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RESEARCH ARTICLE

Thermal processing of mango nectar (*Mangifera indica*) and its effect on chemical, microbiological and sensory quality characteristics

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Abstract

Standardization of thermal processing conditions for RTD Mango nectar in multilayered flexible pouches and its effect on quality characteristics of mango (*Mangifera indica*) nectar were systematically evaluated on a pilot scale using typical batch production operations. Thermal processing is still one of the most effective methods for inactivating undesirable microorganisms in liquid foods. The holding time and pasteurisation values need to be standardized to get complete microbial inactivation, as well as better quality product. Standardization of treatment conditions comprised of 96^0C temperature and holding time of 420s, 600s, 780s and 900s with pasteurisation values of 3.62, 8.03, 12.73 and 15.89 min for treatments T_2, T_3, T_4 and T_5 respectively. Decimal reduction time (D_{96}-*value*) of 1.5 min and Z-*value* of 10^0 C were used to calculate maximum *p-values*. The effect of thermal pasteurization on total carotenoid, ascorbic acid, color (L* a* b* values), viscosity, native micro flora and other physicochemical quality parameters was also evaluated during prolonged storage under ambient temperature (27-30 ± 2^0 C) conditions. The processing and storage of mango nectar had a decisive impact showing a significant ($p<0.05$) degradation effect on the total carotenoids, ascorbic acid and color (L* a* b*) values.

Introduction

Fruit nectars are beverages having a high content of fruit ingredients, sugar and acid. The production of fruit nectars is of great importance in fruit juice industry. They are prepared from fruits which are not suitable for direct processing into juice that is fruits the colour pigment and flavors constituents of which are bound mainly to pulp particles and their pulpy or cloudy preparations are too thick to be drinkable. Clear juices are obtained by pressing but which are too acid to be consumed as such are also processed into nectars (e.g., black currant and sour cherry). Also, fruit juices having strong flavour (e.g., passion fruit) have to be diluted to make an attractive beverage. Fruit nectars can also be made from mature fruits which cannot be used satisfactorily in standard processing (Siliha, 1985).

Conventional thermal processing is the most common method for extending the shelf life of vegetable and fruit juices, by inactivating microorganisms and enzymes, which relies on a mathematical calculation to ensure the safety of the products. Theoretically this is a combination of the time-temperature profile and the microbial destruction/inactivation. Thermal process design is normally adopted to maximize microbial inactivation with minimal collateral degradation to product quality (Gould, 1995). At a pH below 4.5, the risk of growth and toxin production by *Clostridium botulinum* is extremely low and for products with pH values between 4.0 and 4.5, processes are aimed at controlling the survival and growth of spore forming organisms such as *Bacillus coagulans, Bacillus polymyxa, and Bacillus macerans*. A heat process of 9-15 min at 96^0 C is regarded as adequate for this

purpose, when the pH is between 4.0 and 4.3 (Ramesh, 1995). The need to standardize the processing conditions arises when the behavior of different components is considered because the rate of a chemical reaction generally doubles for every 10^0 C rise or 2 minutes processing time extend where as rates of bacterial destruction increases ten-fold under similar conditions. Glevitzky *et al.,* (2007) studied the use of pasteurization units or equivalent for the quality estimation of fruit juices submitted to different thermal treatments. Thermal process time and sensory evaluation for canned cactus pear nectar was studied by Samahy *et al.,* (2008) and found that requiring a thermal treatment of 115.5^0C, cactus pear nectar is proved to be thermally processed at 100.9^0C for 20 min.

Mango (*Magnifera indica L.*) is a tropical fruit relished for its characteristic flavour and taste. Moreover, India is the leading mango growing country sharing more than 50% of the world's production (FAO, 2012). These mangoes are processed both at raw and ripened stages. The raw fruit, because of its acidic taste, is used for preparing chutneys, pickles etc.; while the ripened fruit is used for preparing squashes, jam, jellies, sorbets, milk-shakes, nectar, mango leather and powder, mango papad, sweet meat, etc., (Kumbhar, 1992). It contains high amounts of β-carotene, a well-known carotenoid, which is responsible for the typical yellow color of the mangoes. Moreover, β-carotene is very beneficial for human consumption as it is a pro vitamin A and antioxidant (Pott *et al.,* 2003)

The major constraint on optimizing procedures is that the desired degree of sterility must be achieved (Holdsworth, 1985). However, more processing time concomitant losses in terms of flavor, color, sensory and nutritional qualities occur when foods are heat treated. Therefore standardizing the processing conditions of ready to drink (RTD) by a thermal processing such as in-pack pasteurization is totally justified. There are many studies on processing of mango pulp in metal containers, polymeric bottles etc. However, there is no systematic study for thermal pasteurization of Ready-to-Drink (RTD) mango nectar in multilayered flexible packaging material and its effect on physico-chemical quality parameters. Therefore the main objectives of this work were to standardize thermal process and determination of *p-value* of Ready-to-Drink (RTD) mango nectar in multilayer laminated pouches and to study the effect of in-pack pasteurization on total carotenes, ascorbic acid, color, native micro flora and other physico-chemical quality parameters of RTD mango nectar.

Materials and methods

Chemicals and Raw materials

All the chemicals were purchased from Sigma Aldrich Chemicals Pvt. Ltd. (Bangalore-India). Fresh ripe Mallika variety (hybridization of the Indian mango varieties Neelum and Dasheri) mango (*Mangifera indica)* purchased from local market at Mysore India. The day before pulping and stored at 4^0C until processing. The fruits were washed with tap water followed by sterile water.

