

Full Length Research Paper

Development of a mango pulp and the acceptability and storability of the product

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Abstract

Mango, the king of tropical fruits had a great potential for value added products due to its greater impact on human health. Mango pulp is a preservation technique that overcomes the postharvest losses during the seasons. The current study was focused to develop a pulp from *Karthakolomban* mango cultivar and evaluate its physical, biochemical, microbial properties, acceptability and storability. Mango pulp was prepared after steam blanching of fruits for 15 min to preserve the colour at storage time. Developed mango pulp contains 0.58 mg β carotene/100 g, 4.83 mg gallic acid/g, 245.9 mg ascorbic acid/100 g and 374.4 μ M Trolox/100 g, as antioxidant. Microbial counts were less than the standard maximum limits for the mango pulp throughout the 3 months storage period. TSS and the titratable acidity were significantly increased ($p < 0.05$) and pH, colour change and moisture were not significantly different during the three-month storage period. However, pH of the pulp was slightly reduced at the time and carotenoid, phenol, ascorbic contents and antioxidant activity were not significantly different and not observed gradual increases or decreases. Sensory evaluation revealed that jam prepared from developed mango pulp at initial stage and two months after storage were significantly different from control for the colour, taste, odor, consistency and overall acceptability. The developed mango pulp is successfully accepted by the people. *Karthakolomban* mango pulp had superior properties for adding value to the fruit without any preservatives and retained antioxidant properties up to three months.

Key words: Mango, pulp, physico-chemical properties, storage time, value addition

INTRODUCTION

Mango (*Mangifera indica*) belongs to the family *Anacardeaceae*. Mango is native to Indo-Pak subcontinent. Mango is one of the most widely grown fruit crops in different regions of Sri Lanka including Kurunegala, Anuradhapura, Hambanthota, Puttalam, Moneragala, Jaffna districts and Mahaweli H & C.

The total production of mango was 151,733 mt and extent of cultivation was 28,272 ha. As a fresh fruit, mango has a high demand both in local and international markets and at present Sri Lanka export about 80,000 Mt annually (DOA, 2016).

Fruit crops are excellent source of phytochemical properties helpful for human diet resulting in healthy life (Anjum et al., 2018). Mango is a very popular fruit due to its superior taste, colour and flavour. Apart from its organoleptic properties, its high nutritional value including

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high level of vitamin C, carotenoids, vitamin E contents and moderate levels of phenolic compounds are attractive characteristics of this fruit (Vinci et al., 1995; Shieber et al., 2000). Moreover, consumption of mango has been reported to have medicinal and functional benefits in preventing several diseases (DOA, 2016).

Mango is a seasonal crop and in wet and intermediate zones, crops bloom from January to March and are harvested in May to July while mangoes from the dry zone bloom between July to September and are harvested from November to January (Maha season crops). Therefore, production decline in between the two seasons, resulting in higher prices (Peiris and Senevirathna, 2001). Furthermore, high postharvest loss has been reported in the season due to non-existence of a cold chain system, lack of proper storage facilities and inadequate processing facilities and agro-based industries with improved value addition technologies. Therefore, introduction of appropriate processing techniques, which can preserve organoleptic, rheological, nutritional and other quality attributes of fresh mango, will be beneficial in solving this problem. Moreover, the development of products stable in high ambient temperature with minimal quality degradation could be an added advantage under the tropical climate. Hence this study was undertaken to develop a paste from commercial mango variety (Karthakolomban) and study the acceptability and storability of the product for three months.

MATERIAL AND METHODS

Materials

All chemicals and standards including plate count agar, metaphosphoric acid, DIP, hexane, acetone, Folin-Ciocalteu reagent, NaOH, ethanol, ABTS stock solution, potassium persulphate and phenolphthalein were purchased from Analytical Instruments, Colombo. Fully ripe mangoes (variety: Karthakolomban) were purchased from the commercial farmer orchard situated in Anuradhapura and Standard packaging materials (glass jars) were obtained from Piramal Glass Ceylon PLC, Rathmalane.

