	Zero time	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**
				100% Papaya juice			
T_0 (Control)	9.0 ± 0.5^{a}	-	-	-	-	-	-
T_1	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.0 ± 0.5^{b}	8.0 ± 0.5^{b}	8.0 ± 0.5^{b}
T_2	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.5 ± 0.5^{ab}	8.5 ± 0.5^{ab}
T_3	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.5 ± 0.5^{ab}	8.5 ± 0.5^{ab}
				75% Papaya juice + 25% Orange juice			
T_0 (Control)	9.0 ± 0.5^{a}	-	-	-	-	-	-
T_1	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.0 ± 0.5^{bc}	8.0 ± 0.5^{bc}	7.5 ± 0.5^{c}
T_2	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.5 ± 0.5^{ab}	8.0 ± 0.5^{bc}
T_3	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.5 ± 0.5^{ab}	8.0 ± 0.5^{bc}
				75% Papaya juice + 25% Strawberry juice			
T_0 (Control)	9.0 ± 0.5^{a}	-	-	-	-	-	-
T_1	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.0 ± 0.5^{b}	8.0 ± 0.5^{b}	8.0 ± 0.5^{b}
T_2	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.5 ± 0.5^{ab}	8.5 ± 0.5^{ab}
T_3	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.5 ± 0.5^{ab}
				75% Papaya juice + 25% Mango juice			
T_0 (Control)	9.0 ± 0.5^{a}	-	-	-	-	-	-
T_1	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.0 ± 0.5^{b}	8.0 ± 0.5^{b}	8.0 ± 0.5^{b}
T_2	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.5 ± 0.5^{ab}	8.5 ± 0.5^{ab}
T_3	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.5 ± 0.5^{ab}
				75% Papaya juice + 25% Guava juice			
T_0 (Control)	8.5 ± 0.5^{a}	-	-	-	-	-	-
T_1	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.0 ± 0.5^{ab}	8.0 ± 0.5^{ab}	7.0 ± 0.5^{c}	7.0 ± 0.5^{c}	7.0 ± 0.5^{c}
T_2	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.0 ± 0.5^{ab}	8.0 ± 0.5^{ab}	8.0 ± 0.5^{ab}	7.5 ± 0.5^{bc}
T_3	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.0 ± 0.5^{ab}	8.0 ± 0.5^{ab}	7.5 ± 0.5^{bc}

*** Means of ten determinations ± SD, values within the same column and row followed by the same letter are not significantly different ($P \leq 0.05$).**
**** T_1 = Pasteurization at ~ 65ºC/20 min. ** T_2 = 0.05% potassium sorbate + 0.05% potassium metabisulphite.**
**** T_3 = Pasteurization at ~ 65ºC/20 min + 0.05% potassium sorbate + 0.05% potassium metabisulphite.**

Table 12. Sensory characteristics (overall quality)* of papaya juice samples during cold storage (at ~ 4ºC).

Treatments**	Storage intervals (month)						
	Zero time	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**
				100% Papaya juice			
T_0 (Control)	8.5 ± 0.5^{a}	-	-	-	-	-	-
T_1	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.0 ± 0.5^{ab}	8.0 ± 0.5^{ab}	7.0 ± 0.5^{c}	7.0 ± 0.5^{c}	7.0 ± 0.5^{c}
T_2	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.0 ± 0.5^{ab}	8.0 ± 0.5^{ab}	8.0 ± 0.5^{ab}	7.5 ± 0.5^{bc}
T_3	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.0 ± 0.5^{ab}	8.0 ± 0.5^{ab}	7.5 ± 0.5^{bc}
				75% Papaya juice + 25% Orange juice			
T_0 (Control)	9.0 ± 0.5^{a}	-	-	-	-	-	-
T_1	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.0 ± 0.5^{b}	8.0 ± 0.5^{b}	7.0 ± 0.5^{c}
T_2	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.5 ± 0.5^{ab}	8.0 ± 0.5^{b}
T_3	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.5 ± 0.5^{ab}	8.0 ± 0.5^{b}
				75% Papaya juice + 25% Strawberry juice			
T_0 (Control)	9.0 ± 0.5^{a}	-	-	-	-	-	-
T_1	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.0 ± 0.5^{bc}	8.0 ± 0.5^{bc}	7.0 ± 0.5^{d}
T_2	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.0 ± 0.5^{bc}	7.5 ± 0.5^{cd}
T_3	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.5 ± 0.5^{ab}	7.5 ± 0.5^{cd}
				75% Papaya juice + 25% Mango juice			
T_0 (Control)	9.0 ± 0.5^{a}	-	-	-	-	-	-
T_1	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.0 ± 0.5^{b}	8.0 ± 0.5^{b}	7.0 ± 0.5^{c}
T_2	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.5 ± 0.5^{ab}	8.0 ± 0.5^{b}
T_3	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	9.0 ± 0.5^{a}	8.5 ± 0.5^{ab}	8.5 ± 0.5^{ab}	8.0 ± 0.5^{b}
				75% Papaya juice + 25% Guava juice			
T_0 (Control)	8.5 ± 0.5^{a}	-	-	-	-	-	-
T_1	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.0 ± 0.5^{ab}	8.0 ± 0.5^{ab}	7.0 ± 0.5^{c}	7.0 ± 0.5^{c}	7.0 ± 0.5^{c}
T_2	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.0 ± 0.5^{ab}	8.0 ± 0.5^{ab}	8.0 ± 0.5^{ab}	7.5 ± 0.5^{bc}
T_3	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.5 ± 0.5^{a}	8.0 ± 0.5^{ab}	8.0 ± 0.5^{ab}	7.5 ± 0.5^{bc}