Mango Nectar preparation and processing

Mangoes were deskinned manually pulp cut into pieces, pulped using pulper, diluted, filtered through mesh filters and poured into sterile stainless steel vessel prior to processing. The fresh pulp was diluted (1:1.5) with sterile water and then total soluble solids (^{0}Brix) were adjusted (20 ^{0}Brix) with sucrose followed by acidification (pH 3.3) with citric acid RTD mango nectar (200 ml) was filled in pre-fabricated multilayer laminated pouches consisting of 12 µm Polyethylene terephthalate / 9µm Aluminium foil / 15µm Nylon / 80µm Cast. Polypropylene (Total thickness 116µm) of 200 ml capacity with a dimension of 15 X 20 cm under sterile conditions and hermetically sealed using impulse sealing machine (Model: HP Impulse Sealer, M/s Sunray Industries Mysore, India). The filled, sealed pouches were divided into five lots and treated as follows (Figure 1);

T1: Control (Un treated)
T2: Thermal processing for 420 seconds
T3: Thermal processing for 600 seconds
T4: Thermal processing for 780 seconds
T5: Thermal processing for 900 seconds

Thermal processing

The packed samples were thermally treated using steam jacketed kettle with the help of steel basket with proper closure. The samples of T_2, T_3, T_4 & T_5 batch was thermally treated (in-pack Pasteurization) for the total heating time *(fh)* of 420 s, 600 s, 780 s and 900 s respectively at 96^0C. Heat penetration of the mango nectar was continuously monitored through copper-constantan thermocouples fixed at the geometrical centre of the flexible pouch and the steam jacketed kettle. Thermocouple outputs were connected to a data logger (Model: CTF 9004, M/s. Ellab, Denmark). The temperature of the mango nectar and steam jacketed kettle was measured from the thermo-electro-motive-force at regular intervals of 60 seconds. Once the treatment time was over, samples were immediately removed and placed in running tap water 2-3 minutes for cooling. The total heating time *(fh)* and *p-value* was calculated for all treatments. The thermally processed pouches were tested for sterility and used for further analysis.

Process standardization and P-value determination

The thermal process for RTD mango nectar was standardized for various total heating times *(fh) (*420, 600, 780 and 900 s) at a fixed product temperature of 96^0C. The total heating time *(fh)* was standardized with respect to an inactivation of native micro flora in the mango nectar. The *p-value* was determined using a 6D process of inactivation for *Bacillus coagulans* as well as native micro flora and minimize the degradation of quality characteristics. Generally the load of *Bacillus coagulans* in acid juices/nectars is approx 10^5-10^6 spores. The *D Value* of the *Bacillus coagulans* spores at 96^0C can be up to 1.5 min *and Z Value* is 10^0C (Peng et al., 2012). According to 6D Concept of inactivation, the minimum processing time was 9 mins (D_{96} *Value* X 6D: 1.5 X 6 = 9 mins). The *Z Value, D_{96} Value* and reference temperature were fed into Ellab Val suit Pro software prior to the processing. During processing the time-temperature profile was monitored, recorded and *p-value* was calculated with help of Ellab Val suit Pro software for thermally processed RTD mango nectar.

Various parameters of the samples were analyzed as described below and all the experiments were carried out in triplicate;

Physical properties

The soluble solids (^{0}Brix) were measured using a hand Refractometer (RF.5580 Euromex Brix hand Refractometer). Measurements were performed at 25.0 ± 2^0 C. The refractometer prism was cleaned with distilled water after each analysis.

The pH was determined with a 700 Digital pH meter at 23^0C (Eutech Instruments, Made in Singapore). The pH meter was standardized using pH buffer of 4.0, 7.0 and 10.2.

The *CIE (L* a* b*)* was measured using a Hunter Lab Scan Spectrophotometric colorimeter controlled by a computer that calculates color ordinates from the reflectance spectrum. (Hunter Lab Color Flex EZ $45/0^0$ color spectrophotometer, Made in USA). The results were expressed in accordance with the CIELAB system with reference to illuminant D_{65} and with a visual angle of 10^0. The samples were placed in an optical glass tray, using the white plate of the colorimeter as the background (Standard white plate no. CFEZ0503 X=79.05, Y=84.00, Z=87.76). This background was used to standardize the measurements. The measurements were made through a 30 mm diaphragm.

Viscosity was measured from using 100 ml of Mango nectar juice with rotatory viscometer (Model Rheotech GmbH, Viscosimeter RC 01/02, Made in Germany) having a precision cylindrical spindle (R_2) rotating (UL) adapter. Mango nectar was placed in the UL adapter and viscosity determined at 100 rpm. The viscosity was expressed in centi poise (cP).

Sensory quality was determined using 9 point Hedonic scale rating (Table 1) according to method of Ranganna (1999). For sensory taste and odor evaluation, 20 untrained volunteers were selected. The samples (Treated juices without storage and with storage) were presented in a 100 ml. For characteristics, (Odor, Taste and Over all Acceptability) the judges rated the preferred samples in comparison with control (untreated).