Sample collection

150 of well grown, fully matured, disease free mangoes (variety: Karthakolomban) at 50% of yellow colour peel stage were randomly collected from commercial farmer orchard situated in Anuradhapura and transported to the food processing laboratory of Institute of Postharvest Technology. Diseased and damaged fruits were rejected to minimize the biological variability.

Development of processing parameters

Prior to processing, mangoes were blanched to avoid colour changes of the product. Steam blanching was done in 100 °C for three time periods. (10, 15 and 20 min), and the optimum blanching conditions were selected based on the pulp colour. After establishing blanching parameters, preliminary experiments were conducted to establish process parameters of the product and find the optimum time temperature combination to process the mango pulp. Fruits were washed, blanched, peeled, cut into pieces, prepared pulp and was heated up to 80 °C for 20 min until it reaches to 14-19 °Brix value of total sugar content (Jayathunge et al., 2015).

Analysis of microbial, physical and chemical properties of the product

Microbiological analysis

Total Plate Count (TPC) was determined using plate count agar. Mango pulp (10 g) was aseptically transferred to 90 mL maximum recovery diluent and serial dilutions prepared. Aliquots (1000 µL) of appropriate dilutions were poured into plates with plate count agar. After incubation at 30 °C for 48-72 h, colonies were counted and results were expressed as CFU/mL of mango pulp (SLS 516:1, 1991).

Colour measurements

Colour was measured using a Konica Minolta portable colorimeter (CR-400, Japan). A standard white tile (Y=93.9, X=0.3125, Y=0.3191) was used to calibrate the instrument and L*a*b values were directly taken from the colorimeter. Overall colour change ($\Delta E = \sqrt{\Delta L^2 + \Delta a^2 + \Delta b^2}$) were calculated based on measured L*a*b values (Jayathunge et al., 2015).

Total soluble solid measurements

Total soluble solid content was measured using a digital refractometer (ATAGO, PAL-01, Tokyo). Distilled water was used to calibrate the instrument and total soluble solid content of the pulp was directly taken from the refractometer (Ranganna, 1986).

pH measurements

pH of the pulp was measured using a digital pH meter (Thermo Orine, 420A⁺ USA)

Moisture content

Moisture content of the pulp was measured according to

the standard method of AOAC (2005). To the nearest milligram, about 5g of the pulp was weighed in the moisture dish. The dish was placed in the oven for 5 hours. Dish was cooled in a desiccator and weighed. Moisture content was calculated as follows.

$$\text{Moisture (\%)} \text{ by mass} = \frac{m_1 - m_2}{m_1 - m_0} \times 100$$

Where,

m_1 – Mass in g, of the dish with the sample before drying

m_2 – Mass in g, of the dish with the sample after drying

m_0 – Mass in g, of the empty dish

Measurements of acidity

Acidity of the pulp was measured using method of AOAC (2005). One g of the pulp was diluted up to 20 mL with distilled water and it was mixed well. The dilution was titrated with 0.1M NaOH after adding 2-3 drops of phenolphthalein into the titration flask. The titrated volume was taken once the colour change into pink colour. The acidity of sample was calculated based on the volume of 0.1M NaOH used for neutralizing the acid in the sample (Nielsen, 2010).

$$\text{Titrateable acidity} = \frac{B \times 0.1 \times 0.064 \times 100}{W}$$

Where,

W – Weight of the sample taken for analysis

B Volume of 0.1 NaOH required for titration

Quantification of total carotenoids

Total carotenoids were determined using the method described by Koca et al. (2007) with modifications. Extractions were carried out using mango pulp samples and hexane: acetone (7:3) as solvent (5 g/25 mL) until the sample become colourless. The hexane phase was separated from the combined extracts using a separation funnel. Total carotenoids were quantified with colorimetric detection at 450 nm using UV-vis spectrophotometer (HACH, DR6000, Germany). β -carotene was used as a standard (0.5-10 $\mu\text{g/mL}$).

