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Shanthi K
Associate Professor (FSN), Department of Food Science and Nutrition, Community Science College and Research Institute, Madurai, Tamil Nadu Agricultural University, India

Banumathi P
Former Professor, PHTC, Community Science College and Research Institute, Tamil Nadu Agricultural University, Madurai, Tamil Nadu, India

Dr. S. Amutha
Dean, Community Science College and Research Institute, Madurai, Tamil Nadu Agricultural University, India

Corresponding Author:
Shanthi K
Associate Professor (FSN), Department of Food Science and Nutrition, Community Science College and Research Institute, Madurai, Tamil Nadu Agricultural University, India

Storage stability of pulse protein enriched mango bars in different packaging materials

Shanthi K, Banumathi P and S Amutha

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Abstract
Mango pulp is good source of carbohydrates, vitamin C and inorganic potassium, but lacks in protein and fat and therefore it is not considered to be nutritionally complete food. On the other hand, green gram contains 23.33 g protein and 1.17 per cent fat and easily digested when consumed as food. The direct use of green gram in food products results in the incorporation of protein and calories. It has great potential to provide good quality protein and calorie at low price and helps in combating protein-calorie malnutrition in the country. The present study was carried out to develop pulse protein enriched mango bars from mango variety (Neelum) with green gram flour. The developed bars were packed in different packaging materials such as, metallised polyester poly ethylene laminate pouches (MPP), poly propylene 250 gauge (P_2) and 150 gauge (P_3) and stored at room temperature to study the storage behaviour. During storage, there was a reduction in ascorbic acid, β-carotene, total sugars, moisture, pH, protein, fat, crude fibre and total ash, whereas an increase was found in acidity, reducing sugars, TSS contents in all the samples. The bar samples stored in MPP (P_1) recorded higher percentage of nutrient with good organoleptic qualities and minimum microbial count at the end of the storage period (six months).

Keywords: Neelum variety, pulse protein, green gram, chemical changes, microbial qualities, organoleptic qualities

Introduction
Mango (*Mangifera indica* L.) is said to be the 'King of tropical fruits' because of its high palatability, excellent taste and exemplary nutritive value. India produces 19506.20 Thousand MT of fruits from an area of (2212.24 Thousand Ha during 2016-17 (Horticultural Statistics at a Glance 2018). Mango fruit bar is a dried pulp with proper amount of sugar and acid mixture which is an important product of commerce in mango growing areas in India. Mango pulp is rich in carbohydrates, minerals, vitamin C, pectin, carotenoids, but lacks protein, fat and some essential amino acids. Pulses, on the other hand are good sources of important dietary nutrients, protein, fat, minerals and vitamins. Protein fortification of foods is current interest, because of nutritional awareness of consumers, government guidelines, and changing demographics. These factors generate the necessity of producing nutritionally rich food products. Protein supplementation is one way to meet the need for nutritious foods, particularly baked products, biscuits, cookies, crackers and snack bars which are widely consumed and have relatively long shelf lives and good eating qualities (Pratima Awathi *et al*., 1999) [9]. The present study was undertaken to develop pulse enriched mango bars and to assess its keeping qualities.

Materials and Methods
Mango fruit '*Neelum'* and greengram dhal were procured from the local market in Madurai and were used to the study. Mango pulp was prepared after peeling and destining the fruits and pulp was heated slightly for 10 minutes for enzyme inactivation. The greengram dhal was roasted slightly, ground into fine flour and steamed for 10 min. and further used for fruit bar preparation.

Preparation of mango bar
The mango pulp (1000 g) was mixed with 250 g of sugar, 2.5 g of citric acid and 20 g of corn flour. The mixture was concentrated to 50º Bx, cooled and 400 PPM of KMS was mixed.

Then the bar mix was poured in a greased tray to 0.5 cm thickness and dried in mechanical drier at 60 ºC for 6 h. The second layer was poured above the first dried layer. The process was repeated until it reached 1.5 cm thickness. The dried leather was cut into rectangular bars (9x3x1.5cm), packed in MPP pouch (P_1), poly propylene pouch 250 gauge (P_2) and 150 gauge (P_3), heat sealed and stored in air tight stainless steel containers at room temperature for further storage studies. Flow chart for the preparation of protein enriched mango bar is given in the Fig 1.