Chemical properties

Ascorbic acid content in mango nectar was estimated following the method of Ranganna (1999). A 10 ml sample of Mango nectar was mixed with 20% Meta phosphoric acid in a pestle and mortar, and transferred to a 100 ml volumetric flask by decantation. Extraction was repeated thrice with a few ml of Meta phosphoric acid and each and made up to the volume with distilled water. 10ml of vitamin C extract was titrated against the standard 2, 6 dichlorophenol indophenol dyes. The Ascorbic acid content of each sample was estimated according to the following equation: Ascorbic acid mg/100ml = T.V x dye factor x volume made up x 100 / volume taken for titration x sample weight. The Ascorbic acid content was expressed as mg /100 ml

Total Carotenoids were determined spectrophotometrically (UV- Spectrophotometer, Spectronic® Genesys™ 2 Instruments, Made in USA) following the method of Ranganna (1999). A 5g sample was mixed with 20ml of acetone and kept in dark for 10-15min, then the contents were filtered through a sintered funnel under suction and 20 ml of acetone was added twice to extract the pigments followed by addition of 20ml of hexane to extract the pigment completely. The combined extract was transfer to a separating funnel. After 5 min the aqueous layer was completely discarded and transferred the hexane layer to 250ml volumetric flask and volume was made up to the mark with hexane. A pinch of anhydrous sodium sulphate was added and absorbance was read at 450nm against hexane as blank. The carotenoid content of each sample was estimated according to the following equation: Absorbance x 250 x1000/250 x Wt of sample. The carotene was expressed as µg /ml.

Microbial analysis

Microbial analysis was carried out as per Rivas *et al.,* (2006). For the microbial counts, samples were serially diluted, plated in total count agar (PCA) for total plate (aerobic) counts, and in acidified Potato dextrose agar (PDA) for molds and yeast counts. Plates were incubated at 30^0C for 48h and 5 days for Total Plate Counts and molds and yeast respectively. Violet Red Bile Agar was used for Coliforms.

Data analysis

All the analyses were carried out in triplicate. The data were analysed statistically to determine standard deviations and significance (Snedecor and Cochran, 1988).

Results and Discussion

Process standardization and p-value determination

The pilot scale production of RTD mango nectar was carried out through the process standardization to reduce the thermal stress without affecting the quality attributes of the product. The total heating time *(fh)* was optimized. The temperature of the product was pre-set to 96^0C and total heating times *(fh)* of 420 s, 600 s, 780 s & 900 s were given for T_2, T_3, T_4 & T_5 respectively. The total heating time *(fh)* with respect to 6D concept of inactivation was calculated as 540 seconds (9 mins) of minimum heating time starting with 420 s and increasing upto 900. The first batch of mango nectar (T_2) was thermally processed at 96^0 C for a total heating time *(fh)* of 420 s achieving a *p-value* of 3.62; however the native micro flora could not be completely inactivated in T_2 and T_3 batches of RTD mango nectar. The fourth and fifth batches of RTD mango nectar (T_4 and T_5) were also processed at 96^0 C for a total heating time *(fh)* of 780 & 900 seconds respectively. The *p-values* of T_4 and T_5 batches were 12.73 and 15.89 respectively. The native micro flora in the T_4 and T_5 batches of RTD mango nectar was totally inactivated. According to the microbial inactivation and maximum retention of total carotenoid as well as ascorbic acid, the T_4 batch (total heating time *(fh)*: 780 s) was standardized to thermally process mango (*Mangifera indica*) nectar in multilayered flexible pouches on a pilot scale. Further the standardized T_4 batch was analysed throughout the ambient storage to evaluate the effect of thermal pasteurization on total carotenoids, ascorbic acid

Effect of thermal processing and storage on Physical properties of Mango nectar

Table 2 results revealed the effect of thermal processing and storage (days) on the physical properties (Total soluble solids (^{0}Brix), pH and CIE Color values of Control (T_1 batch-Untreated) on standardized T_4 batch (96^0C for total heating time *(fh)*: 780 s) of mango nectar. The total soluble solids of mango nectar, increased to 20°

Brix from the 19° Brix after thermal processing. Similarly Tandon *et al.,* (2003) also found that the soluble solids of pasteurized juice were more than in the control juice, which may be due to water evaporation during thermal processing. He also reported that there was no significant change in the total soluble solids during the storage. In this study also total soluble solids remained almost invariable and no significant ($p<0.05$) changes were observed during storage. In another study reported by Bull *et al.,* (2004) also ^{0}Brix did not change significantly during the storage period of thermally processed orange juice. The pH of the RTD mango nectar was not significant ($p>0.05$) affected by storage. It proved that the mango nectar maintained good quality during storage since pH is one of the main quality characteristics that describe the stability of bioactive compounds and quality of fruit juices (Sanchez-Moreno *et al*., 2006).

During thermal pasteurization, the ascorbic acid degradation may take place resulting in an increased in pH of mango nectar over the control (Table 2). Our study was consonant with Bull *et al.,* (2004); he also found that thermally processed Valencia and Navel orange juice did not have any significant modifications, in pH throughout the storage. A similar study has been reported by Rivas *et al*., (2006) showing no pH variations in thermally treated juice (blended orange and carrot juice) during storage. Yeom *et al*., (2000) also did not observe any significant changes in heated orange juice during storage.