Quantification of total phenolic content

Total phenolic content of the mango pulp was determined using the Folin-Ciocalteu's reagent described by Singleton, Orthofer and Lamuela-Reventos (1999) with some modifications. One g of the pulp was diluted up the volume of 25 mL. Solution was centrifuged at 15,000 rpm for 20 min at 4 °C (HERMLE, Z326K, Germany). Surpenant solution was used for the analysis. 0.2 mL of diluted sample extract was transferred in tube containing 1.0 mL of a 1/10 dilution of Folin-Ciocalteu's reagent in water. After 0.8 mL $\text{Na}_2\text{CO}_{3(\text{aq})}$ (7.5% N/V) was added to the sample after 10

min. Those are allowed to stand at room temperature for 30 min. Total phenolic content was quantified with colorimetric detection at 743 nm using UV-vis spectrophotometer (HACH, DR6000, Germany). Gallic acid was used as a standard (0.2-4 mg/ L).

Quantification of ascorbic acid content

Ascorbic acid content was quantitatively determined according to the 2,6-dichlorophenolindophenol (DIP) method described by Klein and Perry (2006) with some modifications. Mango pulp samples were extracted with 1% metaphosphoric acid (1 g/10 mL) and centrifuged (3800 rpm/20 min) (HERMLE, Z326K, Germany). An aliquot of 0.25 mL of the supernatant was added to 2 mL of 0.05 mM DIP, mixed for 15 seconds and measured at 515 nm in an UV-vis spectrophotometer (HACH, DR6000, Germany). L-ascorbic acid was used as a standard (0-400 $\mu\text{g/mL}$).

Quantification of antioxidant activity

Antioxidant activity of the mango pulp was measured using the 2,2-azino-di-3-ethylbenzothiazolone-6-sulphonic acid diammonium salt (ABTS) decolouration method with some modifications. Mango pulp was extracted with 80% ethanol (4 g/10 mL) and centrifuged (3800 rpm/20 min) (HERMLE, Z326K, Germany). The total antioxidant activity was measured in the supernatant. ABTS radical cation was produced by reacting ABTS stock solution (7 mM) with potassium persulphate (2.45 mM) and allowing the mixture to stand in the dark at room temperature for 16 h before being use for the analysis. Absorbance readings were taken 1 min after initial mixing of the reaction mixture (sample extract 250 μL and ABTS^+ 2 mL) at 734 nm using an UV-vis spectrophotometer (HACH, DR6000, Germany). The standard curve was determined using Trolox within the linear range of 100-800 μM (Re et al., 2002).

Sensory evaluation of the developed product

Mango jam was prepared using mango pulp and control sample was prepared using fresh mango pulp. Three samples were prepared for the sensory evaluation including; the jam prepared from developed mango pulp at initial stage, the jam prepared from developed mango pulp after two-month storage in ambient temperature and the jam from fresh mango pulp as control. The prepared jam was tested for colour, taste, consistency/texture, odor and overall acceptability by using a sensory evaluation panel consisting of 30 panelists with a Nine-point Hedonic scale (1- extremely dislike, 2- dislike very much, 3- moderately dislike, 4- slightly dislike, 5- neither like nor dislike, 6- slightly like,

7- moderately like, 8- like very much and 9- extremely like).

Storage study

Developed mango pulp was packaged in glass jars and stored under ambient conditions for three months period. Samples were withdrawn in two weeks interval in triplicates and physical and chemical properties analysis of colour, TSS, pH, acidity, moisture content, carotenoid content, phenolic content, ascorbic content, antioxidant activity and microbiological content were analyzed.

Statistical analysis

The data of physical and chemical properties analysis and microbiological analysis were statistically analyzed by one-way ANOVA with MINITAB Ver. 18. Treatments means were compared at $p < 0.05$ according to the Fisher comparison method to explore which means are significantly different from each other. The results of sensory evaluation were analyzed by the Kruskal and Wallis pairwise test of the MINITAB Ver. 18 statistical package.

RESULTS AND DISCUSSION

Development of processing parameters

Pre-treatment condition of blanching was affected to the colour of the mango pulp (Table 3.1). Steam blanching at 100 °C for 15 min resulted to bright yellow coloured product which was accepted, while steam blanching at 100 °C for 10 min and 20 min resulted to a brownish yellow coloured products which was not accepted by the sensory panel. Therefore, steam blanching at 100 °C for 15 min was found to be the most effective pre-treatment in preservation of yellow colour of the mango pulp product. Ndiaye et al. (2009) also have reported that, colour of the mango could be improved by steam blanching for small time periods (5 min) with the non-effects of colour changes in storage time.

