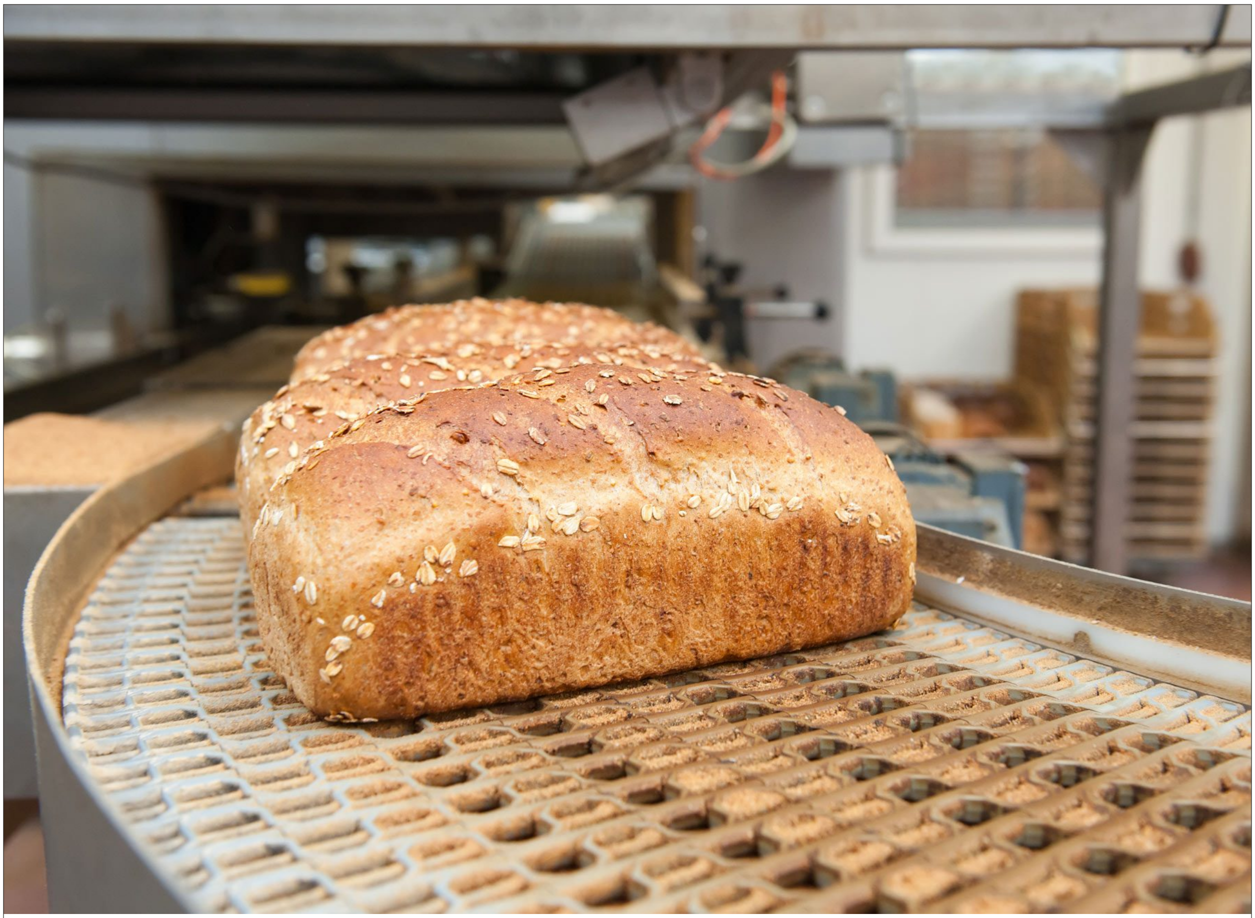

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Development of Stable Restructured Mango Gel

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Abstract: Restructured mango gel was prepared by alginate texturization of mango pulp using sodium alginate, glucono-δ-lactone and calcium hydrogen orthophosphate. The requisite quantities of the chemical additives were mixed, added together to the neutralized mango pulp in a mixer and allowed to set at 4°C for 16 h. The mango gel was cut into 1.5 cm cubes and stabilized by Hurdle Technology (HT) through adjustment of water activity to 0.89, pH 4.4 and pasteurization in polypropylene pouches. Storage studies were carried out in foil laminate packs at three different temperatures i.e. 4°C, RT (20-33°C) and 37°C and evaluated for chemical parameters, Hunter colour values as well as microbiological and organoleptic characteristics. Studies showed that HT preserved texturized mango gel could be kept in acceptable condition up to 12 months at RT and 6 months at 37°C. During storage a considerable reduction in sulphur dioxide, carotenoids and an increase in acidity were observed. Decrease in L, a, b values was also observed in all the samples stored under different temperatures. The product was also found to be microbiologically stable and safe up to 12 m.