The color is one of the important parameters for standardizing processing conditions. Color degradation of RTD mango nectar by thermal processing was investigated using Hunter color lab instrument. The carotene degradation is one of the important factors to cause color change in thermally processed mango nectar. Table 2 represents the CIE Color values of the thermally processed (T_4) mango nectar and control (T_1). The control juice sample had redness (a*), yellowness (b*) and luminosity (L*) values of 0.14 ± 0.005, 20.61 ± 0.005 and 19.62 ± 0.010 respectively. The redness (a*), yellowness (b*) and luminosity (L*) value of mango nectar increased significantly ($p<0.05$) after thermal processing and also throughout the storage. The increase in the Luminosity (L*) values evidently indicated the degradation of carotene pigment in mango nectar. Redness (a*) values were also higher than the control samples. It is due to the decrease in the yellowness. A similar study was performed by Zhang *et al.,* (1997) and they reported a significant ($p<0.05$) color degradation in the heat pasteurized juice samples. The viscosity of the mango nectar has been represented in Figure 3. The reliability of mango nectar expressed in viscosity is essential part for the quality of mango nectar. The viscosity of Control (T_1) and thermally processed (T_4) mango nectar samples was 102 cP and 104 cP respectively as shown in Figure 3. The Shear force (cP) and shear rate (%) was significantly increased during the storage. The thermally processed mango nectar had increased Shear force (cP) and shear rate (%) i.e. 119 ± 0.00 cp and 29.7 respectively. It is due to the water loss during high temperature processing and a similar trend was observed in the case of ambient temperature (27-30^0 C) storage.

The sensory scores were based on the 9 point hedonic scale rating (Table 1) given by the panelists. The overall acceptability (OAA) scores of the control RTD mango nectar were higher (8.8) (Table 3). During storage the sensory scores declined significantly ($p<0.05$). The color may be the main factor to bring down the panelist scores of the mango nectar. It is due to the effect of thermal processing however RTD mango nectar was acceptable after 180th day of storage under ambient (27-30^{0}C) temperature conditions. Studies reported by Min & Zhang (2003); Dunn and Pearlman (1987) also showed similar trends. The thermally processed RTD mango nectar had significant ($p<0.05$) lower overall acceptability scores.

Effect of thermal processing and storage on chemical properties of Mango nectar

Ascorbic acid content of fresh RTD mango nectar was found to be 9.2 ± 0.005 mg/100ml. While thermally treated (T_4) samples had 5.174 ± 0.005. Ascorbic acid is a highly labile vitamin which degrades very easily on exposure to heat, air and light. The thermal processing leads to a significant ($p<0.05$) degradation in the Ascorbic acid content (Figure 4). After thermal processing degradation was found to be 43.7 %. Further it was reduced up to 75.26 % during storage. Our results are in accordance with authors Elez-Martinez and Martin-Belloso (2007); Odriozola-Serrano *et al.,* (2009) who studied the Vitamin C losses in orange and strawberry juices respectively.

The major carotenoids, which are responsible for the colour of fresh and pasteurized mango nectar (Pott *et al*., 2003), were measured by Spectrophotometric method and have been represented in Figure 5. Total carotenoid content was 21.6 ± 0.5 µg/ml for fresh juice. In pasteurized (T_4) RTD mango nectar, total pigment content decreased to 16.43 ± 0.057 µg/ml, resulting in a significant ($p<0.05$) loss 23.93%. During storage carotene content was further decreased by 63.05%.

Effect of thermal processing and storage on micro flora

The native micro flora in case of T_2 and T_3 treatments (at 96^0 C for a total heating time *(fh)* of 420 and 600 seconds) was not completely inactivated, T_2 and T_3 samples had a total plate count of 3.0, 1.77 log CFU/ml, 2.00, Nil CFU/ml Coliforms and 1.90, 1.07 CFU/ml Yeast and moulds while the control (T_1) had a microbial load of 6.59, 6.46 and 4.38 log CFU/mL for total plate count, coliforms and yeast and moulds respectively (Figure 6). The T_4 and T_5 treatments were completely inactivated the native micro flora of RTD mango nectar and throughout the storage no microbial counts were detected. Similar results have been reported by Fontanet *et al.,* (2013) who studied the thermally processed grape juices and found the microbial counts to drastically decrease in thermally processed grape juice.

Table 1: 9 point hedonic scale used for evaluation of RTD Mango nectar Sensory

Score/Rating	Standard Hedonic Scale
9	Like Extremely
8	Like Very Much
7	Like Moderately
6	Like Slightly
5	Neither like nor dislike
4	Dislike Slightly
3	Dislike Moderately
2	Dislike Moderately
1	Dislike Extremely

Table 2: Effect of thermal processing and storage on Physical properties of RTD Mango nectar

Storage Days	°Brix	pH	Hunter Color Values		
			L*	a*	b*
Control	19	3.31 ± 0.00	19.62 ± 0.010	0.14 ± 0.005	20.61 ± 0.005
0	20	3.47 ± 0.00	28.52 ± 0.010	0.24 ± 0.005	15.61 ± 0.005
15	20	3.47 ± 0.00	28.54 ± 0.010	0.35 ± 0.005	14.84 ± 0.011
30	20	3.47 ± 0.00	29.14 ± 0.005	0.45 ± 0.005	14.57 ± 0.063
45	20	3.48 ± 0.00	29.85 ± 0.005	0.59 ± 0.005	14.20 ± 0.057
60	20	3.48 ± 0.00	30.14 ± 0.005	0.61 ± 0.010	13.94 ± 0.023
75	20	3.48 ± 0.00	31.15 ± 0.005	0.71 ± 0.005	13.85 ± 0.057
90	20	3.49 ± 0.00	31.24 ± 0.005	0.72 ± 0.005	13.78 ± 0.050
105	20	3.49 ± 0.00	32.15 ± 0.005	0.70 ± 0.010	13.68 ± 0.057
120	20	3.49 ± 0.00	32.24 ± 0.010	0.73 ± 0.005	13.52 ± 0.050
135	20	3.50 ± 0.00	33.15 ± 0.005	0.71 ± 0.005	13.42 ± 0.057
150	20	3.49 ± 0.00	34.15 ± 0.023	0.71 ± 0.005	13.12 ± 0.057
165	20	3.49 ± 0.00	35.00 ± 0.005	0.73 ± 0.010	12.55 ± 0.050
180	20	3.48 ± 0.00	35.15 ± 0.010	0.74 ± 0.005	12.12 ± 0.058