*** Means of ten determinations ± SD, values within the same column and row followed by the same letter are not significantly different ($P \leq 0.05$).**
**** T_1 = Pasteurization at ~ 65ºC/20 min. ** T_2 = 0.05% potassium sorbate + 0.05% potassium metabisulphite.**
**** T_3 = Pasteurization at ~ 65ºC/20 min + 0.05% potassium sorbate + 0.05% potassium metabisulphite.**

CONCLUSION

In the light of the obtained results, it could be concluded that, the papaya fruits could be successfully used singly or in combination with orange, strawberry, mango and guava to obtain delicious and healthy nutritious juices. The combined action of the thermal treatment (pasteurization at ~ 65ºC/20 min) and chemical preservatives (0.05% potassium sorbate + 0.05% potassium metabisulphite) on the quality and shelf stability of papaya juices stored under refrigeration conditions (~ 4ºC) for 6 months was better than using either of them alone. The modified papaya juices (75% papaya + 25% orange/strawberry/mango/guava) had acceptable quality attributes, improved nutritional value, improved shelf stability and microbiological safety for up to 6 months.

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تحسين الثبات التخزيني والحفاظ على جودة عصائر الباباظ المعدلة والمخزنة تحت ظروف التبريد

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تم خلط بيوريه (مهروس اللب) الباباظ الطازج مع البرتقال – الفراولة – المانجو – الجوافة لتحسين الخصائص الغذائية والجودة للعصائر المختلطة. تم تقييم العصائر المنتجة من حيث قيمتها الغذائية وخواصها الفيزوكيميائية والميكروبيولوجية والحسية. كما تم دراسة تأثير البسترة (65°م / 20 دقيقة) و/أو المواد الحافظة الكيميائية (0،05% سوربات البوتاسيوم + 0،05% ميتا كبريتيت البوتاسيوم) على خواص الجودة والثبات التخزيني لعصائر الباباظ المعدلة وذلك خلال التخزين المبرد (4°م) لمدة 6 شهور. أوضحت النتائج أن الفعل المشترك للمعاملة الحرارية والمواد الحافظة الكيميائية (T_3) على خواص الجودة والثبات التخزيني لعصائر الباباظ خلال التخزين المبرد (4°م) لمدة 6 شهور كان أفضل من استخدام أي منهما منفرداً. كما بينت النتائج أنه خلال التخزين المبرد انخفضت قيم المحتوى الرطوبي والأس الهيدروجيني وحامض الأسكوربيك والفينولات الكلية انخفاضاً معنوياً مع زيادة زمن التخزين ، في حين زادت قيم كلٍ من المواد الصلبة الكلية الذائبة والحموضة القابلة للمعايرة. وكان لكلٍ من معاملات الحفظ وفترات التخزين تأثير معنوي على هذه القيم لجميع عينات عصير الباباظ. وعلى الرغم من هذا الانخفاض ظلت جميع عينات العصير مصادر مرضية لحامض الأسكوربيك والمركبات الفينولية على مدى فترة التخزين التي استمرت ستة أشهر. كما تبين أن الجودة الحسية لعصائر الباباظ ظلت مقبولة لمدة تصل إلى ستة أشهر في ظل التخزين المبرد. كما وجد أن العدد البكتيري الكلي في جميع عينات العصير أقل من الحد الحرج لعصائر الفاكهة ولم تتواجد الخمائر والفطريات أثناء التخزين المبرد. وبالتالي لم يرتبط أي خطر ميكروبي محتمل بظروف التخزين. كنتيجة عامة وفي ضوء النتائج المتحصل عليها يتضح أن ثمار الباباظ يمكن استخدامها بنجاح بصورة منفردة أو بالاشتراك مع البرتقال والفراولة والمانجو والجوافة للحصول على عصائر مغذية لذيذة وصحية. عصائر الباباظ المعدلة (75% باباظ + 25% برتقال أو فراولة أو مانجو أو جوافة) كان لها خصائص جودة مقبولة وقيمة غذائية محسنة بالإضافة للثبات التخزيني والأمان الميكروبيولوجي لمدة تصل إلى ستة أشهر.