STANDARDIZATION AND QUALITY EVALUATION OF PROTEIN ENRICHED MANGO BARS

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled **"Standardization and quality evaluation of protein enriched mango bars"** is a bonafide record of research work done by me during the course of research and that this thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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Certified that this thesis, entitled **"Standardization and quality evaluation of protein enriched mango bars"** is a record of research work done independently by **Miss. Sherin, N.A.** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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ABBREVIATIONS

A.O.A.C	-	Association of Official Analytical Chemists
Bx	-	Brix
CD	-	Critical Difference
cfu	-	colony forming units
CMB	-	Control mango bar
EDTA	-	Ethelene Diamine Tetra Acetic acid
g	-	Gram
kg	-	kilogram
KMS	-	Potassium meta bisulphite
µg	-	Micro gram
mg	-	Milli gram
ml	-	Milli liter
MPP	-	Metallised polyester polyethylene laminate pouch
%	-	Per cent
PEMB	-	Protein enriched mango bar
PP	-	Polypropylene (250 gauge)
ppm	-	Parts per million
TSS	-	Total soluble solids

INTRODUCTION

1. INTRODUCTION

India produces about 130 million tones of fruits and vegetables. Due to the perishable nature of the fruits and vegetables, yearly post harvest losses in this category are very high amounting to rupees 23000 crores. This wastage can be avoided by processing into value added products or adequately distributed in different parts of the country (Rasul, 2002).

Mango (*Mangifera indica L.)* fruit is considered to be one of the best fruits in the world market due to its excellent flavour, attractive fragrance, beautiful colour, delicious taste and health promoting properties. Mango is one of the choicest and most appreciated of all fruits because of its aromatic flavour and taste. Through the ages, mango has been acknowledged as an excellent fruit, relished by adults and children alike. No other fruit except banana is so closely associated with the history of agriculture. Mango undoubtedly deserves to be the national fruit of India. In area, production, nutritive value and popularity of appeal, no other fruit can compete with it. It occupies the same position in India, as is occupied by apple in temperate climates and grapes in sub tropical areas (Kulkarni *et al.*, 2004).

Mango fruit is processed in a variety of forms. From ripe mangoes, the ranges of products include canned mango products (slices in syrup, pulp, juice and nectar), frozen mango products, ready to serve beverages and dehydrated products (mango fruit bar, mango cereal flakes, mango powder), strained baby food and mango toffee. Unripe mangoes are processed as slices in brine, powder, pickles, chutneys and raw mango beverages etc. (Ramteke *et al.*, 1999).

Mango fruit bar is a dried pulp with proper amount of sugar and acid mixture, which is an important commercial product in mango growing areas of India. This product also known by the names, mango sheet and mango leather and it is popular in Andhra Pradesh as 'Thandra'. 'Thandra' is a term acquired from

the Telugu script to represent a dry fruit product. 'Thandra' is an old age traditional method of preserving mango fruit and it is widely accepted by all age groups. Andhra Pradesh is the leading state in India producing more than 200 tones of mango leather per year.

Fruit bars, which can be prepared by drying fruit pulps after adjusting brix and acidity, offer tremendous advantage in simplicity in processing, low investment and high consumer acceptance. Though processes are available for making bars from mango, guava, banana, pineapple etc. only mango bar is marketed commercially, owing to its high acceptance. There seems to be good potential of mango bars even for export (Arya, 1992).

Mango pulp though rich in carbohydrates, minerals, vitamin C, starch, pectin and carotenoids, lacks in protein, fat and some essential amino acids. Legumes on the other hand are good sources of important dietary proteins, minerals and vitamins. So a combination of mango pulp with pulse flour could result in the development of a more nutritious mango bar. Such a low cost protein enriched food, becomes an efficient tool for nutritional improvement.

In view of the usefulness of protein enriched fruit products, the present study "Standardization and quality evaluation of protein enriched mango bars" was undertaken with the following objectives.

1. To standardize protein enriched mango bars and
2. To evaluate the nutritional and organoleptic qualities and shelf life of the mango bars.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The literature connected to the study entitled "Standardization and quality evaluation of protein enriched mango bars" is presented under the following heads.

2.1 Mango and its processing

2.2 Fruit bars

2.3 Protein enriched fruit bars

2.4 Significance of packaging on fruit bars

2.5 Quality evaluation of fruit bars on storage

2.1 MANGO AND ITS PROCESSING

Mango *(Mangifera indica L.)* belonging to family *Anacardiaceae* is the national fruit of India and rightly known as the "king of fruits" owing to its attractive colour, excellent taste, exotic flavour, exemplary nutritive value and its delicacy for the table of rich as well as food for millions of poor people during summer. It is gaining popularity in various parts of the world mainly due to its wide adaptability, high yield and attractive fruit colour (Dhemre and Waskar, 2003). The mango (*Mangifera indica L.)* is the most important fruit of Asia, and currently ranks fifth in total production among major fruit crops world wide, after banana and plantain (Hymavathi and Khader, 2004).

Lal *et al.* (1986) had pointed out that India is the home of mangoes and a large number of varieties are found in almost all parts of the country. The authors also reported that mango has earned a reputation of being the apple of the tropics, because it is so wide spread. Mango is a major fruit crop of India and occupies 42.6 per cent total area under fruit crops with a total production of 92 lakh tones but post harvest losses have been reported to be as high as 17.9 per cent (Srinivas *et al.,* 1997). Mango is not considered as a commercial crop of Kerala, but mango trees are inevitable components of homesteads in the state. The total estimated

area under mango cultivation is 75,911 hectares with an annual production of 323,517 tones. The first mango fruits of the season come to the Indian markets from Kerala (Radha and Nair, 2000). India produces 11,000 tones of total world production of 15,000 tones of mango annually (Singh and Kaur, 2000). Mango (*Mangifera indica L.)* is a tropical fruit relished for its characteristic flavour and taste. Although India is a major cultivar of mango about 20 to 25 per cent of the crop is being wasted due to post harvest practices, inadequate packaging and limited value addition (Kumar *et al.,* 2003a). In India, mango ranks first in both area and production among fruits and occupies 40 per cent of area under fruits (Gowda and Huddar, 2004).

Nine table varieties, four juice varieties and five hybrids of mangoes grown in Andhra Pradesh (India) were evaluated for canning as slices, juices and nectars. Baneshan, Suvarnarekha and 5/5 Rajapuri x Langra were found suitable for canning as slices. Navaneetham, Baneshan, Goabunder, Royal special, Hydersaheb and 9/4 Neelum varieties were found good for the preparation of juices, while Baneshan, Navaneetham, Goabunder and Sharbatgadi varieties were good for nectars (Murthy *et al.,* 1984). Bangalora and Banganapalli in South and Fazri in East India are the only varieties extensively used in processing industry (Yadav *et al.,* 1995). Totapuri mango is the only variety used by the mango pulp processing industry due to its high pulp recovery, economic price and easy availability (Venkataratnam, 1996). Bangalora (Totapuri) is a most widely cultivated mid season variety of southern India. The fruits are larger with attractive yellow colour, thick skin and very good keeping quality. The fruit quality is relatively inferior to treat as table variety and it is preferred by the processing industry due to its high yielding capacity as well as competitive lower price (Yadav, 1997). Totapuri is an important variety of mango used mainly for processing purposes especially for the preparation of intermediate products like mango pulp, which is one of the major items of export (Gajanana *et al.,* 2002). Bangalora or Totapuri is a regular bearing high yielding variety, which is being

processed on a large scale. But, it has a mild flavour and the colour is very light due to lower carotenoids (Gowda and Huddar, 2004).

ICAR (1967) analysed 22 varieties of mangoes from different parts of India and showed that the acid content expressed as malic acid ranged from 0.067 to 3.66 per cent in green fruits and 0.18 to 0.56 per cent in ripe fruits. Indian mango cultivars are reported to contain 13.2 to 80.3 mg of vitamin C per 100 g of fruit pulp (Singh, 1968). Bhatnagar and Subramanyam (1973) reported that the β carotene content in mango was found to range between 800 and 13,000 µg per 100 g. Kapur (1974) studied the biochemical changes in mango varieties during growth and he observed that vitamin C content of green, tender mangoes were higher whereas it was much lower in ripe mangoes. Mango is a fairly good source of carbohydrate, vitamin C and is a rich source of provitamin A. Mango variety Totapuri contains TSS 14.6^0 Bx, acidity 0.30 per cent, reducing sugar 3.49 per cent, total sugar 9.28 per cent, carotenoids 3679 µg per 100 g and vitamin C 8.53 mg $100\ g^{-1}$ (Lakshminarayana, 1980).

Mango is the richest natural source of β carotene, the precursor of vitamin A. It also contains appreciable amounts of vitamin C and minerals (calcium, phosphorus and iron) (Gopalan *et al.*, 1985). The authors also reported the mineral constituents of ripe mango fruit from India as 400 mg per 100 g fruit. Calcium, phosphorus and iron are equivalent to 14, 16 and 1.3 mg per 100 g respectively. Dube (1988) reported that the ripe mango contained energy 74 Kcal, fiber 0.7 g, calcium 14 mg, iron 1.3 mg, carotene 2743 µg and vitamin C 16 mg. Sahni *et al.* (1994) reported a maximum TSS of 20^0, 16^0, 12^0, 10^0 and 9^0 Bx in mango, plum, apple, orange and pineapple respectively. The highest acidity (1.89 per cent) was present in plum followed by pineapple, orange, apple and mango (0.25 per cent).

The main constituents of the mango fruit are moisture (81%), carbohydrates (16%), protein (0.6%), fat (0.4%) and minerals (0.4%) (Anon, 1995). The acids such as tartaric acid, malic acid and traces of citric acid present

in the pulp help to maintain alkaline reserve of the body. Manay and Shadaksharaswamy (1995) reported that mango fruits contain 10 to 20 per cent sugar and are an important source of vitamin A, B and C. They also reported that the mango fruits have a rich, luscious aromatic flavour and a delicious taste in which sweetness and acidity are delicately blended and so this makes the mango fruit one of the most highly priced dessert fruits of the tropics. High viscosity of Totapuri is being confirmed by the study of Gowda *et al.* (1994) and Gowda and Ramanjaneya (1995). Presence of large amounts of water insoluble solids might be the cause of thicker and high viscosity pulp of Totapuri.