Mean ± SD

Table 3: Effect of thermal processing and storage on Sensory Quality of RTD Mango nectar

Storage Days	Colour	Flavour	Taste	OAA
Control	8.9 ± 0.45	8.7 ± 0.48	8.9 ± 0.46	8.8 ± 0.012
0	8.8 ± 0.42	7.9 ± 0.47	8.1 ± 0.52	8.2 ± 0.050
15	8.7 ± 0.74	7.9 ± 0.47	8.1 ± 0.92	8.2 ± 0.220
30	8.7 ± 0.32	7.8 ± 0.47	8.0 ± 0.52	8.1 ± 0.100
45	8.5 ± 0.44	7.8 ± 0.37	8.0 ± 0.72	8.1 ± 0.180
60	8.4 ± 0.74	7.7 ± 0.44	7.9 ± 0.52	8.0 ± 0.150
75	8.3 ± 0.47	7.7 ± 0.74	7.9 ± 0.42	7.9 ± 0.170
90	8.2 ± 0.92	7.6 ± 0.48	7.8 ± 0.67	7.8 ± 0.220
105	8.1 ± 0.74	7.5 ± 0.47	7.7 ± 0.92	7.7 ± 0.220
120	8.0 ± 0.92	7.8 ± 0.57	7.6 ± 0.83	7.8 ± 0.180
135	7.8 ± 0.42	7.4 ± 0.70	7.5 ± 0.71	7.5 ± 0.160
150	7.6 ± 0.98	7.2 ± 0.87	7.5 ± 0.82	7.4 ± 0.080
165	7.4 ± 0.48	7.0 ± 0.42	7.4 ± 0.80	7.2 ± 0.200
180	7.4 ± 0.52	6.9 ± 0.57	7.4 ± 0.70	7.2 ± 0.090

Mean ± SD

Figure 1: Flow diagram for methodology and treatments applied to RTD Mango nectar