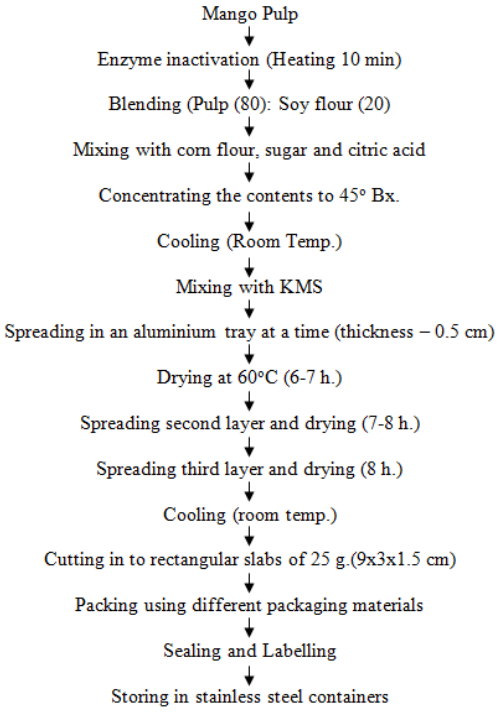

Fig. 1: Flow chart for the preparation of protein enriched fruit bar

Chemical analysis

Samples were analyzed at monthly intervals for moisture, acidity, total soluble solids (TSS, protein, ascorbic acid by 2,6 dichlorophenol indophenol visual titration as per the method described by Ranganna (1995) [10] and β-carotene by NIN manual. The pH of the sample was estimated by the method described by Hart and Fischer (1971) [5]. The total and reducing sugar content of the sample was determined by the Shaffer Somogyi micro method described by MC Donald and Foley (1960) [8]. The initial and final total ash and fat were analyzed as per the procedure of Ranganna (1995) [10]. Crude fibre was estimated by acid and alkali extraction method given by Maynard (1970) [7]. Microbial local (bacteria, yeast and fungi) was determined by the method described by Istavan Kiss (1985) at monthly intervals.

Sensory analysis

Sensory evaluation was done by 10 untrained judges using 4-1 hedonic scale. All the determinations were made in duplicate and mean values were reported.

Statistical analysis

The data obtained from the experiments were subjected to statistical analysis to find out the impact of packaging materials and storage period. Factorial Completely Randomized Design (FCRD) was applied to analyze the study as described by Rangaswamy (1995) [11]

Results and Discussion

Changes in chemical composition of the protein enriched mango bars as influenced by different packaging materials is presented in Table 1, Table 2 and Table 3. From the Tables, it could be clear that the protein enrichment of mango pulp had increased protein, fat, ash and crude fibre contents and decreased acidity, vitamin C and β–carotene contents of the prepared bars.

Table 1: Changes in chemical constituents of protein enriched mango bars during storage

Storage in months	Packaging materials	Moisture (g %)		TSS (o Brix)		Acidity (g %)		pH	
		To	T1	To	T1	To	T1	To	T1
0	1	20.00	15.00	75.00	55.00	0.419	0.300	4.25	4.58
3	P_1	18.50	14.60	75.25	55.50	0.418	0.320	4.16	4.50
	P_2	18.20	14.45	76.00	56.00	0.509	0.427	4.13	4.45
	P_3	18.00	14.27	77.06	56.25	0.601	0.473	4.10	4.40
6	P_1	18.20	14.25	75.68	55.75	0.496	0.378	4.10	4.40
	P_2	18.00	14.00	76.21	56.30	0.538	0.448	4.02	4.30
	P_3	17.50	13.20	77.32	56.50	0.619	0.491	400	400

	Moisture (g %)		TSS (o Brix)		Acidity (g %)		pH	
	SED	CD (0.05)	SED	CD (0.05)	SED	CD (0.05)	SED	CD (0.05)
T	0.00195	0.00386	0.00158	0.00313	0.00016	0.00031	0.00024	0.00048
S	0.00211	0.00417	0.00171	0.00338	0.00017	0.00033	0.00026	0.00052
P	0.00138	0.00273	0.00112	0.00221	0.00011	0.00022	0.00017	0.0034
TSP	0.00893	0.01768	0.00724	0.01432	0.00072	0.00142	0.00112	0.00221

T_0 - Control bar P_1 - MPP Pouch

T_1 - Protein enriched mango bar P_2 - poly propylene (250 gauge) pouch P_3 - Poly propylene (150 gauge) pouch