According to the study by Oommen (1997) Bangalora contains acidity 0.40 per cent, TSS 15.50^0 Bx, total sugar 15.10 per cent, reducing sugar 5.39 per cent, vitamin C 18.30 mg per 100 g, β carotene 1040.01 µg per 100 g, crude fat 0.19 g per 100 g, crude fiber 0.54 g per 100 g, sodium 29.75 mg, phosphorus 14.34 mg, potassium 180.28 mg, magnesium 264.22 mg and calcium 12.60 mg. One pound of mango contained energy 198 Kcal, protein 2.1 g, carbohydrates 51.6 g, fat 0.06 g, calcium 27 mg, iron 0.6 mg, vitamin A 14590 IU, vitamin B_1 0.19 mg, vitamin B_2 0.17 mg and vitamin C 106 mg (Venden and Rajeswari, 1999).

Volatile oil constituents from mango cultivar 'Totapari' grown in India were analysed by Ansari and Ali (1999). The principal monoterpene was alpha-pinene, followed by alpha-terpineol, alpha-copaene and limonene-verbenone. The essential oil contained about 15 sesquiterpene hydrocarbons and 3-epoxides. The prominent sesquiterpene was caryophyllene epoxide, followed by humulene epoxide and beta-selinene. The essential oil also contained 3 aliphatic alcohols and 5 carbonyl components. Studies conducted by Gowda and Huddar (2004) showed that mango variety Totapuri contained TSS 15.11^0 Bx, acidity 0.43 per cent, reducing sugar 7.87 per cent, and vitamin C 8.33 mg and carotenoids 3002 µg.

Mango is used in the processing industry and the products made from ripe fruits are, canned fruit slices in sugar syrup, canned pulp, aseptically packed pulp in 20 to 200 liter jars/ barrels, mango squash, juice, nectar, jam, frozen mango pulp and chemically preserved mango pulp. Products made from green mature fruit include dried slices, slices in brine, pickle and chutney (Adsule and Anand, 1977). Mango *(Mangifera indica L.)* is a tropical fruit relished for its succulence, exotic flavour and delicious taste throughout the world. The unripe fruit because of its acidic taste is used for preparing chutney, pickles etc., while the ripe fruit is used for preparing squashes, jam, nectar, mango leather etc. (Kumbhar, 1992). Mango is indigenously processed right from the early stage of development into a variety of products like pickle, chutney, puree, slices, leather, beverages, jam etc. (Garg and Kalra, 2002).

Palaniswamy *et al.* (1974) evaluated 29 varieties of mango for their suitability for the preparation of pulp, squash, and canned slices based on their physicochemical characters. Three mango based beverages were prepared containing respectively mango pulp 5, 7 and 10 per cent, sugar 9.07, 11.7 and 13.15 per cent, TSS 10, 13 and 15 per cent and acidity 0.1, 0.15 and 0.2 per cent. All the three drinks contained carbon dioxide (3%) gas volume and stored for 210 days. Based on sensory evaluation, the beverage containing 7 per cent mango pulp, 11.7 per cent sugar, 13 per cent TSS and 0.15 per cent acidity was acceptable (Islam *et al.*, 1990).

Sethi (1991) investigated suitable methods for preserving raw mango slices for use in pickles and chutneys. Steeping the slices in solution containing 5 per cent salt, 1.2 per cent acetic acid and 0.1 per cent KMS was found to give better results than dry salting. Mango beverage can be blended with a number of fruits such as papaya and pineapple. Mango beverage blends prepared with papaya (25-33 per cent) was found to be acceptable after six months of storage at room temperature (Kalra *et al.*, 1991). A study was conducted by Balasubramanyam and Kulkarni (1991) to standardize the manufacture of high-fat

dessert type yoghurt with added fruit pulp. Yoghurt made from milk (10 per cent fat) with 8 per cent sugar and homogenized, was found to be of good quality. Addition of mango pulp up to 4 per cent of the milk content marginally improved flavour characteristics.

Seventy five per cent of mangoes in India are aborted before reaching maturity due to adverse climatic conditions. These losses can be minimized by utilizing green fruits either in fresh form for making pickles or mango chutney or as a sun dried acidifying condiment (Amchur) or preserve, jam, beverage and sauce (Pruthi, 1992). Teotia *et al.* (1992) developed a muskmelon - mango beverage blend and found that the beverage made from 50:50 blends was adjudged to be the best because of its balanced flavour.

Kaur and Khurdiya (1993) studied the manufacture of sauce from green and ripe mangoes and the sauce from green mangoes rated high in the organoleptic evaluation. Sahni and Khurdiya (1993) revealed that mango yoghurt having a composition of 20 per cent mango pulp, 25 per cent TSS and 1 per cent acidity was adjudged to be the best. Khurdiya (1993) prepared nectars from pulps of Totapuri and Amrapali alone or as blends and found that the nectars prepared from either Totapuri pulp alone or the blend with Amrapali (75:25) were superior in colour, carotenoid content, viscosity and other sensory qualities.

Pandey *et al.* (1995) studied the preparation of raw mango pana with raw mango pulp (20 per cent), common salt, black salt, roasted cumin, asafoetida, black pepper and red chilly powder, mint and coriander leaves extract, citric acid or lemon juice and with or without sugar. The study showed that 10 minutes processing time was enough to keep the product safe up to nine months and to maintain the appeal of the products. Vinegar was produced from mango pulp by the twin processes of fermentation and oxidation, using *Saccharomyces cerevisae and Acetobacter aceti* (Garg *et al.*, 1995).

Jain *et al.* (1996) studied the performance of four late maturing varieties of mango viz., Amrapali, Mallika, Kesar and Taimuria in Madhya Pradesh for the preparation of nectar and RTS drink. Amrapali and Taimuria recorded highest organoleptic score for mango nectar and RTS drink, and were acceptable for 3 and 4 months of storage.

Gupta (1998) developed a technology for preparation of pickle without oil (oil less pickle). The treatment consists of 20 per cent commercial salt, 7.5 per cent red chilly powder and 1 per cent hing (asafoetida) based on mango pieces. The resultant pickle had 61.33 per cent moisture, 33.13 per cent TSS, 1.31 per cent acidity, 13 per cent ascorbic acid, 2.16 per cent reducing sugars and 8.77 per cent total sugars and had 9 months storage life. An experiment was made to assess the suitability of 50:50 combined pulps of Dashehari and Banganapalli in comparison to Dashehari and Banganapalli used alone, for the preparation of commercial RTS drink. Three different RTS drinks were prepared and it was found that during sensory evaluation at initial, 3 months interval, and after 6 months interval, the RTS drink prepared from combined pulp scored highest marks, as compared to the one prepared from individual variety (Srivastava, 1998).

Sagar and Khurdiya (1999a) standardized the preparation of dehydrated ripe mango slices. The mango slices were heated for two minutes in an equal amount of 70^0 Bx sugar syrup in the presence of 0.1 per cent KMS at 90^0 C and after drying in a cabinet drier at 58 ± 2^0 C gave the best dehydrated products. Sagar and Khurdiya (1999b) standardized the methods of preparation of mango toffee, mango custard powder, mango chutney, mango lassie, and mango shake and mango nectar. Singh *et al.* (1999) developed raw mango pana concentrate with raw mango pulp (1 Kg), green chilly extract (5%), common salt (7%), black salt (4.5%), roasted cumin (2%), asafoetida (0.2%), black pepper (1.5%), red chilly powder, mint, coriander leaves extract and citric acid or lemon juice. The TSS of the concentrate varied from 23 to 26^0 Bx in different recipes. The pana

concentrate that was prepared by using citric acid on dilution with water in 1:6 ratio was adjudged the best. The pana concentrate kept well up to twelve months of storage at room temperature (22-35^0 C).

Different mango products like chutney, pickle, slices, pana, canned slices, mango pulp, mango juice, nectar, squash, toffee, jam, leather, powder, custard powder, preserve and wine were prepared by Emerald *et al.* (2000).

Studies were carried out by Gowda and Huddar (2004) to evaluate four commercial cultivars of mango namely, 'Alphonso', Banganapalli', 'Neelum' and 'Totapuri' and two hybrids, 'Mallika' and 'Amrapali' for their suitability for processing into canned pulp. It was concluded that 'Alphonso' and 'Amrapali' were best suited for canning in the form of pulp. Hymavathi and Khader (2004) developed mango powder rich in β carotene from Baneshan, Suvarnarekha and Totapuri varieties. The powders had pleasant yellow colour with moderate mango flavour and slight gritty texture. The powder was produced using pulp, milk concentrate (khoa) and wheat flour in the ratio of 85:5:10 by vacuum dehydration at 27 mm Hg vacuum and 60^0 C temperature for 11 hours.

2.2 FRUIT BARS

Bar (Thandra) is an old age traditional fruit product acceptable by all age groups (Nanjundaswamy *et al.*, 1976; Rao and Roy, 1980a). Fruit bar or leather is a ready to eat product with soft gel like texture obtained by dehydration of fruit purees into leathery sheets. These products are shelf stable for about 6 months in flexible laminate pouches. They have great potential in supplying nutrients to military persons, mountaineers and astronauts besides growing children (Kalsi, 2002).

Mango fruit bar is a confectionery product prepared by mixing mango pulp with calculated amount of sugar and other ingredients, spreading on trays

and drying in a drier, until the moisture is reduced to the required level. The dried sheet is cut into suitable sizes and packed (Nanjundaswamy *et al.*, 1976). The pulp with or without sugar is spread over bamboo or date palm leaves in successive layers for drying in open sun. But the sun dried product is dark brown and the process is unhygienic and lengthy due to coincidence of rainy season with the ripening of mango fruits (Rameshwar, 1979). According to Rao and Roy (1980a), it often has a dark or deep brown colour and carries a lot of dust, insect eggs and is very sticky.

The ideal sugar/ acid composition for the preparation of mango sheet or leather of the mango cultivars Baneshan, Bombay Green and Dashehari were found to be 25^0 Bx and 0.5 per cent acidity. Addition of pectin at the rate of 0.5 per cent in the cultivar Baneshan and 0.75 per cent in the cultivars of Bombay Green and Dashehari was found to improve the texture of leather. The ideal moisture for the storage stability was found to be 15 per cent or a little more with a relative humidity between 63-70 per cent (Rao and Roy, 1980b).