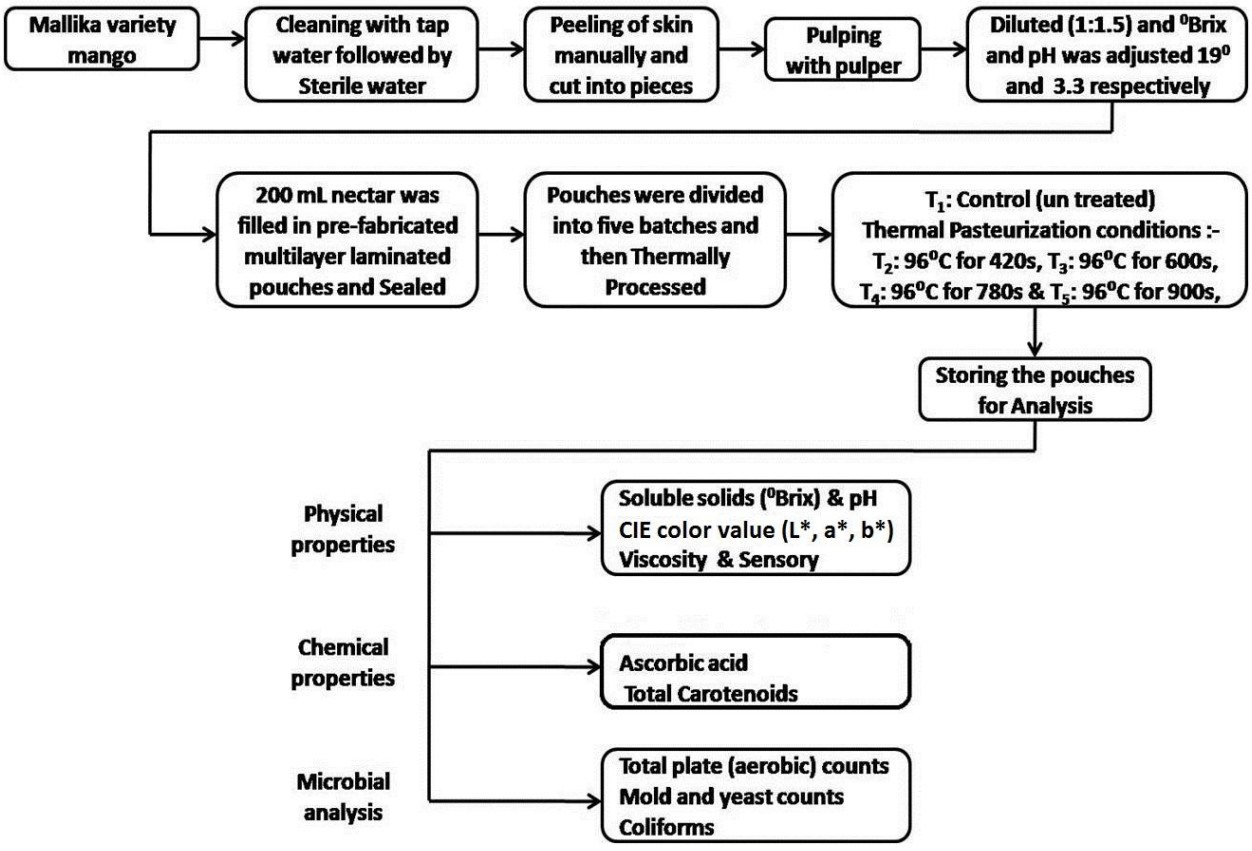


Figure 2: Heat Penetration studies and P_0 values determination of RTD Mango nectar

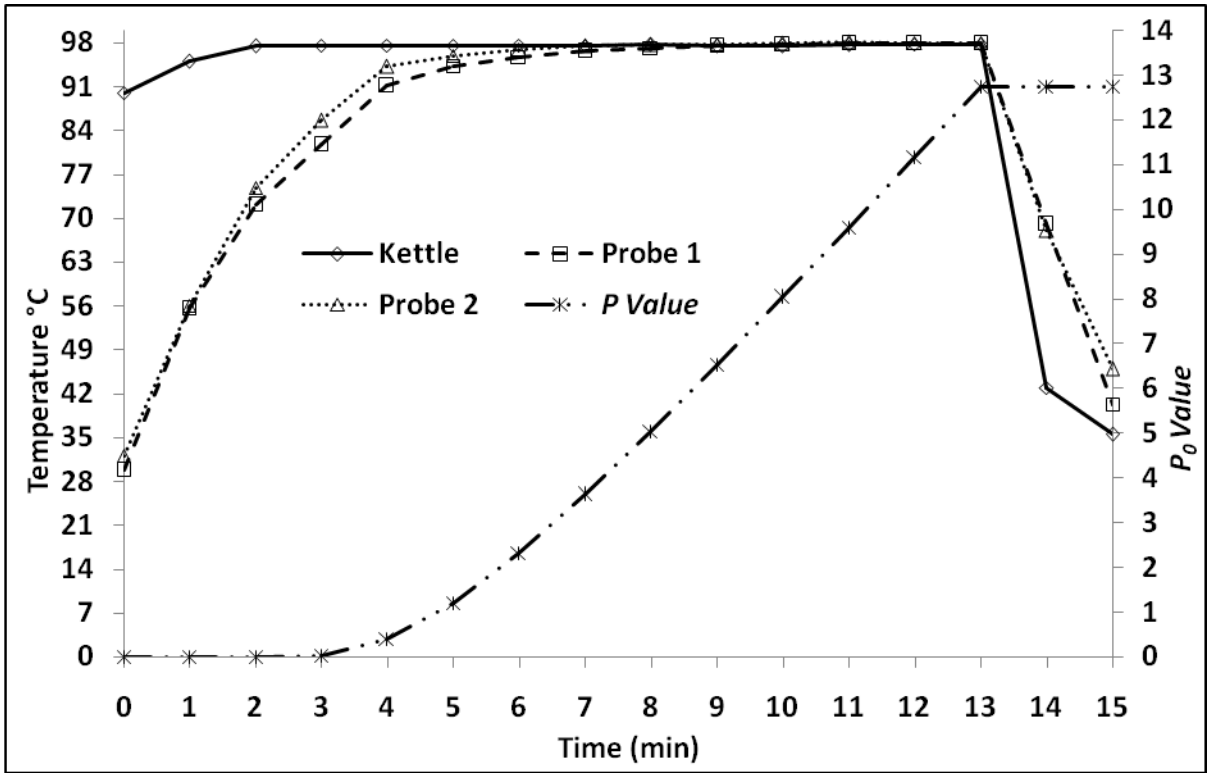


Figure 3: Effect of thermal processing and storage on Viscosity of RTD Mango nectar