Microbial quality of developed Mango pulp

The mean total plate count (TPC) of the developed mango pulp was 0.33×10^4 CFU/mL and during the storage period the results of microbial level shown in Table 3.2. Microbial quality of the products during the storage were significantly different ($p < 0.05$) from each other. However, the product at initial stage, two weeks after storage and four weeks after storage were not significantly different and ranked as low microbial count. Product in six and eight weeks after storage also were not significantly different. Even though the microbial count of the product was increased with the storage time, the count was not exceeding the acceptable level of 10^4 CFU/mL. Oranusi et al. (2012) also have reported

that the microbial quality of the fruit juice ranged from 1.4×10^4 CFU/mL to 2.6×10^5 CFU/mL and the range is within acceptable standards for human consumption.

Colour change of mango pulp

ΔE represents the colour change of mango pulp during the storage period in comparison to the pulp at the initial stage (just after the pulp was developed). The colour change of the mango pulp for three months storage time was not significantly different ($p = 0.087$, $p > 0.05$) from each other (Table 3.3). Steam blanching reduced the browning index of the developed mango pulp and non-enzymic browning had not occurred because of stable browning index. Ndiaye et al. (2009) have mentioned that, steam blanching at suitable time period was affected on the colour changes of mango during storage period. Jayathunge et al. (2012) also reported that, pre-treatment condition of blanching affected the colour preservation of tomato products.

Total soluble solids (TSS)

It was observed that total soluble solid contents of the developed mango pulp were gradually increased during the storage period and significantly different ($p < 0.05$) with each other. From the initial stage to three months storage period TSS content of the developed mango pulp increased from 16.1 °Brix to 16.87 °Brix. On the other hand, samples stored in sixth and eighth weeks of storage, has not showed a significant different (Table 3.3). Datey et al. (2009) also evaluated that, during the storage TSS of the mango pulp was steadily increased up to the end of the storage (90 days). Similarly, Germain and Linden (1981) also mentioned that high sugar contents of pulps from ripe fruits might be attributed to the transformation of starch into soluble solids under the action of phosphorylase enzyme during ripening.

pH and acidity

It was observed that pH of the developed mango pulp was not significantly different ($p = 0.605$, $p > 0.05$) with the time period of three months (Table 3.3). And the acidity of the developed mango pulp during storage period was significantly different ($p < 0.05$) with each other by showing increasing pattern of titratable acidity during the storage period of three months. Similarly, Datey et al. (2009) reported that, pH of the mango pulp at ambient temperature reduced constantly while increasing the titratable acidity with the advancement of storage period. Akhtar et al. (2010) also reported that, the pH of the stored mango pulp samples decreased concomitantly for 90 days, however, the differences remained non-significant for Pakistan local mango varieties (Dusahri, Chaunsa, Ratol and Langra). On the other hand, Abbassi et al. (2009), observed increase in pH and decrease in titratable acidity with increasing the storage time of Pakistan mango variety Summer Bahisht Chaunsa.

Table 3.1. Effect of blanching and blanching time on product quality.

Treatment condition	Observation
Steam blanching at 100°C	
10 min	Colour was not in acceptable level (brownish yellow colour)
15 min	Colour was in acceptable level (bright yellow colour)
20 min	Colour was not in acceptable level (brownish yellow colour)

Note: Three samples from each treatment were observed.

Table 3.2. Microbial quality of the developed mango pulp during storage period.

Storage time (weeks)	Total plate count (CFU/mL)
0	^d 0.33×10 ⁴ ±0.03
2	^d 0.42×10 ⁴ ±0.11
4	^d 0.73×10 ⁴ ±0.18
6	^c 7.12×10 ⁴ ±0.70
8	^c 6.82×10 ⁴ ±1.37
10	^b 14.01×10 ⁴ ±0.91
12	^a 18.42×10 ⁴ ±1.65

Note: Each value represents mean of triplicates
Values are means ± standard deviation

Table 3.3. TSS, pH, acidity, moisture content and colour changes of developed Mango pulp during storage.