Key words: Mango, restructured, hurdle technology, texturization, gel, alginate

INTRODUCTION

Mango is one of the most popular and highly prized desert fruit of the tropics. It is liked by the people for its rich luscious aromatic flavour and a delicious taste with evenly blended sweetness and acidity. Nutritionally, it is a rich source of carotenoids, organic acids, polyphenols, minerals etc. India produces 10.8 million metric ton of mango annually (FAO, 2004). Most of the mangoes are consumed as fresh. In India both raw and ripe mangoes are used for making various product like pickle, mango bar, canned mango slices, canned mango pulp, nectar squashes, ready-to-serve beverage, juice, jam, osmotically dehydrated mango etc. (Ramteke *et al*., 1999). However the major product processed for export is canned mango pulp followed by mango chutney and canned slices in brine. Although the export trade on mango products worldwide is meager compared to orange, pineapple etc, the research efforts on extension of shelf life and value addition to mango as well as improvement in quality are continued. Effect of various coating materials and formulations on the shelf life of mangoes during storage has been evaluated (Thittoa *et al*., 2002; Nuzab *et al*., 2005). Martinez-Ferrer *et al*. (2002) conducted studies on modified atmosphere packaging of minimally processed mango and reported that the shelf life could be extended upto 25 days at 5°C with good colour, flavour, aroma and texture. Effect of different hydrocolloids on the quality of mango product has been investigated by Gujral and Brar (2003). Jaya and Das (2004) reported the effect of maltodextrin, glycerol mono stearate and tricalcium phosphate on vacuum dried mango powder. Quality attributes of mango soy fortified yoghurt with added stabilizer has been discussed by Pradyuman and Mishra (2004). In spite of so many products from mango available commercially the scope for development of value added products

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is quite open considering the enormous production of different varieties of mango in India. Development of value added product by alginate texturization of fruit pulp has been known for many years (Luh *et al*., 1976; Hannigan, 1983; Glicksmann, 1983). Sodium alginate is chosen as a suitable hydrocolloid because of its ability to form thermostable gel which facilitates further processing by thermal treatment. Alginate texturization of fruit pulp and juices has already been reported (Nussinovitch and Peleg, 1990; Kaletune *et al*., 1990; Moquet *et al*., 1992). Fruit-alginate interactions and their effect on gel formation are reviewed with regards to the use of these gels in novel, restructured fruit product (Mancini and McHugh, 2000).

However most of these studies involved textural characteristics of the gel rather than their physico chemical, sensory and shelf stability characteristics.

The objective of the present investigation was to develop a shelf stable product from mango by alginate texturization and subsequent processing to evaluate the same during storage under different temperature conditions.

MATERIALS AND METHODS

Processing

Canned mango pulp (Badami variety) in tin cans (A1) was purchased from the local manufacturer (M/s Globe Foods Limited, Mysore) and used for texturization at our laboratory Mysore, INDIA. Total soluble solids, pH and acidity of the pulp were 18° Brix, 3.9 and 0.28%, respectively. The process flow diagram for restructuring of mango pulp as well as its stabilization is given in Fig. 1. In brief the process consist of neutralization, addition of chemical additives i.e. sodium alginate (Across) glucono-δ-lactone (Sigma) and calcium hydrogen phosphate (Across) and blending. The mixture was allowed to set for 16 h at 5°C, cut into 1.5 cm cubes and stabilized by hurdle technology as described by Jayaraman *et al*. (1997) by soak infusion for 4 h in a sugar solution (70° B) containing citric acid and potassium metabisulphite. The osmosed cubes after draining were packed in polypropylene pouches (300 G; 50 g) and pasteurized for 20 min in boiling water.