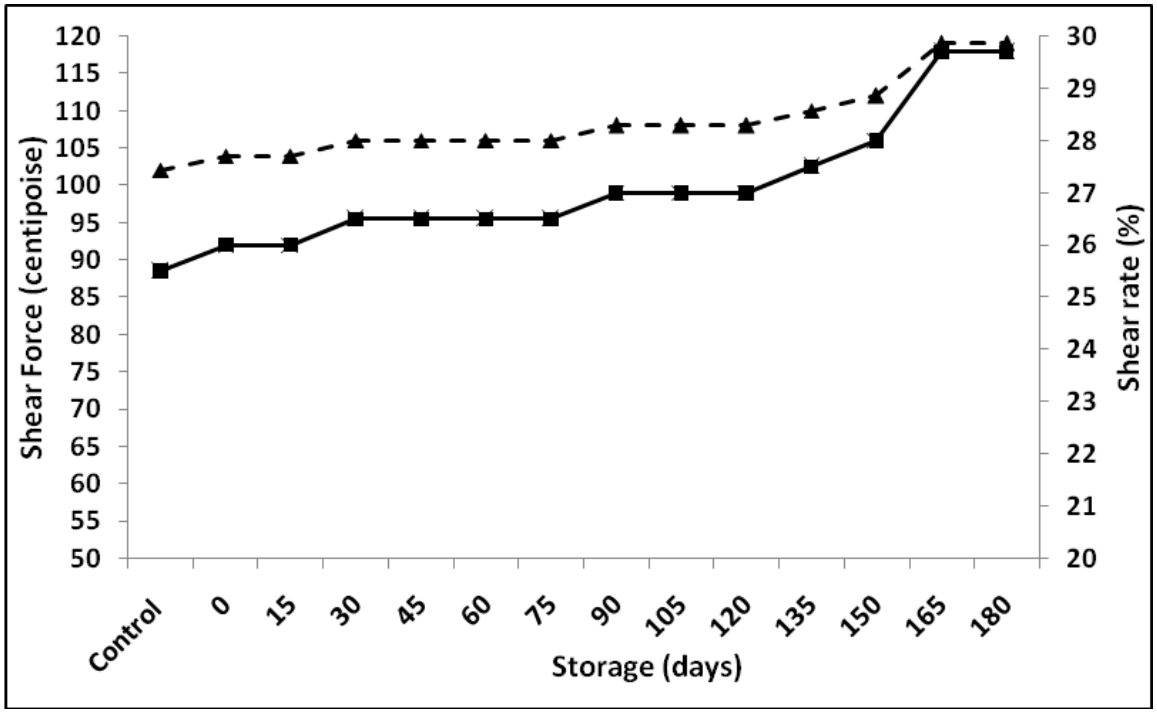


Figure: 4 Effect of thermal processing and storage on Ascorbic acid content of RTD Mango nectar

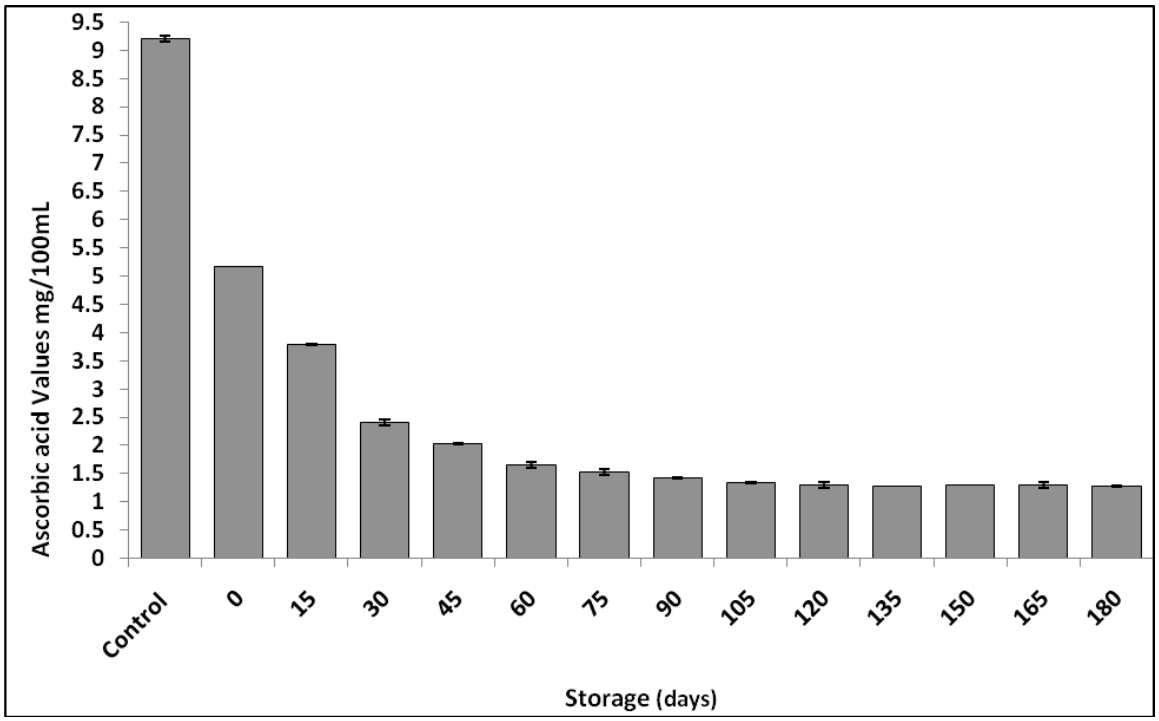


Figure: 5 Effect of thermal processing and storage on Carotenoids in RTD Mango nectar