All the mango varieties are not suited for the preparation of mango bar (Gahilod *et al.*, 1982). Thick pulpy varieties yielded superior product and thin pulps required blending with thick pulps of fruits like banana. The authors studied the suitability of mango varieties for processing of mango leather, where the pulp of seven different varieties of mangoes were deaerated, adjusted to 20^0 Bx and dehydrated in the form of sheets. The organoleptic scores indicated that varieties Amlet and Dilpasand were rated superior to Dori, Pairi, Totapuri, Mushadapedi and Neelum varieties.

The mango bar from Alphonso fruit was prepared by adding sugar 20 per cent, citric acid 0.2 per cent and KMS 700 ppm and found that the product was best in sensory qualities and the product dried in the tray drier gave good quality fruit bar (Gowda *et al.*, 1995). Kalsi and Dhawan (1998) prepared guava fruit bar from newly developed guava hybrids H_{25} – 25, H_{11}-7, H_3-22, Lucknow- 49 and

Allahbad Safeda by mixing extracted pulp with sugar, citric acid, KMS and glucose and heating to 80-85^0 C for five minutes and drying to about 15 per cent moisture level. Among the various hybrids and cultivars, the cultivar Allahbad Safeda was found superior followed by cultivar Lucknow-49, and hybrids H_{11}-7 based on the organoleptic rating.

Jackfruit bar was prepared from Local and Vellipala varieties by using pulp (1kg), sugar (250 g), citric acid (4.0 g) and corn flour (20 g). The mixture was concentrated to 50^0 Bx, cooled; 400 ppm of KMS was mixed and dried in the oven at 50^0 C for 12 hours. The dried bars were cut into rectangular bars (9.0 x 2.6 x 1.0 cm), packed and stored at room temperature (Krishnaveni *et al.*, 1999). Sandhu *et al.* (2001) standardized the methods for preparation of guava pulp and guava leather in two cultivars namely Allahbad Safeda and Banarsi Surkha. Guava leather prepared from pulp had good organoleptic acceptability and had a shelf life of 3 months under ambient conditions.

Gill *et al.* (2004) studied the effects of sodium alginate and drying temperature on colour, texture and sensory properties of 'Dashehari' mango leather. Fruit pulp was concentrated to 20, 25 and 30^0 Bx and dried at 50, 60 and 70^0 C with sodium alginate concentration at 0, 0.5 and 1 per cent respectively. Results indicated that highly acceptable mango bars could be prepared using 25^0 Bx pulp with 0.5 per cent sodium alginate at a drying temperature of 60^0 C.

Mathur *et al.* (1972) blended mango pulp with other fruits like banana, guava, papaya, jamun and pine apple, pasteurized the blend and used three stage air cabinet drying. Mango-pineapple bar was reported to be superior to other samples. Processing time for mango bar is usually 30-35 hours or more (Rameshwar, 1979; Rao and Roy, 1980a). Colour and taste of mango bar have been found to improve by addition of sucrose to pulp before drying in the tray drier. Sucrose, however, induces thermo plasticity to the dried product (Rao and Roy, 1980a).

The methods for the preparation of fruit slabs with a soft gel texture, suitable for direct eating from several fruits using appropriate ingredients by simple cabinet drying was standardized by Jayaraman (1993). Mir and Nath (1995) optimized the cabinet drying process by adding additives like citric acid, KMS and cane sugar to mango pulp. They reported that the retention of colour and flavour were improved. Man and Taufik (1995) prepared jack fruit leather by blanching the edible portion of the fruit for three minutes at 84^0 C and by soaking it in 2.1 per cent sodium meta bisulphate for 30 minutes. To the purees were added 10 per cent sugar, 200 ppm sorbic acid and 500 ppm sulphur dioxide as sodium meta bisulphate. The mixture was dried over water bath at 45^0 C for 16 hours and 3 hours in an oven. It was cooled and packed in polypropylene pouches. Both types of jackfruit leathers were acceptable after 2 months of storage at both ambient temperature and at 8^0 C.

To prepare mango fruit bar, the mango pulp was mixed with sugar to 25^0 Bx. Two grams of citric acid per kilogram of pulp was added. The mixture was then heated for two minutes at 80^0 C, and partially cooled. Sulphur dioxide at the rate of 1000 ppm was added before drying the mixture for 10 hours by solar energy at about 55^0 C, and 16 hours by electric or steam power at 70^0 C. Dried bars were wrapped in cellophane paper packed in cartons and stored at ambient air temperature (Dauthy, 1995). Jackfruit leather was prepared by Premalatha and Manimegalai (1996) using pulp (500 g), sugar (15 g) and citric acid (2 g). The mixture was heated to about 60^0 C and dried in sunlight by spreading in trays. The dried leather was cut in to pieces of desired size and wrapped in butter paper. The jackfruit leather was found to be highly acceptable and scored more than 95 per cent for all quality attributes.

Man and Sin (1997) developed fruit leather from under fertilized floral parts of jackfruit. Attempts were made by Gazi *et al.* (1998) to replace the use of pectin in mango bar by corn flour, which also has setting properties. Mango pulp was dehydrated after fortifying with 1, 2, 3 and 4 per cent corn flour, maintaining

TSS at 21^0 Bx, acidity at 0.7 per cent and sulphur dioxide at 1000 ppm. Organoleptic evaluation showed that mango pulp fortified with 1 per cent corn flour gave a better sheet on drying and compared well with that of pectin added sample, showing the possibility of replacing pectin by a low cost ingredient.

Good quality fruit leather samples from mango/ guava/ banana/ papaya and fig pulp were obtained from the treatment standardized by Naikare *et al.* (1998). Mixed thoroughly with sugar 20^0 Bx, liquid glucose 5.0 per cent, pectin 0.2 per cent, emulsifying agent 0.5 per cent, and KMS 0.1 per cent, pasteurized the pulp and spread on aluminium tray into 0.5 cm thick layer. Dried in cabinet drier at 50^0 C for 24 hours. The product with 16 per cent moisture has extended shelf life and retained sensory, physico chemical and microbial qualities upto 6 months.

Padmini *et al.* (1999) reported that the fruit bar from red flesh papaya had a very attractive bright red colour, soft texture and good taste. The bars can be enriched by the addition of dry fruits and nuts, which make it more delicious. Studies by Hemakar *et al.* (2000) showed that mango pulp with 20 per cent guava pulp gave a better sheet on drying followed by the one with 15 per cent guava pulp. The ideal moisture to have storage stability was found to be in between 10 to 15 per cent with relative humidity in between 65-75 per cent. According to Manimegalai *et al.* (2001) thandra or bar contains sufficient dissolved solutes to decrease water activity below that required to support microbial growth.

Mango leather (Aam papad) is a popular mango product prepared mostly by small/ cottage scale industries (Garg and Kalra, 2002). An attempt has been made by Kumar and Manimegalai (2002) to develop fruit bars from sapota. Guava fruit bar was prepared by Kalsi (2002) by concentrating the fruit pulp or puree along with sugar, acid, glucose and KMS and drying in cabinet drier. Guava fruit bar prepared contained total sugar 80 per cent, pectin 2 per cent, acid 1.3 per cent, vitamin C 5 per cent and reducing sugar 50 per cent. The effect of cold

temperature storage on the quality attributes of pawpaw and guava leathers was evaluated by Babalola *et al.* (2002). Pawpaw leather was significantly higher than guava leather in calorific content, water activity, pH and total mould count throughout the duration of storage. However guava leather was better in texture.

Cheriyan and Cheriyan (2003) evaluated the organoleptic qualities of papaya leather and papaya-mango blended leather (60:40) in comparison with plain mango leather. The results on sensory parameters indicated that blended leather was superior in most of the quality attributes. Storage up to 8 months could be possible with papaya-mango blended leather and there was no evidence of microbial contamination. Mango bar was prepared by Singh *et al.* (2003) with two different sugar concentrations: 30 and 65 per cent. This was followed by a heating step as in traditional methods. However, results showed that even if heating was avoided, the pulp soaked in sugar and then dried, was of good quality.

When heat from any source other than sunlight is used to reduce the moisture, the process is called dehydration (Heid and Josyln, 1963). Dehydrated foods if stored under proper conditions, will not spoil from microbial attack as reported by Peter *et al.* (1966). Maini *et al.* (1982) reported that more fruits are preserved by drying than any other methods, as these methods have major advantage of greater concentration in dry form, production with minimal labour, less expensive, and economic equipments for processing and storage.

Bains *et al.* (1989) studied the tray drying of apple puree to suggest optimum operating conditions for obtaining good quality leather and inferred that two stage drying operation involving a high temperature, low humidity and high flow rate combination in the first stage followed by a lower temperature finish drying, was found to yield better product. Videv *et al.* (1990) observed that when high temperature was used for dehydration it caused internal browning, textural changes and loss of fruit flavour.

The preservation of fruits and vegetables by dehydration offers a unique challenge (Singh and Heldman, 1993) and it may be considered as an alternate low cost preservation process (Unde *et al.*, 1999). While drying pulps at temperature normally prevailing in tray driers, they tend to stick to the trays. To overcome this problem addition of drying aids such as malto dextrin is added to get non-sticky product (Bhandari *et al.*, 1997). The drying of the fruit to make leather is a convenient method of marketing the fruit as confectionary (Man and Sanny, 1997).

Pestil, well known fruit leather in Turkey, was prepared by Maskan *et al.* (2002) from boiled grape juice and starch mixture by using traditional technique. Drying of pestil was carried out by hot air drying and sun drying. Depending on sample thickness and air temperature, the drying time ranged between 50-140 minutes to achieve the commercial moisture content of pestil in air drying whereas, sun drying took 180-1500 minutes.

Drying is the most commonly used method for the production of fruit leathers and fruit preservation. Removal of water from liquid foods imparts microbiological stability with bulk reduction, thereby reducing transportation, storage and packaging costs (Mittal *et al.*, 2003). Commercially, tray drying is the common method of preparation of mango bar as it overcomes the problem of exposure to open atmosphere and requirement of long processing time (Rao and Das, 2003).

2.3 PROTEIN ENRICHED FRUIT BARS

Sawaya *et al.* (1983) formulated date bars both plain and chocolate coated, fortified with soy protein isolate (SPI) and dry skim milk (DSM) in different proportions. This resulted in an increase of protein, fat, fiber, ash, sodium, potassium, calcium, magnesium, zinc, phosphorus and all essential amino acids

and they found no difference in sensory evaluation of control and fortified date bars stored up to 6 months at 7^0 C and 25^0 C.