Mango pulp

↓

Neutralized with 2M NaOH

↓

TSS contents was adjusted to 25°B

↓

Blended with chemical additives

↓

Kept for gel setting

↓

Cut the gel into 1.5 cm cubes

↓

Stabilized by hurdle technology

↓

Packed in PP and pasteurized

↓

Stored under different temperature conditions

Fig. 1: Flow diagram for the preparation of resturctured mango gel

Analytical Methods

Moisture was determined by drying in a vacuum oven (Pathak electrical, Mumbai) at 60°C. Total soluble solids were measured using hand refractometers (Erma, Japan) of 0-28° B and 28-54° B ranges and expressed as °Brix. pH of the macerated sample was measured with a digital pH meter (Century, India). Titratable acidity was determined by titrating against 0.1N NaOH upto a pH of 8.4 using digital pH meter (AOAC, 1980). Reducing and total sugar contents were determined by Lane and Eynon method as reported by Ranganna (1986). Total carotenoids in the sample were determined as described by Ranganna (1986). Sulphur Dioxide was estimated by AOAC (1980) method using rosaniline hydrochloride.

Colour parameters of the product were measured by a colour difference meter, Chromoflash (Model 2810, Ashco, India) using 10° standard observer and illuminant D65 and expressed as L, a, b, c and h where L represents lightness index; a and -a, redness and greenness, respectively; b and-b, yellowness and blueness, respectively; c and h, chroma and hue according to Hunter L, a, b system.

Storage Studies

The inpack pasteurized samples were further packed in paper (60 gsm)-aluminium foil (0.02 mm)-polyethylene (75 μ) (PFP) laminated pouches and kept for storage under three different temperature conditions of low temperature (0-5°C), ambient temperature (RT, 20-33°C) and 37°C. Samples were taken out every two months and subjected to sensory evaluation and physico-chemical analyses. Microbiological analysis initially and during storage for Total Plate Count (TPC), coliform, spores, yeast and mold was carried out, using the methods recommended by APHA (1976).

Sensory Evaluation

Sensory evaluation of each sample at each time interval, from either of the storage temperature conditions was carried out by ten-semi trained panelists drawn from the scientific staff of the laboratory for colour, aroma, taste, texture and overall acceptability using a nine point hedonic scale as recommended by IS 6273 (1971) where 9 was equivalent to like extremely and 1 dislike extremely.

Statistical Analysis

The data obtained from both the physico-chemical analysis and the sensory evaluations were analysed statistically for analysis of variance (ANOVA) using a Completely Randomized Design (CRD) and Least Significant Difference (LSD) at $p \leq 0.05$ using Software (Stat Soft, USA).

RESULTS AND DISCUSSION

Preliminary experiments on the basis of trial and error involving sensory evaluation showed that 90 % pulp was suitable to obtain a gel of acceptable quality from alginate texturized mango pulp. Though it was observed that the gel formation took place at all level of mango pulp, we have attempted a higher pulp level to obtain a gel product with good flavour and taste characteristic product. So that maximum pulp level was used for the gel formation. In our experiment we found that using high level of pulp (90%) did not affect the gel strength as was observed by Mouquet *et al*. (1992). However, the concentration of alginate was kept at 1% considering the texture of the gel so that it can withstand thermal stabilization during further processing. The process for gel formation depended on a controlled reaction where soluble sodium alginate reacted with sparingly soluble calcium salt under conditions of suitable pH and and concentration. Rate of reaction is very critical for smooth gel formation. Rapid lowering of pH as well as release of calcium generally produces the grainy texture. The choice of calcium salt is also very important (Glicksman, 1969). Hence in our process neutralization, addition of glucano-δ-lactone and calcium hydrogen orthophosphate facilitated in obtaining a smooth as well as firm gel.

The gel was subsequently stabilized by hurdle technology using these hurdles viz., pH, a_w and in pack pasteurization. A pH just below 4.37 was achieved using citric acid in the soaked solution for 2½ h. During the same period the a_w 0.84 was achieved. The soaked material was pasteurized in polypropylene pouches for 20 min, so that the integrity of the restructured cubes was not affected. Restructured mango gel when processed by hurdle technology was found to have water activity of 0.89 and pH 4.37. It was reported earlier by Kaletunc *et al.* (1990) as well as Nussinovitch and Paleg (1990) that large quantities of fruit pulp produced weak gel and were not texturally very effective. Mouquet *et al.* (1992) adjusted the brix level of the pulp used for gelation at 50°C. So that the high soluble dry matter content was achieved which could reduce the cost of drying stage if required and process was carried at higher temperature. However in our investigation we have achieved the gel formation at 20° brix at low temperature and utilize the same gel for further stabilization by soaking in a 70° brix sugar solution. The °brix of the final stabilized gel was found to be 45°, so that the flavour of mango is not affected much.