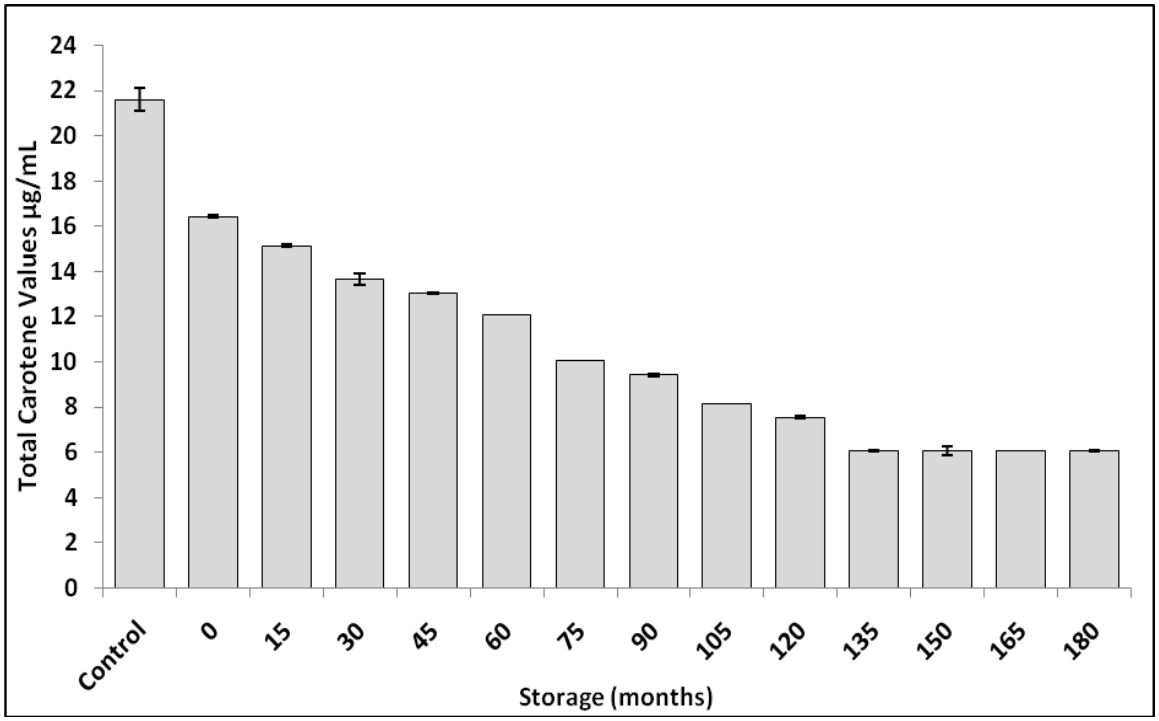
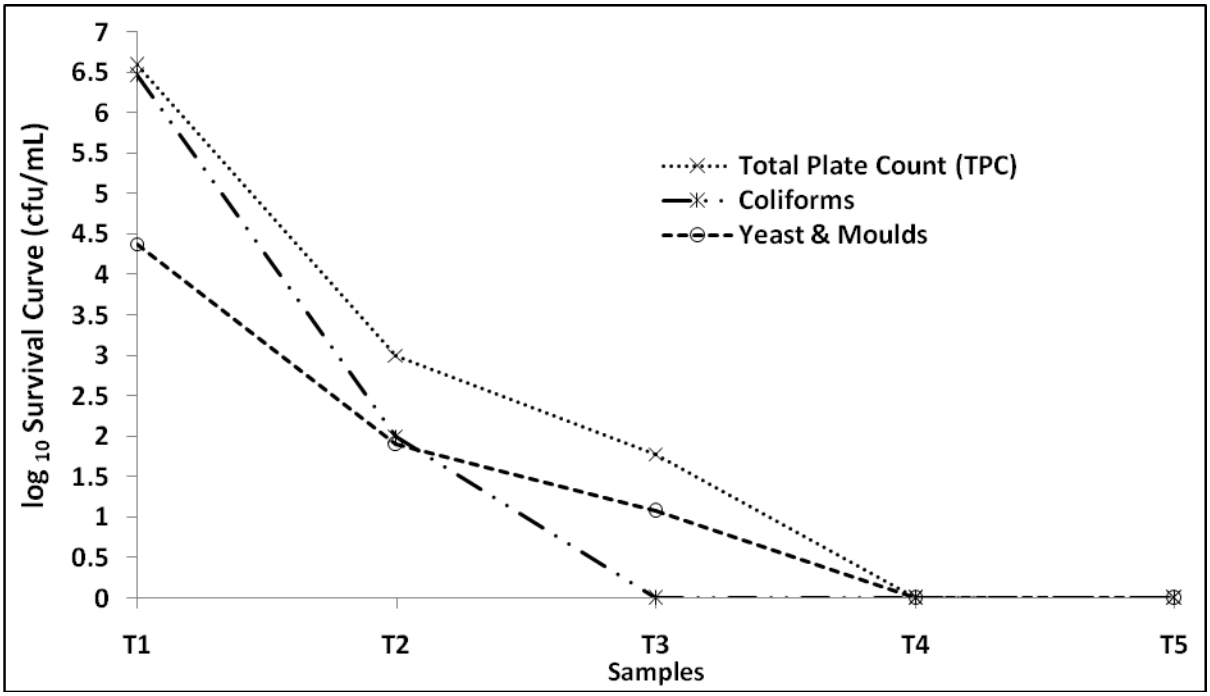


Figure: 6 Effect of thermal processing on Micro flora of Control (T_1) and (T_2, T_3, T_4 & T_5) treated RTD Mango nectar



Conclusion

Standardization of process condition and quality degradation of RTD mango nectar due to thermal processing was studied. The standardized T_4 batch with total heating time (*fh*) of 780 s in-pack processing lead to the minimal degradation of color, carotene content, ascorbic acid content and complete inactivation of micro flora in RTD mango nectar. The color, carotene content, ascorbic acid content and sensory scores of the mango nectar were significantly ($p<0.05$) reduced during 180 days of ambient (27-30^{0}C) temperature storage, but still the quality of the nectar was good upto 180 days. It is concluded that thermal processing at 96^0 C for a total heating time *(fh)* of 780 s with *p-value* of 12.73 would be a good method to produce microbiologically stable mango nectar with the good retention of quality attributes.

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