Table 2: Changes in chemical constituents of protein enriched mango bars during storage

Storage in months (S)	Packaging materials (P)	Reducing sugars (g/100g)		Total sugars (g/100g)		Ascorbic ac id (mg /100g)		β-carotene (µg/100 g)		Protein (g/100g)	
		To	T1	To	T1	To	T1	To	T1	To	T1
Initial	P1-P3	13.05	7.90	59.52	53.00	27.98	13.75	380.25	296.4	1.400	5.600
3	P_1	13.25	8.50	59.05	52.05	25.16	13.10	349.70	273.0	1.385	5.600
	P_2	13.50	8.85	58.70	51.50	13.95	12.35	340.70	262.0	1.379	5.570
	P_3	14.50	9.10	54.75	50.00	19.79	11.00	339.90	254.0	1.375	5.530
6	P_1	13.40	9.00	58.33	51.00	23.95	12.00	327.00	265.0	1.358	5.460

	P_2	14.10	9.25	56.70	50.55	20.83	11.25	322.80	258.7	1.298	5.320
	P_3	16.90	9.55	48.30	50.25	17.36	10.00	313.80	242.0	1.295	5.300

	Reducing sugars (g/100g)		Total sugars (g/100g)		Ascorbic ac id (mg /100g)		β-carotene (µg/100 g)		Protein (g/100g)	
	SED	CD (0.05)	SED	CD (0.05)	SED	CD (0.05)	SED	CD (0.05)	SED	CD (0.05)
T	0.00028	0.00055**	0.00140	0.00276**	0.00197	0.00389**	0.011023	0.02024**	0.00008	0.00016**
S	0.0030	0.00060**	0.00151	0.00299**	0.00212	0.00420**	0.01105	0.02187**	0.00009	0.00017**
P	0.00020	0.00039**	0.00099	0.00195**	0.00139	0.0275**	0.00723	0.01431**	0.00006	0.00011**
TSP	0.00128	0.00253**	0.00640	0.01267**	0.00901	0.01784**	0.04687	0.09277**	0.00037	0.00073**

T_0 - Control bar P_1 - MPP Pouch
T_1 - Protein enriched mango bar P_2 - Poly propylene (250 gauge) pouch P_3 - Poly propylene (150 gauge) pouch

Table 3: Changes in fat, total ash and crude fibre contents of protein enriched mango bars during storage

Samples		Fat (g/100g)		Total ash (g/100g)		Crude fibre (g/100g	
		Initial	Final	Initial	Final	Initial	Final
To	P_1	1.00	0.98	1.40	1.39	2.40	2.36
	P_2	1.00	0.96	1.40	1.38	2.40	2.20
	P_3	1.00	0.95	1.40	1.37	2.40	2.10
T_1	P_1	1.24	1.22	1.60	1.59	4.00	3.88
	P_2	1.24	1.20	1.60	1.58	4.00	3.82
	P_3	1.24	1.18	1.60	1.57	4.00	3.80

Table 4: Microbial population of the protein enriched mango bars during storage

Storage (months)	Treatments	Bacteria x 10^{-3} (cfu/g)			Fungi x 10^{-2} (cfu/g)			Yeast x 10^{2} (cfu/g)		
		P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
0	T_0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
	T_1	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
3	T_0	1.0	1.0	2.0	1.0	2.0	2.0	1.0	2.0	2.0
	T1	2.0	2.0	3.0	1.0	2.0	3.0	2.0	2.5	3.0
6	T_0	3.0	4.0	5.0	4.0	4.0	5.0	3.0	4.0	4.5
	T_1	4.0	4.0	6.0	3.0	4.0	5.0	4.0	4.0	6.0

** - Significant at 5% level

Table 5: Changes in the organoleptic characteristics of protein enriched mango bars during storage

Storage (Months)	Treat- ments	Appearance			Colour			Flavour			Texture			Taste			Overall acceptability		
		P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
0	T_0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	T_1	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
3	T_0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	T_1	3.9	3.9	3.8	3.9	3.9	3.8	3.8	3.7	3.7	3.9	3.8	3.7	3.9	3.9	3.8	3.9	3.8	3.8
6	T_0	3.9	3.8	3.9	3.9	3.7	3.6	3.9	3.8	3.7	3.9	3.9	3.8	3.9	3.7	3.6	3.9	3.9	3.8
	T_1	3.5	3.4	3.4	3.4	3.0	2.8	3.5	3.4	3.2	3.5	3.4	3.0	3.5	3.4	3.2	3.5	3.4	3.2