Khalil *et al.* (1984) fortified date bars with yeast protein and dry skim milk in different proportions and the fortified bars showed higher amounts of protein, fat, fiber, ash and minerals than that of control/ unfortified bars. Sensory evaluation scores showed that all the bars were equally acceptable and could be stored up to 6 months at ambient temperature of 25^0 C without significant loss of quality attributes. Ruals *et al.* (1990) evaluated the nutritional quality of flakes made of banana pulp and full fat soy flour. The full fat soy flour incorporated with pulp of ripe bananas (60:40 dry basis) contained protein 19.7 g, fat 7.6 g, carbohydrate 60.09 g and digestibility was found to be 83.1 per cent.

The preparation of protein enriched apricot soy fruit bar was standardized by Chauhan *et al.* (1993). Apricot pulp and soy slurry was mixed with sugar syrup to raise the TSS to 30^0 Bx and 50 ppm of sulphur dioxide was also added to the mixture. The content was spread on tray (45 x 30 cm) and dehydrated at 65 ± 1^0 C in a mechanical cabinet drier for 14 hours. Dried product was packed in polyethylene sheets. The product having 70 per cent apricot pulp and 30 per cent soy slurry with 15.3 per cent moisture, 7.8 per cent protein and 16.5 mg per 100 g ascorbic acid was found to be the best in sensory qualities. Mir and Nath (1993) prepared fortified mango bars by adding desiccated coconut powder (2%) and soy protein concentrate (4.5%) into the Langra mango pulp.

Kalamgh and Unde (1996) developed khoa bar and milk powder bar from wood apple. The bar was prepared by using pulp with sugar in the ratio of 2:5. The mixture was heated for half an hour. At this stage, khoa or milk powder was added at the ratio of 4:1 and heated to mix the ingredients thoroughly. It was moulded, cooled, sealed and packed in plastic polyethylene wrappers and stored in cool place. They were highly acceptable. Chauhan *et al.* (1997) developed protein enriched mango fruit bar. The mango pulp supplemented with soy slurry

had increased protein and fat contents and decreased total acid and ascorbic acid content. The fruit bar having 70 per cent mango pulp and 30 per cent soy slurry with 14.5 per cent moisture, 11.35 per cent protein and 50 mg 100 g^{-1} ascorbic acid was adjudged to be the best in sensory qualities like flavour, texture and taste.

Chauhan and Sharma (1997) studied the fortification of fruits and ginger with soybean for protein rich toffees. The maximum suitability of soy slurry to the pulps was 20 per cent in apple based, 30 per cent in apricot based, 20 per cent in ginger based and 30 per cent in guava based toffees. Fruit leather prepared by fortification of plum, peach and apricot pulp with sprouted soy slurry separately in different treatment combinations had increased protein, fat and ascorbic acid contents and decreased sugar content compared to control. The product having 85 per cent fruit pulp and 15 per cent soy slurry recorded higher sensory scores in all the three types of fruit leather (Kaushal and Bhat, 1999). Supplementation of soya protein isolate with apricot pulp for leather making showed that with the increased ratio of apricot pulp, acidity and relative flow time registered an increase (Chauhan and Tyagi, 1999).

Fortified mango bars developed by Mir and Nath (2000) by adding 2 per cent desiccated coconut powder (DCP) or 4.5 per cent soy protein concentrate (SPC) to the pulp and it raised the percentage of proteins in bars to 2.4 and 4.1 respectively. The plain mango bar contained 2.2 per cent proteins. Addition of SPC raised calcium, phosphorus and iron contents of the mango bar. A study was carried out by Gujral and Khanna (2002) on the dehydration behaviour, texture, colour and sensory acceptability of protein enriched mango leather. Soya protein concentrate, skim milk powder and sucrose were added at levels of 0 per cent, 4.5 per cent and 9 per cent to improve nutritive value and sweetness of the product. It took 7.60 hours of drying time at 60 ± 1^0 C for mango leather to reach 10 per cent moisture content. Soya protein concentrate lowered the sensory acceptability of

mango leather whereas sucrose and skim milk powder at levels of 4.5 per cent each resulted in mango leather with the highest acceptability.

A process for preparation of protein rich tamarind leather was developed by Vashishtha and Mittal (2003). The product having 40 per cent jaggery, 0.1 per cent salt, 3 per cent soy protein isolate and 2 per cent coconut powder was adjudged to be the best organoleptically. Fortified papaya fruit bar was standardized by Kushwaha and Verma (2003) by raising TSS of extracted pulp 90^0 Bx to 300^0 Bx by adding different proportion of cane sugar, gram flour and skimmed milk powder. Fortified papaya fruit bar prepared by adding pulp (82%), sugar (13.6%), pectin (0.6%), citric acid (0.7%) and skimmed milk powder (3.25%) was found to be the best.

A study was conducted by Shanthi *et al.* (2003) to develop protein enriched mango bar from mango variety Totapuri with pulse protein. Protein supplementation of bar had increased protein, fat, ash and crude fiber contents whereas total sugar, vitamin C and β carotene showed lesser values than control sample.

2.4 SIGNIFICANCE OF PACKAGING ON FRUIT BARS

A package intended for confectionary items has to perform several functions during storage and sales. The functional packaging requirements for confectionary include protection against dust, contaminants, moisture pick up or loses, colour and flavour losses, resistance to impact, ease of opening, size, shape, weight limitations, appearance, printability and low cost (Potter, 1989 and Kumar, 1992). Packaging has a "techno-economic function" aimed to maintain the quality of food stuff packed, with a view to retain the quality for a reasonable period (Thangaraj and Jaiswal, 1998). Packaging is indispensable in the modern food industry. It acts as a barrier to oxygen, moisture, light and smells depending upon the sensitivity of a particular food to the prevailing environment. Thus it helps to

retain the sensory characteristics of food products. The sensory quality of a packaged food is the result of a complex interaction between the food, the package and the environment (Alam and Kaur, 2002). Packaging is and has been an integral part of our daily lives. It protects the commodities during transportation and storage. (Chaudhuri *et al.*, 2005).

Metallised poly laminate is an ideal packaging material for all products, which require critical protection from moisture, oxygen and other degrading substances. Metallised plastics have been partially replaced not only by aluminium foil but also cellophane for wrapping confectionary products (Veeraraju and Rangarao, 1990). Laminates find extended use in food packaging due to their performance properties. A bilayer structure comprising polyethylene terephthalate and low density polyethylene offers barrier and seal characteristics. The residual solvents used for adhesion may pose problem resulting in tainting of packed product (Kumar *et al.*, 2003b).

Nadanasabapathi *et al.* (1993) evaluated the indigenously available packaging materials such as paper/ aluminium foil/ low density polyethylene of 40, 20 and 12 micron, metallised polyester/ high density-low density polyethylene and nylon/ ionomer for packing ready to eat commercially available mango bar. Aluminium foil based materials are found necessary for long term storage of mango bar such as supplies to armed forces.

Jeyarani *et al.* (1997) found that cereal pulse based sweet bars packed in pouches of polypropylene (50 micron) and metallised polyester/ polyethylene had a shelf life up to 150 days at ambient (65% RH and 27^0 C) condition. While at accelerated (90% RH and 38^0 C) condition, the products kept well for 90 days in polypropylene pouches and 150 days in metallised PET/ PE pouches.

Krishnaveni *et al.* (1999) studied the storage stability of jack fruit bars packed in butter paper, polypropylene (PP) and MPP at room temperature. The

bar samples stored in MPP recorded high per cent of nutrient retention and minimum microbial count at the end of 180 days. The organoleptic score of the bar sample in MPP was found to be higher followed by samples packed in PP and butter paper. Premalatha *et al.* (1999) studied the storage of papaya based fruit bars in butter paper, polypropylene and MPP at room temperature for 180 days and revealed that while butter paper packing was suitable for short term storage, polypropylene and MPP packaging were ideal for long term storage.

Guava leather wrapped in butter paper and packed in polyethylene bags was found to be suitable up to 3 months under ambient conditions (Sandhu *et al.*, 2001). According to Manimegalai *et al.* (2001) thandra/ bar is a semi moist food that can be stored safely for longer time at room temperature in polyethylene pouches. Studies by Manimegalai *et al.* (2001) showed that jackfruit thandra (bar) stored in metallised polyester polyethylene laminate pouches (MPP) recorded higher per cent of nutrient retention and minimum microbial count than the samples in polypropylene pouches (PP) at the end of 180 days. The sensory evaluation score values of the bar in MPP were found to be higher than by the samples in PP.

Shanthi *et al.* (2003) packed protein enriched mango bars in MPP pouches (p_1), polypropylene pouches of 250 gauges (p_2) and 150 gauges (p_3) and stored at room temperature for 6 months. High quantum of nutrient retention and higher percentage of organoleptic scores were observed in the sample packed in MPP followed by p_2 and p_3 during storage. Mango bars wrapped in polyethylene/ wax paper or aluminium foil for storage had significantly low microbial load and had a high preservation index quality (Singh *et al.*, 2003).

2.5 QUALITY EVALUATION OF FRUIT BARS ON STORAGE

Rao and Roy (1980b) studied the storage behaviour of mango sheets of the cultivars Baneshan, Bombay Green and Dashehari. The results indicated that the

moisture content of mango sheet was reduced from 17.07 to 16.02, 16.64 to 15.51 and 16.28 to 15.09 per cent, and increase in acidity, and reducing sugars respectively from 1.75 to 2.04, 1.35 to 1.62 and 1.07 to 1.35 and 29.45 to 34.92, 17.70 to 23.60, and 10.08 to 15.02 per cent in Baneshan, Bombay Green and Dashehari cultivars respectively at 500 ppm level of sulphur dioxide. Good retention of carotenoids at lower temperature (20^0 C) and complete loss of ascorbic acid were observed in samples stored at high temperature (40^0 C) during the storage period of 90 days.

Gahilod *et al.* (1982) observed a reduction in reducing sugars, ascorbic acid and carotenoid contents and increase in acidity and non enzymatic browning in mango leathers packed in polythene bags and stored for 70 days at 10 ± 1^0 C. The chemical changes that commonly occurred during storage of fruit products are absorption or loss of moisture, increase in acidity or decline in pH, increase in reducing sugars and decrease in total sugars (Mitra and Bose, 1984).