It was observed that during 12 months storage at 5°C, RT (20-33°C) and 37°C, moisture, pH, sulphur dioxide and carotenoids decreased whereas °brix and acidity increased steadily (Table 1). Changes in these parameters were highest at 37°C followed by RT and 5°C. Increase in acidity and lowering of pH might be due to liberation of acid from glucono-δ-lactone in water. Reduction in moisture content in the sample may be due to syneresis which in turn increased the °brix. Loss of sulphur dioxide was found to be drastic particularly at RT and 37°C. Loss of SO_2 was found to be significant ($p \leq 0.05$) at both RT and 37°C while loss of carotenoids was significant at 37°C. In general it was observed that changes in all the physico chemical parameters were more significant at 37°C as compared to those at 5°C and RT.

Colour Parameters

'L' value which indicates lightness decreased with storage time as well as temperature. Changes in 'L' value of the samples kept at 5°C were not substantial while it was quite considerable at both RT

Table 1: Changes in the physicochemical properties of restructured mango stored under different temperature conditions (n = 3)

Storage period (months)		Moisture (%)	°Brix	pH	Acidity (%)	SO_2 (ppm)	Carotenoid (mg/100 g)
Initial		47.48^{a}	45.00^{a}	4.37^{a}	0.78^{a}	280.64^{a}	22.92^{a}
	5°C	47.21^{a}	46.20^{a}	4.36^{a}	0.79^{a}	268.79^{b}	23.02^{a}
2 m	RT	46.93^{a}	46.20^{a}	4.36^{a}	0.80^{a}	182.14^{g}	21.88^{a}
	37°C	46.54^{a}	46.20^{a}	4.36^{a}	0.82^{a}	94.48^{h}	20.16^{b}
	5°C	46.94^{a}	46.80^{a}	4.35^{a}	0.82^{a}	251.57^{c}	23.16^{a}
4 m	RT	46.12^{b}	47.00^{b}	4.34^{a}	0.84^{a}	72.73^{i}	21.23^{a}
	37°C	45.91^{b}	47.00^{b}	4.32^{b}	0.88^{b}	61.20^{j}	20.00^{b}
	5°C	45.90^{b}	47.20^{b}	4.31^{b}	0.84^{a}	225.00^{d}	21.65^{a}
6 m	RT	45.83^{b}	47.40^{b}	4.30^{b}	0.85^{a}	68.05^{j}	19.84^{b}
	37°C	45.21^{c}	47.40^{b}	4.26^{c}	0.88^{b}	54.57^{k}	17.97^{c}
	5°C	45.82^{b}	47.80^{c}	4.29^{b}	0.86^{a}	215.93^{e}	19.45^{b}
8 m	RT	45.21^{c}	47.80^{c}	4.26c	0.87^{a}	42.50^{l}	17.04^{c}
	37°C	44.01^{d}	48.20^{c}	4.23^{d}	0.89^{b}	12.48^{n}	17.29^{c}
	5°C	45.21^{c}	48.20^{c}	4.28^{c}	0.89^{b}	211.80^{e}	17.96^{c}
10 m	RT	44.81^{d}	48.60^{d}	4.25^{d}	0.91^{b}	27.20^{m}	15.72^{d}
	37°C	-	-	-	-	-	-
	5°C	45.00^{c}	48.80^{d}	4.27^{c}	0.90^{b}	193.71^{f}	17.16^{c}
12 m	RT	44.13^{d}	49.00^{d}	4.20^{d}	0.93^{b}	27.84^{m}	9.68^{e}
	37°C	-	-	-	-	-	-

Means with same superscript within same coloumn are not significantly different at $p \leq 0.05$

and 37°C. Decrease in 'L' value indicated darkening of the sample colour as the storage progressed. The same was reflected in case of 'a' value (redness) which showed increasing trend as the storage time advanced as well as under higher storage temperatures. Decrease in 'L' values and increase in 'a' values indicated browning of the product during storage (Table 2). Generally high water activity in the range of 0.7-0.9 favours the development non-enzymatic browning a higher rate (Williams, 1976). Increase in browning could also be due to substantial loss of sulphur dioxide during storage (Table 1). The decrease in yellowness or 'b' value during storage may be attributed to loss of carotenoids. Chroma (C) or saturation index equivalent to purity in the CIE system, steadily decreased during the entire storage period from its initial value of 32.02 to 26.12 (at RT) and 22.51 (at 37°C) at the end of 12 m storage. Magnitude of decrease was found to be higher at 37°C. Hue angle (h), measures the shift in colour from the a axis, the decrease in 'h' signifies the increase in red colour. In this case 'h' was found to decrease steadily as the storage progressed.