The bar samples packed in different packaging materials showed a reduction in moisture content. The moisture content was found to maximum in control bar than protein enriched mango bar. Aruna *et al.,* (1999) [1] observed a decrease in moisture content of papaya bar from 19.62 to 18.63 g per cent after 6 months of storage at 25-40°C and attributed it to evaporation of water from the bar due to high storage temperature and loss of sulphur dioxide. It was observed that control bar samples packed in P_3 showed higher moisture loss (2.5%) followed by P_2 (2.95) and P_1 (1.8%) pouches.

Total soluble solids of bar samples showed a slight increase in samples packed in all the packaging materials. It might due to an increase in moisture content of the bars during storage. A slight increase in acidity observed among different packaging materials during storage of control and protein enriched mango bars. Similar pattern of increasing trend was reported by Doreyappa Gowda *et al*., (1995) [3] in mango bars during storage. A slight increase in acidity can be attributed to loss of moisture, resulting in the concentration of product during storage. As a result of increase in acidity, a significant decrease in pH of the control and protein enriched mango bars as noticed. Similar trend was recorded in papaya bars (Aruna *et al*., 1999) [1]. The reducing sugar content was lower in protein enriched mango bars when compared to control at initial stage. After six months of storage the maximum reducing sugar content was observed in T_0P_3 (16.90g%) and minimum values in T_1P_1 (8.10 g%). The increase in reducing sugar during storage was probably due to acid hydrolysis of sucrose. Increasing trend in reducing sugar content of mango bar was observed by Doreyappa Gowda *et al*., (1995) [3] and in protein enriched bars by Chauhan *et al*., (1997) [2]. Total sugar content decreased during storage. The per cent loss of total sugars was high in the samples in P_3 packaging materials than P_2 and P_1.

The reduction in total and non-reducing sugars might be due to significant increase in reducing sugars by acid hydrolysis of total and non-reducing sugars and there by inversion of total and non-reducing sugars to reducing sugars. Similar pattern was observed by Aruna *et al*., (1999) [1] in papaya bars during storage. A significant reduction was noted in ascorbic acid and β-carotene contents of bar samples during storage. The ascorbic acid and β-carotene contents were found to be higher in the samples packed in different packaging materials contained more β-carotene and ascorbic acid contents than protein enriched bars.

There was not much changes noted in protein, fat, crude fibre and ash contents during storage of the samples. After six months of storage, the protein content were 1.35 g (T_0P_1), 1.298 (T_0P_2), 1.295 (T_0P_3), 8.860 (T_1P_1), 8.820 (T_1P_2) and 8.750 (T_1P_3) g /100g respectively. The initial fat, total ash and crude fibre content of the control bar (T_0) were 1.00, 1.40, and 2.36 g/100g respectively, whereas the protein enriched bars had 1.24, 1.40 and 2.40 g/100g of fat, total ash and crude fibre contents respectively.

Microbial Changes

The bacteria, yeast and fungal population during storage is presented in Table 3. The fungal and yeast count of bars packed in various packaging materials were zero at initially and increased slightly during storage. Samples in MPP pouches showed only a minimum microbial count (acceptable range) at end of six months of storage. The preservative (KMS) added while preparing the bars might have prevented the growth of microorganisms.

Sensory evaluation

Table 5 shows the organoleptic score values for bar samples during storage. Results of sensory evaluation showed that the appearance, colour, flavour, texture, taste and overall acceptability control bars packed in P_1, P_2 and P_3 packaging materials were highly acceptable upto three months of storage at room temperature. The soy bars were recorded good organoleptic scores throughout the study period irrespective of packaging materials.

Conclusion

Quality characteristics like chemical, organoleptic and microbial counts were studied in protein enriched mango bars during storage at room temperature for six months. A significant reduction in moisture, pH, total sugars, vitamin C, protein, fat, total ash and crude fibre content were observed in all the samples during storage, whereas acidity, TSS and reducing sugars showed an increasing trend in all the samples. Among the packaging materials studied, the samples packed in MPP showed minimum nutrient loss and also retained maximum consumer acceptability scores throughout the study period.

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