Mir and Nath (1993) studied the storage changes of three types of mango bars (plain mango, mango-desiccated coconut powder (DCP) and mango soy protein concentrate bars) during 90 days at 18^0 C, 27 ± 3^0 C (65 per cent RH) and 38 ± 1^0 C (92 per cent RH). They observed an increase in moisture, acidity and reducing sugars. The total carotenoids and beta-carotene decreased from 9.2 to 9.1, 8.8 to 6.3, 8.5 to 6.2 mg per cent and from 5.4 to 2.5, 5.3 to 3.4 and 5.0 to 3.3 mg per cent after 90 days of storage at 38^0 C in plain mango bar; mango - DCP bar and mango - SPC bar respectively.

Yousif (1994) studied the storage of plain and chocolate-coated date bars for upto 6 months at 25 ± 5^0 C. Storage for six months caused a significant decrease in moisture, pH and sugar content and increase in Bx and pigment level of both type of date bars. The mango-soy fruit bar, a protein enriched product stored at room temperature for six months showed an increase of moisture, acidity and reducing sugars from 14.0 to 18.2, 11.5 to 14.6 and 33.0 to 38.8 per cent

respectively. A decrease in ascorbic acid (65 to 53.40 mg 100 g^{-1}) and an increase in non-enzymatic browning (0.32 to 0.74) were noticed by Chauhan *et al.* (1997).

Aruna *et al.* (1999) investigated the changes in papaya fruit bar during storage at room temperature and concluded that there was no alterations in acid, insoluble ash, total ash and weight, volume and bulk density. TSS of the papaya bars decreased significantly and a reduction in moisture, pH, vitamin C, total carotene, β carotene, total and non reducing sugar, pectin and sulphur dioxide, and an increase in acidity, reducing sugars and non enzymatic browning were observed in papaya bar at room temperature on 3, 6 and 9 months of storage. Jack fruit bar samples showed a reduction in ascorbic acid content from 7.30 to 4.75 mg per cent after 180 days of storage (Krishnaveni *et al.*, 1999).

According to Hemakar *et al.* (2000) after 6 months of storage, guava-mango sheet showed an increase in moisture (11.5 to 11.95%), reducing sugar (13.84 to 16.40%) and total sugar (62 to 62.56%) and a decrease in acidity (1.63 to 1.39%) and vitamin C (55 to 35 mg $100g^{-1}$). Guava leather showed a reduction in moisture (29.30 to 21.50%) and ascorbic acid (76.50 to 64.69 mg %) and an increase in TSS (50.60 to 52.20%), acidity (0.41 to 0.44%), reducing sugar (6.12 to 9.93%), and total sugar (38.29 to 44.39%) (Sandhu *et al.*, 2001). After 180 days of storage jackfruit bar showed a reduction in TSS, total sugar, ascorbic acid, β carotene and an increase in acidity and reducing sugar (Manimegalai *et al.*, 2001). During storage of guava fruit bar sugar and pectin contents, acidity, and browning increased while ascorbic acid and tannin contents decreased (Kalsi and Dhawan, 2001).

Studies by Kumar and Manimegalai (2002) in sapota bar showed a gradual increase in the acidity (0.303 to 0.394%) and reducing sugar (7.29 to 8.36%) on storage. Studies by Shanthi *et al.* (2003) showed a reduction in moisture, pH, vitamin C, total sugars and proteins and an increasing trend in acidity, TSS and reducing sugars in protein enriched mango bars.

Rao and Roy (1980b) observed that mango sheets with added sulphur dioxide were organoleptically acceptable at all storage temperatures of 20^0, 30^0 and 40^0 C even after three months of storage. A higher initial sensory score for colour, texture, aroma and taste for mango bar fortified with desiccated coconut powder (DCP) was observed by Mir and Nath (1993) and during 90 days of storage at 18^0 C, 27 ± 3^0 C and 38 ± 1^0 C the overall acceptability decreased in both types of bars stored up to 6 months. The sensory evaluation score of mango bars packed in flexible packaging materials showed that the product was not acceptable after 5 months of storage, due to the development of undesirable colour (Nadanasabapathi *et al.*, 1993).

Man and Taufik (1995) observed a decrease in colour and texture values of the jackfruit leather during storage of two months. Sensory evaluation showed that jackfruit leather was acceptable after two months of storage at both ambient temperature and at 8^0 C. The organoleptic quality of osmotically dehydrated papaya stored at 0^0 C was unchanged and little changes in colour, flavour and texture at room temperature (27^0 C) and at elevated temperature (37^0 C) were observed by Ahmed and Chaudhary (1995).

Gowda *et al.* (1995) prepared mango bars by different methods of drying and stored for 6 months. The fruit bar prepared by drying in shade or tray drier gave good quality product in terms of better colour, texture and flavour leading to higher overall acceptability.

Aruna *et al.* (1999) observed a significant difference in colour and appearance of papaya fruit bars during storage and organoleptic scores decreased 29.02 (initially) to 24.93, 24.93, 22.13 and 19.80 when stored at 5^0 to 8^0, 9^0 to 24^0, 25^0 to 34^0 and 35^0 to 45^0 C respectively. Krishnaveni *et al.* (1999) studied the organoleptic score values of jack fruit bars during storage and studied that the sensory attributes like colour, flavour, texture and taste of the samples were highly acceptable up to 90 days of storage at room temperature.

Overall organoleptic score of guava bar reduced from 8.33 to 7.13 after 3 months of storage (Sandhu *et al.*, 2001). The freshly prepared jackfruit bar samples had firm texture, which had changed to mild to moderate hardness during 6 months of storage (Manimegalai *et al.*, 2001).

Sensory score studies in relation to period of storage by Babalola *et al.* (2002) showed that guava leather gave better result in overall acceptability at zero, one and two months of storage at 8 ± 1^0 C. Guava leather also gave better sensory qualities in fruitiness, smell, chewiness, toughness, colour, and overall acceptability when varietal influence is considered. At the end of storage a decreasing trend in organoleptic score values of protein enriched mango bars were observed (highly acceptable to acceptable) by Shanthi *et al.* (2003).

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present study entitled "Standardization and quality evaluation of protein enriched mango bars" was aimed to standardize protein enriched mango bars and to evaluate the nutritional and organoleptic qualities and shelf life of the products. The materials and methods used for the study are given under the following headings.

3.1 *Collection of sample*
3.2 Standardization and storage of mango bars
3.3 Organoleptic evaluation of mango bars
3.4 Chemical analysis of mango bars
3.5 Enumeration of microbial and storage insect pests
3.6 Benefit cost analysis
3.7 Statistical analysis

3.1. COLLECTION OF SAMPLE

Mango variety Totapuri was used for preparing mango bar. Totapuri was selected for the study since it is one of the most common variety used by the processing industry due to its high pulp recovery, economic price and easy availability (Venkataratnam, 1996). It is the most widely cultivated mid season variety of southern India. The fruits are large with attractive yellow colour, thick skin and very good keeping quality. Ripe mangoes were collected from Thrissur market.

Green gram dhal was used as a source of protein for enriching the mango bar. Green gram dhal purchased from the market was roasted for five minutes and powdered. The flour was steamed for 10 minutes, dried and used for enriching mango bars.

3.2. STANDARDISATION AND STORAGE OF MANGO BAR

Mango bars (CMB) were prepared using standardized procedure. Protein enriched mango bars (PEMB) were standardized with suitable blending materials. The most suitable combination of mango pulp and pulse flour for protein enriched mango bars was found out by conducting initial trials with three combinations. Following are the combinations: -

1. Mango pulp (control)
2. Mango pulp (800 g) + pulse flour (200 g)
3. Mango pulp (600 g) + pulse flour (400 g)

Organoleptic evaluation was conducted and the most acceptable combination selected was mango pulp (control) and mango pulp (800 g) + pulse flour (200 g). The acceptability was found to be more for products with more mango pulp.

Proportion of ingredients used in the preparation of mango bars are given in table 1. The flow chart for the preparation of mango bar is given in Fig. 1.

Table 1. Proportion of ingredients in mango bars

SI No	Ingredients	Mango bar (CMB)	Protein enriched mango bar (PEMB)
1.	Fruit pulp (g)	1000	800
2.	Green gram dhal (g)	-	200
3.	Corn flour (g)	20	20
4.	Citric acid (g)	2.5	2.5
5.	KMS (ppm)	400	400
6.	Sugar (g)	200	200

Method

- Mango pulp was heated slightly to inactivate the enzymes present (10 minutes)
- Pulp was mixed with sugar, citric acid, corn flour and green gram dhal flour
- Concentrated the mixture on a medium flame by stirring continuously
- Cooking was continued till final TSS reached 50^0 Bx
- Cooled at room temperature
- KMS was added and mixed well
- Concentrated pulp was spread in a tray to a thickness of 0.5 cm and dried at 60^0 C for 6 hours in a cabinet drier
- When the first layer was dried, spread the second layer and dried at 60^0 C for 6 hours
- Spread the third layer and dried
- Cut into uniform pieces

Mango bars prepared were packed in two different packaging materials namely metallised polyester polyethylene laminate pouches (MPP) and polypropylene (PP) pouches (250 gauge), 200 gram in each pack. Mango bars packed were stored in ambient storage conditions for a period of three months.

3.3 ORGANOLEPTIC EVALUATION OF MANGO BAR

3.3.1 Selection of judges for acceptability studies

A series of acceptability trials were carried out using simple triangle test as suggested by Jellinek (1985) and selected a panel of 15 judges. Sensory evaluation was carried out using score cards on a five point hedonic scale.