Sensory Evaluation

Sensory characteristics of shelf stable restructured mango in terms of colour, aroma, taste, texture and overall acceptability have been presented in Table 3. The scores in hedonic scale obtained periodically at two months interval upto 12 m under three different temperature conditions were statistically evaluated. Gradual decrease in the scores of all the attributes was observed as the storage time progressed. Significant differences ($p \leq 0.05$) were noticed in case of colour, aroma and OAA at 37°C as compared to those in case of 5°C and RT stored samples from 4 m storage onwards. However in case of taste and texture significant differences were observed from 6 and 8 m storage onwards, respectively. It may be inferred that colour and aroma influenced the OAA more than taste and texture. Texture was found to be less influenced by the temperature. It may be concluded from the overall acceptability score that the product was acceptable organoleptically upto 12 m at room temperature and 6 m at 37°C.

Microbiological Analysis

The data in Table 4 showed that TPC, coliform, spores, yeast and mold were negligible initially as well as during storage up to 12 m under all the temperature conditions. It indicate that hurdles applied i.e. a_w, pH and pasteurization were quite effective to stabilize the product microbiologically.

Table 2: Changes in the colour values of restructured mango stored under different temperature conditions (n = 3)

Storage period (months)		L	a	b	c	h
Initial		75.006	8.571	30.852	32.020	74.476
	5°C	74.012	8.637	29.911	31.133	73.893
2 m	RT	71.504	9.021	27.903	29.325	72.083
	37°C	69.214	9.928	24.275	26.227	67.756
	5°C	72.468	8.934	28.658	30.018	72.687
4 m	RT	69.214	9.865	26.216	28.011	69.375
	37°C	65.432	10.106	23.002	25.124	66.281
	5°C	70.915	9.859	26.321	28.107	69.467
6 m	RT	67.668	10.732	25.118	27.315	66.861
	37°C	60.323	11.568	20.716	23.727	60.823
	5°C	70.115	10.031	25.171	27.096	68.269
8 m	RT	65.060	11.532	24.343	26.936	64.653
	37°C	58.288	12.021	19.621	23.011	58.502
	5°C	69.263	11.238	24.692	27.129	65.527
10 m	RT	64.218	12.479	23.723	26.805	62.254
	37°C	57.133	12.989	18.563	22.656	55.016
	5°C	58.625	12.063	23.051	26.017	62.378
12 m	RT	62.864	12.989	22.659	26.118	60.170
	37°C	55.289	13.614	17.932	22.514	52.791

Table 3: Changes in the over all acceptability scores of restructured mango stored under different temperature condition (n = 10)