Property	Storage time (weeks)						
	0	2	4	6	8	10	12
Colour change	^a 0.00±0.00	^a 0.12±0.36	^a 0.23±0.08	^a 0.29±0.12	^a 0.35±0.06	^a 0.47±0.05	^a 0.59±0.16
TSS	^a 16.1±0.10	^b 16.4±0.01	^c 16.5±0.01	^d 16.6±0.03	^d 16.7±0.01	^e 16.8±0.05	^f 16.9±0.02
pH	^a 4.50±0.07	^a 4.29±0.29	^a 4.45±0.02	^a 4.41±0.16	^a 4.45±0.03	^a 4.34±0.10	^a 4.38±0.11
Acidity	^a 0.57±0.00	^b 0.59±0.00	^c 0.60±0.00	^d 0.64±0.00	^e 0.66±0.00	^f 0.70±0.00	^g 0.71±0.00
Moisture content	^a 94.7±0.76	^a 94.3±0.70	^a 94.9±0.07	^a 94.7±0.14	^a 94.7±0.04	^a 94.5±0.46	^a 94.8±0.44

Note: Each value represents the mean of triplicates. Values are means ± standard deviation and the same letter following the value within the each raw indicates no significant different at $p < 0.05$.

Moisture content

The moisture content of the developed mango pulp during storage was not significantly different ($p=0.756$, $p>0.05$) with the storage period (Table 3.3) and remained more or less constant during the storage. Sirinivasa et al. (2002) reported similar non-significant moisture change in packaged mango fruits during the storage time.

Total carotenoid content

It was observed that total carotenoid content of the developed mango pulp was significantly different ($p<0.05$) with each other (table 3.4) and reduced with the storage. The obtained results were reflected by the colour change of mango pulp during storage period. However, results were not significantly different during initial stage of the storage period. Wibowo et al. (2015)

Table 3.4. Total carotenoids, total phenolic content, ascorbic acid content and antioxidant activity of the developed Mango pulp during storage.

Property	Storage time (weeks)						
	0	2	4	6	8	10	12
Total carotenoids (mg β carotene/ 100 g)	^a 0.58±0.01	^{ab} 0.56±0.01	^c 0.47±0.11	^{bc} 0.50±0.01	^c 0.46±0.00	^d 0.37±0.04	^d 0.29±0.01
Total phenol content (mg gallic acid/g)	^b 4.83±0.23	^b 5.10±0.33	^b 5.10±0.71	^a 6.18±0.17	^a 6.08±0.14	^a 6.06±0.21	^a 6.26±0.18
Ascorbic acid (mg/ 100 g)							
Antioxidant activity	^a 254.9±23.0	^{abc} 218.2±29.2	^c 177.9±25.0	^{ab} 235.3±36.2	^{bc} 197.3±17.4	^{abc} 210.9±34.6	^c 187.3±10.9
ABTS (μ M Trolox/ 100 g)	^d 374.4±13.92	^c 411.1±9.19	^c 407.0±10.82	^c 419.7±8.90	^b 443.9±9.55	^b 453.9±2.55	^a 476.1±2.96

Note: Each value represents the mean of triplicates. Values are means \pm standard deviation and the same letter following the value within the each raw indicates no significant different at $p < 0.05$.

Also reported the correlation between carotenoid content with colour changes of pasteurized orange juice during storage.

Total phenolic content

Total phenolic content of the developed mango pulp just after processing was 4.83 mg gallic acid /g and significantly changed ($p < 0.05$) during the storage time. However, the change was not significant at initial, two weeks and four weeks after storage time. Overall, the total phenolic content of the developed mango pulp showed an increasing pattern during the storage time.

Patras et al. (2009) also observed a significant increase in phenol content in tomato pulp at storage.

Ascorbic acid content

Ascorbic acid (vitamin C) is an indicator of the nutritional quality in fruit pulps. It can be considered in processing because it is the most heat labile vitamin. Ascorbic acid content of the developed mango pulp was 254.9 mg/ 100 g at the start point of storage time. It was observed that the ascorbic acid content of the product was significantly different ($p < 0.05$) from each other showing fluctuations during storage time (Table 3.4).