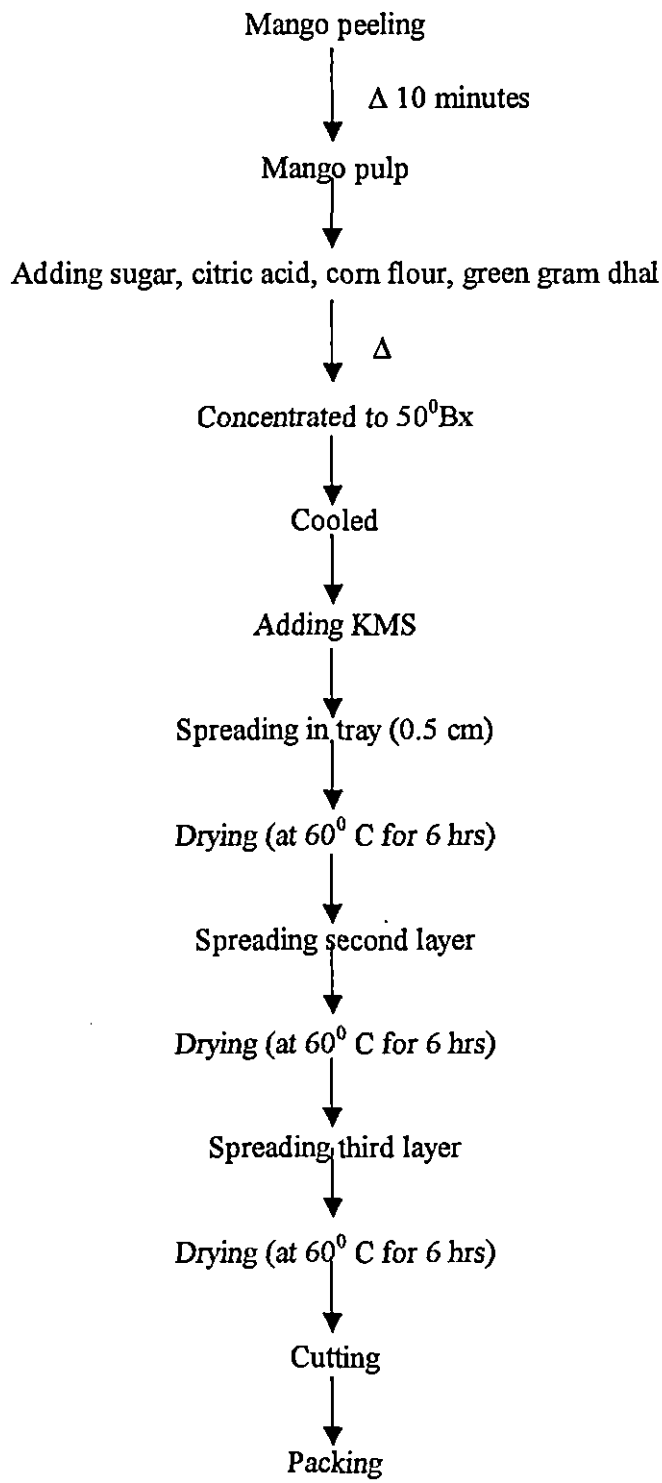

Fig. 1. Flow chart for the preparation of mango bar

3.3.2 Sensory evaluation

Sensory evaluation of mango bars was carried out using score card method (Swaminathan, 1974) by a panel of 15 selected judges.

Organoleptic evaluation was done initially and at the end of storage period. Five quality attributes like appearance, colour, flavour, texture and taste were evaluated for each sample. Each of the above mentioned quality attribute was assessed on a five point hedonic scale. Overall acceptability of the mango bar and protein enriched mango bar was calculated using the average of above mentioned quality attributes. The score card is given in Appendix 1.

3.4. CHEMICAL ANALYSIS OF MANGO BAR

The mango bars stored in two different packaging materials for three months were analysed initially and after the storage study for the following chemical constituents.

1. Moisture
2. Acidity
3. TSS
4. Reducing and total sugar
5. Vitamin C
6. β carotene
7. Protein
8. Crude fiber
9. Calcium
10. Iron
11. Potassium

3.4.1 Moisture

The moisture content was estimated using the method of A.O.A.C (1980) and expressed in g per 100 g.

To determine the moisture content 10 g of the sample was taken in a petri dish and dried at 60^0 C to 70^0 C in hot air oven. Cooled it in a desiccator and weighed. The process of heating and cooling was repeated until constant weight was achieved. The moisture content was calculated from the loss in weight during drying. The period of drying varied from two to three hours.

3.4.2 Acidity

Acidity was estimated by the method suggested by Ranganna (1986).

Ten g of the sample was digested with boiling water. An aliquot of the digested sample was titrated with standard alkali using phenolphthalein as an indicator. Acidity was expressed in terms of citric acid as percentage.

3.4.3 Total soluble solids (TSS)

The TSS content was estimated using the hand refractometer.

3.4.4 Reducing and total sugar

The content of reducing sugar and total sugar was estimated by adopting the method given by Lane and Eynon (Ranganna, 1986).

To 25 g of sample, an amount of distilled water was added and then clarified with neutral lead acetate. The excess lead acetate was removed by adding potassium oxalate. The volume was then made up to 250 ml. An aliquot of this

solution was titrated against a mixture of Fehling's solution A and B using methylene blue as indicator. The reducing sugar was expressed as percentage.

To estimate total sugar content, 25 ml of the clarified solution was boiled gently after adding citric acid and water. It was later neutralized with sodium hydroxide and the volume made up to 250 ml. An aliquot of this solution was titrated against a mixture of Fehling's solution A and B. The total sugar content was expressed as percentage.

3.4.5 Vitamin C

The vitamin C content of the sample was estimated by the method of A.O.A.C (1955) using 2, 6-dichlorophenol-indophenol dye.

One g of the sample was extracted in four per cent oxalic acid using a mortar and pestle and made up to 100 ml. Five ml of the extract was pippeted, added 10 ml of four per cent oxalic acid and titrated against the dye. Ascorbic acid content of the sample was calculated from the titer value.

3.4.6 β carotene

The β carotene content of the sample was estimated by the method suggested by Ranganna (1986).

Five g of the sample was extracted with acetone, adding few crystals of anhydrous sodium sulphate. Mixed the supernatant with 10-15 ml petroleum ether in a separating funnel. Collected upper layer and made up to 100 ml with petroleum ether. Recorded the absorbance at 452 nm using petroleum ether as blank.

3.4.7 Protein

The protein content was estimated using the method suggested by Fischer (1973).

In one liter distilled water 0.382 g of NH_4Cl was dissolved and from that 100 ppm, 120 ppm, 140 ppm, 160 ppm, 180 ppm and 200 ppm were read colorimetrically for the preparation of standard graph. The sample (0.5 g) was digested in concentrated sulphuric acid for 10 minutes and added 2-3 ml of hydrogen peroxide drop wise till the solution become colourless. The solution was made up to 100 ml. From the working solution, 5 ml was taken and 1 ml of 10 per cent sodium silicate followed by 2 ml of 10 per cent sodium hydroxide were added and made up to 50 ml. To this 1.6 ml of Nessler's reagent was added and the red colour developed was read at 410 nm. Standard graph was prepared and estimated the protein content.

3.4.8 Crude fiber

The crude fiber content was estimated by acid-alkali digestion method as suggested by Chopra and Kanwar (1978).

Two g of sample was boiled with 200 ml of 2.25 per cent sulphuric acid for 30 minutes. It was filtered through a muslin cloth and washed with boiling water and again boiled with 200 ml of 1.25 per cent sodium hydroxide for 30 minutes. Repeated the filtration through muslin cloth and washed with sulphuric acid, water and alcohol in a sequential manner. Transferred the residue to a pre weighed ashing dish. The residue was ignited for 30 minutes in a muffle furnace at 250^0 C, cooled in a desiccator and weighed. The fiber content of the sample was calculated from loss in weight on ignition.

3.4.9 Calcium

The calcium content was estimated using titration method with EDTA as suggested by Page (1982).

Five ml of diacid extract made up to 100 ml was taken and added 10 ml water, 10 drops of hydroxylamine, 10 drops of triethanol amine and 2.5 ml sodium hydroxide and 10 drops of calcone were added. Then it was titrated with EDTA till the appearance of permanent blue colour. It was expressed in mg per 100 g of sample.

3.4.10 Iron

The iron content was analysed colorimetrically using ferric iron, which gives a blood red colour with potassium thiocyanate (Raghuramulu *et al.*, 2003).

To an aliquot of the mineral solution enough water was added to make up to a volume of 6.5 ml followed by 1 ml of 30 per cent sulphuric acid, one ml of potassium persulphate solution and 1.5 ml of 40 per cent potassium thiocyanate solution. The intensity of the red colour was measured within 20 minutes at 540 nm. A standard graph was prepared using serial dilutions of standard iron solution. The iron content of the sample was estimated from the standard graph.

3.4.11 Potassium

The potassium content was estimated using flame photometer as suggested by Jackson (1973).

One g of the sample digested in diacid, was made up to 100 ml. One ml of sample solution was made up to 25 ml and read directly in flame photometer.

3.5 MICROBIAL AND STORAGE INSECT PEST STUDIES

The total microbial count of mango bars stored in two different packaging materials were analysed initially and at the end of the storage period. The method used for the evaluation was serial dilution and plate count method as described by Agarwal and Hasija (1986). Ten g of sample was added to 90 ml sterile Ringer's solution and shaken for ten minutes. One ml of this solution was transferred to a test tube containing 9 ml sterile Ringer's solution to get 10^{-2} dilution and similarly 10^{-3}, 10^{-4}, 10^{-5} and 10^{-6} dilutions were prepared.

Enumeration of total microbial count was carried out using nutrient agar media for bacteria, potato dextrose agar media for fungi and sabouraud's dextrose agar medium for yeast. The dilution used for bacteria was 10^{-5} and for fungi and yeast, 10^{-3} dilution was used.

By examining mango bar under the microscope, presence of storage insect pests was assessed.

3.6 BENEFIT COST ANALYSIS OF MANGO BAR

The benefit cost analysis of the mango bar was worked out to assess the extent of expense aroused to prepare the products and to calculate benefit cost ratio.

The cost was worked out based on the prices of various commodities needed for the preparation of the product. The final product yield was computed by taking into consideration the quantity of mango and other ingredients required to prepare a definite quantity of the product. The market price of the product was taken into consideration and benefit cost ratio was calculated thereafter.

3.7 STATISTICAL ANALYSIS

The data was analysed as a Completely Randomized Design (CRD) using MSTAT C package.

RESULTS

4. RESULTS

The results pertaining to the study entitled 'Standardization and quality evaluation of protein enriched mango bars' are presented under the following heads.