		Colour	Aroma	Taste	Texture	OAA
Initial		7.73 ± 0.79^{a}	7.87 ± 0.32^{a}	7.60 ± 0.53^{a}	7.30 ± 0.48^{a}	7.67 ± 0.48^{a}
	5°C	7.92 ± 0.74^{a}	7.75 ± 0.42^{a}	7.80 ± 0.42^{a}	7.50 ± 0.52^{a}	7.89 ± 0.32^{a}
2 m	RT	7.33 ± 0.82^{a}	7.25 ± 0.62^{a}	7.40 ± 0.52^{a}	7.25 ± 0.62^{a}	7.25 ± 0.48^{a}
	37°C	6.33 ± 1.16^{b}	6.42 ± 0.70^{b}	6.42 ± 0.70^{a}	6.67 ± 0.67^{a}	6.50 ± 0.53^{b}
	5°C	7.92 ± 0.32^{a}	7.42 ± 0.70^{a}	7.67 ± 0.31^{a}	7.38 ± 0.52^{a}	7.92 ± 0.32^{a}
4 m	RT	6.92 ± 0.74^{a}	7.00 ± 1.05^{a}	7.60 ± 0.52^{a}	6.74 ± 0.48^{a}	7.20 ± 0.63^{a}
	37°C	5.23 ± 1.05^{c}	5.90 ± 1.20^{b}	6.70 ± 1.30^{a}	6.34 ± 0.95^{a}	6.00 ± 0.88^{b}
	5°C	8.00 ± 0.47^{a}	7.54 ± 0.70^{a}	7.80 ± 0.42^{a}	7.28 ± 0.73^{a}	7.81 ± 0.42^{a}
6 m	RT	6.77 ± 0.63^{a}	6.85 ± 0.92^{a}	7.62 ± 0.52^{a}	6.62 ± 0.74^{a}	6.92 ± 0.82^{a}
	37°C	4.15 ± 0.79^{d}	5.85 ± 1.32^{b}	6.00 ± 0.94^{b}	6.23 ± 1.32^{a}	6.00 ± 1.37^{b}
	5°C	8.00 ± 0.67^{a}	7.90 ± 0.57^{a}	7.94 ± 0.57^{a}	7.34 ± 0.48^{a}	8.16 ± 0.32^{a}
8 m	RT	6.80 ± 0.63^{a}	6.40 ± 0.97^{b}	6.65 ± 0.97^{a}	6.92 ± 1.10^{a}	6.87 ± 0.92^{a}
	37°C	4.80 ± 1.48^{d}	5.20 ± 1.48^{c}	4.82 ± 1.32^{c}	5.61 ± 1.17^{b}	5.20 ± 1.40^{c}
	5°C	7.80 ± 0.42^{a}	7.51 ± 0.53^{a}	7.50 ± 0.53^{a}	7.41 ± 0.70^{a}	7.53 ± 0.53^{a}
10 m	RT	6.50 ± 0.85^{b}	6.23 ± 0.92^{b}	6.31 ± 0.82^{a}	6.63 ± 0.70^{a}	6.31 ± 0.82^{b}
	37°C	-	-	-	-	-
	5°C	7.62 ± 0.52^{a}	7.42 ± 0.82^{a}	7.43 ± 0.27^{a}	7.33 ± 0.52^{a}	7.32 ± 0.83^{a}
12 m	RT	6.38 ± 0.67^{b}	6.00 ± 0.94^{b}	6.12 ± 0.37^{a}	6.42 ± 0.57^{a}	6.01 ± 0.94^{b}
	37°C	-	-	-	-	-

Means with same superscript within same coloumn are not significantly different at $p\leq0.05$

Table 4: Changes in the microbial content of restructured mango stored under different temperature conditions (n = 3)

Storage period (months)		TPC	Coliform	Spores 37°C	Spores 55°C	Yeast and mold
Initial		1.0×10	Nil	Nil	Nil	Nil
	5°C	Nil	Nil	2.0×10	Nil	Nil
2 m	RT	Nil	Nil	Nil	Nil	2.0×10
	37°C	2.5×10	Nil	Nil	Nil	8.5×10
	5°C	4.0×10	Nil	Nil	Nil	1.5×10
4 m	RT	2.5×10	Nil	Nil	Nil	Nil
	37°C	2.0×10	Nil	2.0×10	Nil	Nil
	5°C	Nil	Nil	Nil	Nil	Nil
6 m	RT	Nil	Nil	Nil	Nil	1.0×10
	37°C	1.5×10	Nil	Nil	Nil	Nil
	5°C	Nil	Nil	Nil	Nil	Nil
8 m	RT	Nil	Nil	Nil	Nil	Nil
	37°C	2.0×10	Nil	Nil	Nil	1×10
	5°C	Nil	Nil	Nil	Nil	Nil
10 m	RT	Nil	Nil	Nil	Nil	Nil
	37°C	1.0×10	Nil	Nil	Nil	Nil
	5°C	Nil	Nil	Nil	Nil	Nil
12 m	RT	Nil	Nil	Nil	Nil	Nil
	37°C	Nil	Nil	Nil	Nil	1×10

CONCLUSION

A shelf stable restructured mango product can be developed by alginate texturization and stabilized using a_w, pH and pasteurization as well as the product was acceptable up to 12 m under ambient (20-33°C) and 6 months at 37°C temperature conditions when packed in polypropylene followed by foil laminate pouches. The product was also microbiologically stable during the storage period. The most significant conclusion may be drawn from our investigation was the stability of the hurdle process restructured mango gel i.e., 12 m at ambient temperature and 6 m at 37°C.

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