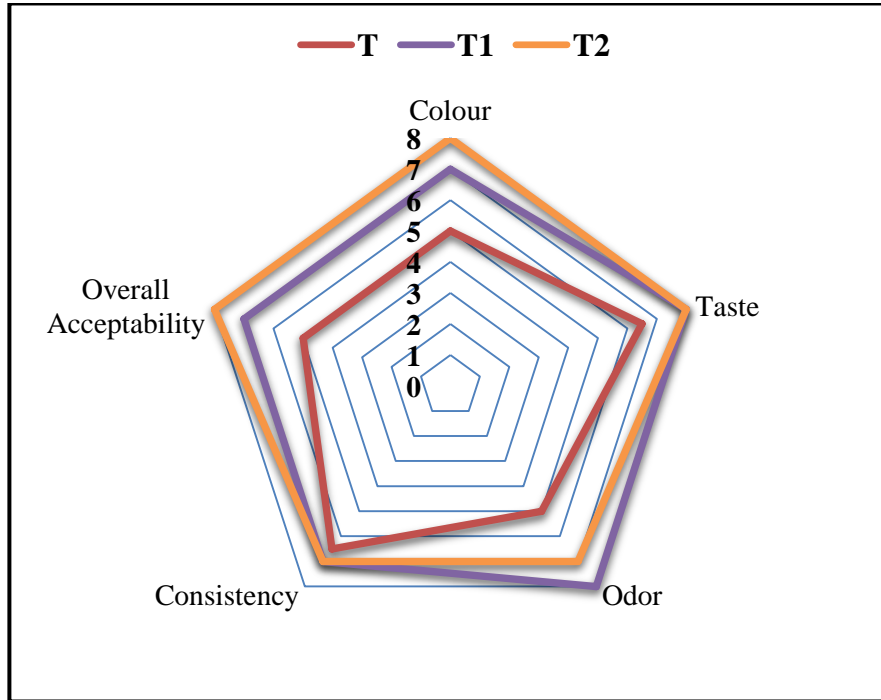


Fig. 3.1. Results of the acceptability through sensory panel.

The change of ascorbic acid content in mango pulp for the long-term study could not be found in the literature.

Antioxidant activity

Antioxidant activity of the developed mango pulp as assessed by 2,2-azino-di-3-ethylbenzothiazine-6-sulphonic acid diammonium salt (ABTS) was reported significantly different ($p < 0.05$) with each other in storage time. But in the case of the results, it was not significant in the pulp at eight and ten weeks after; and the pulp at two, four and six weeks after storage (table 3.4). Takeola et al. (2001) reported that, antioxidant activity of tomato products related to the vitamin C, polyphenols, carotenoids and vitamin E. In this study moderately positive correlation was found between ABTS and ascorbic acid content of the mango pulp during storage time.

Sensory evaluation of the developed product

Results revealed that, jam prepared from pulp obtained from initial stage (T_1) and two months after storage (T_2) were significantly different from all the parameters ($p = 0.000$, $p < 0.01$) from the control (jam prepared from fresh mango) (Figure 3.1) It was resulted that jam prepared from developed mango pulp at initial stage (T_1) and the jam prepared successfully from developed

mango pulp after two months storage in ambient temperature were accepted by the sensory panel.

T_0 – Jam from fresh Mango pulp (control)

T_1 – Jam from developed Mango pulp at initial stage

T_2 – Jam from developed Mango pulp after two-month storage at ambient temperature

CONCLUSIONS

Current study was conducted to develop a mango pulp with the consumer acceptability and the storability without any preservative or any additive. Though, people have judgment that Karthakolomban mango can't process because of its' easily browning nature. The study was able to successfully minimize the colour changes during processing and maintain it for two months storage due to applied steam blanching treatment (for 15 min) prior to processing. The processing conditions of developing mango pulp was successfully established by obtaining a product with low microbial count (10^3) and maintaining the level at acceptable range (10^5) during the storage. Moreover, the product was superior in other physico-chemical properties and organoleptic properties. Finally, as a recommendation, Karthakolomban mango pulp could be a good alternative to preserve fresh mango without using any harmful chemical preservatives, additives and without significant losses in nutritional quality up to three months. This will be a good solution to reduce the

postharvest loss of mango fruits in seasons and to overcome the deficit and higher prices in the off season.

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