4.1 Chemical composition of mango bars

4.2 Organoleptic studies

4.3 Microbial enumeration and storage insect pests in mango bars

4.4 Benefit cost analysis

4.1 CHEMICAL COMPOSITION OF MANGO BARS

A. The chemical constituents of CMB and PEMB are given in table 2, 3 and 4. Table 2 reveals the moisture, acidity, TSS, reducing sugar, total sugar and crude fiber in CMB and PEMB.

Higher moisture content was observed in PEMB (16.09 g 100 g^{-1}). The moisture content of CMB was 13.51 g 100 g^{-1}. Statistically there was significant variation in the moisture content of CMB and PEMB.

The acidity of CMB was 0.65 g 100 g^{-1} and PEMB was 0.46 g 100 g^{-1}. There was significant variation in the acidity of CMB and PEMB.

The illustrations of moisture and acidity of CMB and PEMB is given in Fig.2.

The TSS content of CMB and PEMB were 54.50 and 51.5^0 Bx respectively. Statistically, significant variation was observed in the TSS content of CMB and PEMB. The illustration is given in Fig.3.

Table 2. Moisture, acidity, TSS, reducing sugar, total sugar and crude fiber in CMB and PEMB

	Moisture (g 100 g^{-1})	Acidity (g 100 g^{-1})	TSS (^{0}Bx)	Reducing Sugar (g 100 g^{-1})	Total sugar (g 100 g^{-1})	Crude fiber (g 100 g^{-1})
CMB	13.51	0.65	54.5	13.62	60.31	2.48
PEMB	16.09	0.46	51.5	7.54	51.92	3.38
CD ($P < 0.05$)	1.11*	0.06*	2.17*	0.20*	0.67*	0.19*

* Significant at 5% level

Table 3. Protein, β carotene and vitamin C in CMB and PEMB

	Protein (g.100 g^{-1})	β carotene (μg 100 g^{-1})	Vitamin C (mg 100 g^{-1})
CMB	2.04	377	24.40
PEMB	6.77	283	12.53
CD ($P < 0.05$)	0.07*	10*	0.76*

* Significant at 5% level

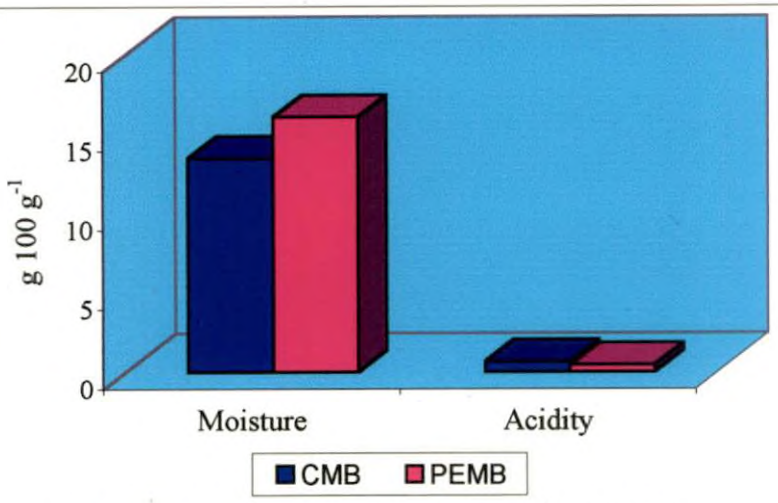

Fig. 2. Moisture and acidity (g 100 g^{-1}) of CMB and PEMB

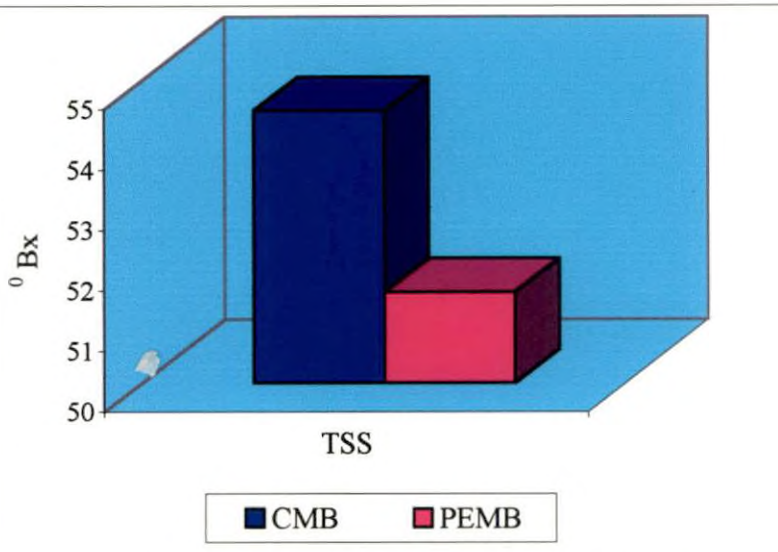

Fig. 3. TSS (^{0} Bx) content of CMB and PEMB

The reducing sugar content of CMB was 13.62 g 100 g^{-1}. Protein enriched mango bar contained 7.54 g 100 g^{-1} of reducing sugar. Significant variation was observed in the reducing sugar content of CMB and PEMB.

Total sugar content of CMB was 60.31 g 100 g^{-1}, which was significantly higher than the total sugar content of PEMB (51.92 g 100 g^{-1}). The reducing sugar and total sugar content of CMB and PEMB is depicted in Fig.4.

The crude fiber content of CMB and PEMB were 2.48 and 3.38 g 100 g^{-1} respectively. Significant variation was observed in the crude fiber content of CMB and PEMB.

Table 3 reveals the protein, β carotene and vitamin C content of CMB and PEMB.

Protein enriched mango bar had significantly higher protein content of 6.77 g 100 g^{-1} than the control samples which had 2.04 g 100 g^{-1}.

The crude fiber and protein content of CMB and PEMB is illustrated in Fig.5.

The β carotene content was high in CMB compared to PEMB. Control mango bar and PEMB contained 377 and 283 μg 100 g^{-1} of β carotene respectively. Statistically, there was significant variation in the β carotene content of CMB and PEMB.

The vitamin C content of CMB was 24.40 mg 100 g^{-1}. Protein enriched mango bar contained 12.53 mg 100 g^{-1} of vitamin C. Significant variation was observed in the vitamin C content of CMB and PEMB.

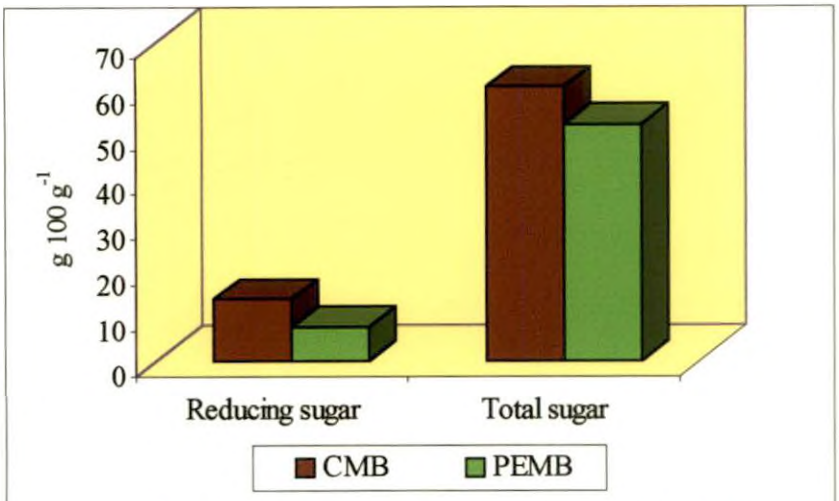

Fig. 4. Reducing sugar and total sugar (g 100 g^{-1}) content of CMB and PEMB

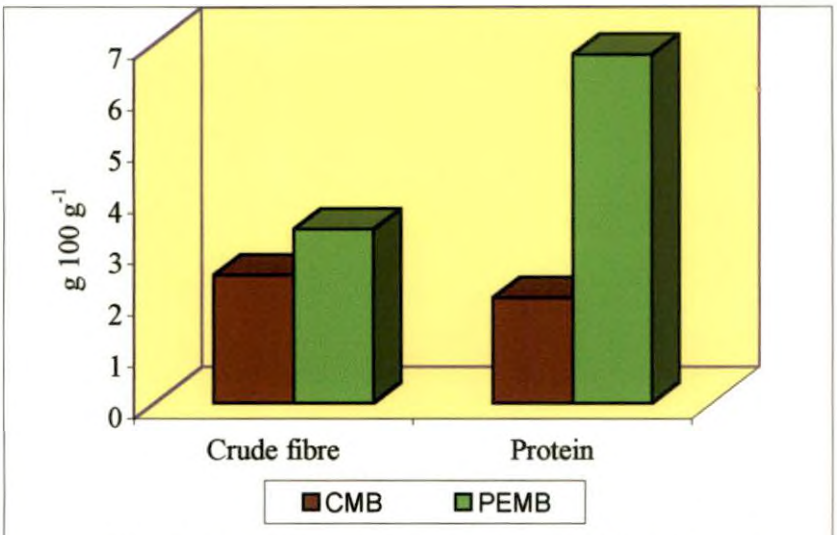

Fig. 5. Crude fiber and protein (g 100 g^{-1}) content of CMB and PEMB

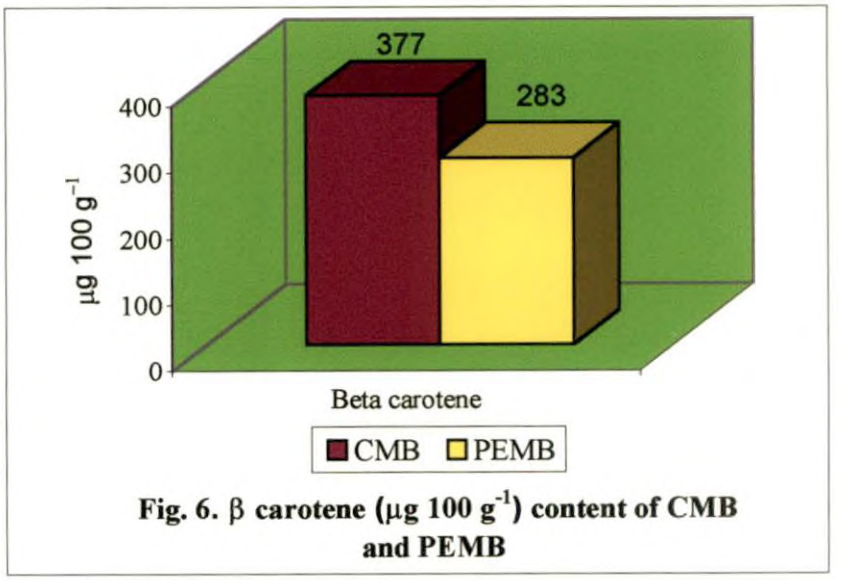

Fig. 6. β carotene (µg 100 g^{-1}) content of CMB and PEMB

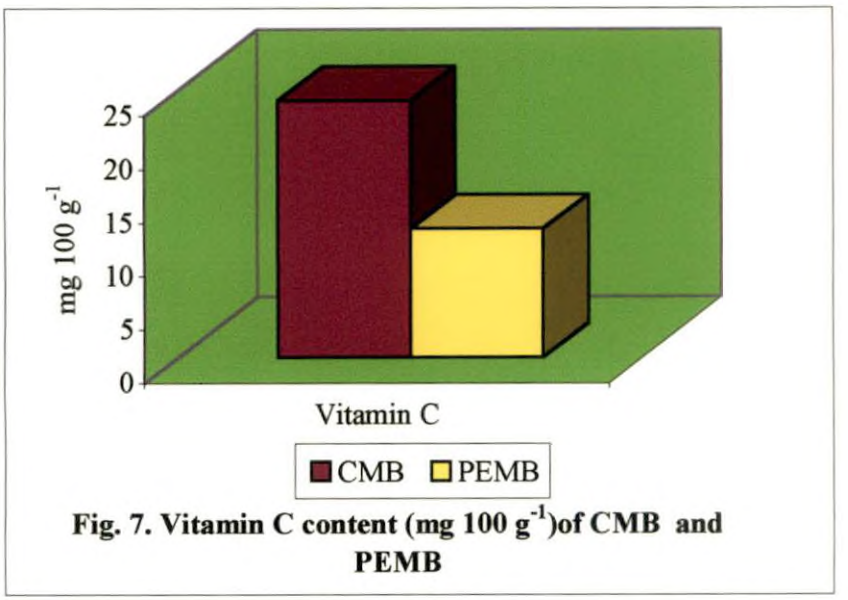

Fig. 7. Vitamin C content (mg 100 g^{-1})of CMB and PEMB

The illustrations of β carotene and vitamin C content of CMB and PEMB are given in Fig.6 and 7. The mineral content of CMB and PEMB are presented in the table 4 and is illustrated in Fig. 8.

Table 4. Mineral content of CMB and PEMB

	Calcium (mg 100 g^{-1})	Iron (mg 100 g^{-1})	Potassium (mg 100 g^{-1})
CMB	67.0	3.84	100.0
PEMB	85.0	4.68	212.5
CD (P < 0.05)	5.75*	0.42*	29.8*

* Significant at 5% level

The calcium content was 67 mg 100 g^{-1} in CMB and 85 mg 100 g^{-1} in PEMB. There was significant variation in the calcium content of CMB and PEMB.

The iron content of CMB and PEMB were 3.84 and 4.68 mg 100 g^{-1} respectively. There was significant variation in the iron content of CMB and PEMB.

Potassium was significantly higher in PEMB (212.5 mg 100 g^{-1}) than the control sample (100 mg 100 g^{-1}).

B. The changes in the chemical constituents of CMB and PEMB during storage using two different packaging materials are presented in table 5. The paired comparison of the changes in the chemical constituents of CMB and PEMB during storage using two different packaging materials are presented in table 5a.

Initial moisture content of control sample (13.51 %) was significantly reduced to 11.96 per cent in samples packed in MPP and stored for 3 months and significantly reduced to 11.16 per cent in sample packed in PP. But there was no

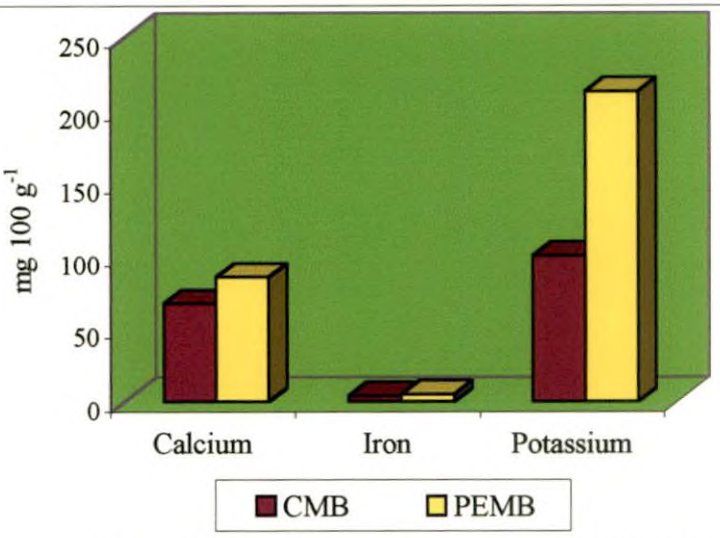

Fig. 8. Calcium, iron and potassium (mg 100 g^{-1}) content of CMB and PEMB

significant variation in the moisture content of control samples packed in MPP and PP after the storage period. In PEMB the initial moisture content (16.09%) was reduced to 14.98 per cent in samples packed in MPP and significantly reduced to 14.69 per cent in samples packed in PP after the storage period. There was no significant variation in the moisture content of PEMB stored in MPP and PP after the storage period. The initial moisture content of the PEMB (16.09%) was significantly high when compared to the initial moisture content of CMB (13.51%). When CMB packed in MPP and PEMB packed in MPP was compared, the moisture content of PEMB was significantly higher (14.98%) than the control samples (11.96%) after the storage period. Similarly, PEMB packed in PP had significantly higher moisture content (14.69%) than CMB packed in PP after the storage period.

Acidity in CMB (0.65%) increased to 0.69 per cent in samples packed in MPP but the increase was not significant. There was a significant increase in acidity (0.78%) in samples packed in PP after 3 months of storage period. There was significant variation in the acidity of CMB packed in MPP and PP after the storage period. In PEMB, the initial acid content (0.46%) increased to 0.49 per cent in samples packed in MPP but the increase was not significant. Acidity was significantly increased to 0.58 percent in samples packed in PP after the storage period. There was significant variation in the acid content of PEMB stored in MPP and PP after the storage period. The initial acidity of CMB (0.65%) was significantly high when compared to the initial acidity of PEMB (0.46%). When control and protein enriched sample packed in MPP were compared, the acid content of CMB was significantly higher (0.69%) than the PEMB (0.49%). Similarly CMB packed in PP had significantly higher acid content (0.78%) than protein enriched samples packed in PP (0.58%) after the storage period.

The effect of storage period and packaging materials on the moisture content and acidity of CMB and PEMB is illustrated in Fig.9 and 10.

Table 5. Changes in the moisture, acidity, TSS, reducing sugar, total sugar and crude fiber content of CMB and PEMB

	Storage period in months	Packaging material	Moisture (g 100 g^{-1})	Acidity (g 100 g^{-1})	TSS (^{0}Bx)	Reducing sugar (g 100 g^{-1})	Total sugar (g 100 g^{-1})	Crude fiber (g 100 g^{-1})
CMB	0	P_0	13.51	0.65	54.50	13.62	60.31	2.48
	3	P_1	11.96	0.69	55.0	13.77	59.63	2.41
		P_2	11.16	0.78	55.75	14.21	59.05	2.33
PEMB	0	P_0	16.09	0.46	51.50	7.54	51.92	3.38
	3	P_1	14.98	0.49	52.50	8.39	51.41	3.37
		P_2	14.69	0.58	53.0	8.63	50.87	3.25
CD (P<0.05)			1.11	0.06	2.17	0.20	0.67	0.19

P_0 – Initial (No packaging) P_1 – MPP P_2 – PP

Table 5a. Paired comparison of the changes in the moisture, acidity, TSS, reducing sugar, total sugar and crude fiber content of CMB and PEMB during storage

	Pairs	Moisture	Acidity	TSS	Reducing sugar	Total Sugar	Crude fiber
CMB	P_0 . P_1	1.55*	0.04	0.50	0.15	0.68*	0.07
	P_0 . P_2	2.35*	0.13*	1.25	0.59*	1.26*	0.15
	P_1 . P_2	0.80	0.09*	0.75	0.44*	0.58	0.08
PEMB	P_0 . P_1	1.11	0.03	1.00	0.85*	0.51	0.01
	P_0 . P_2	1.40*	0.12*	1.50	1.09*	1.05*	0.13
	P_1 . P_2	0.29	0.09*	0.50	0.24*	0.54	0.12
CMB & PEMB	P_0 . P_0	2.58*	0.19*	3.00*	6.08*	8.39*	0.90*
	P_1 . P_1	3.02*	0.20*	2.50*	5.38*	8.22*	0.96*
	P_2 . P_2	3.53*	0.20*	2.75*	5.58*	8.18*	0.92*
CD		1.11	0.06	2.17	0.20	0.67	0.19

Significant at 5% level

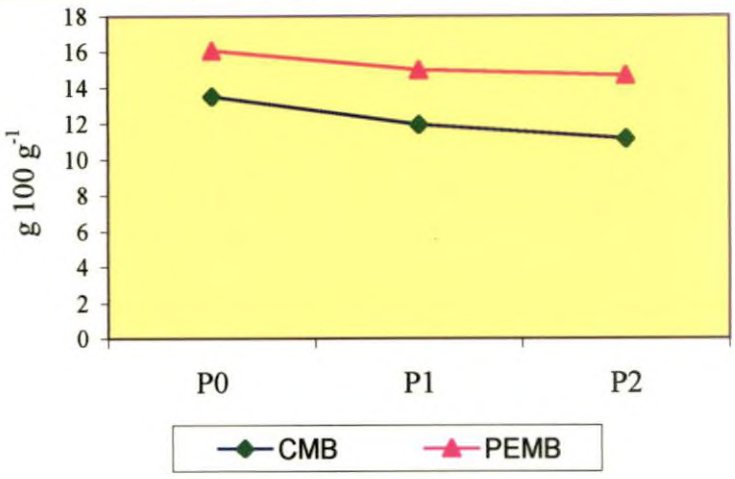

Fig. 9. Effect of storage and packaging materials on the moisture content of CMB and PEMB

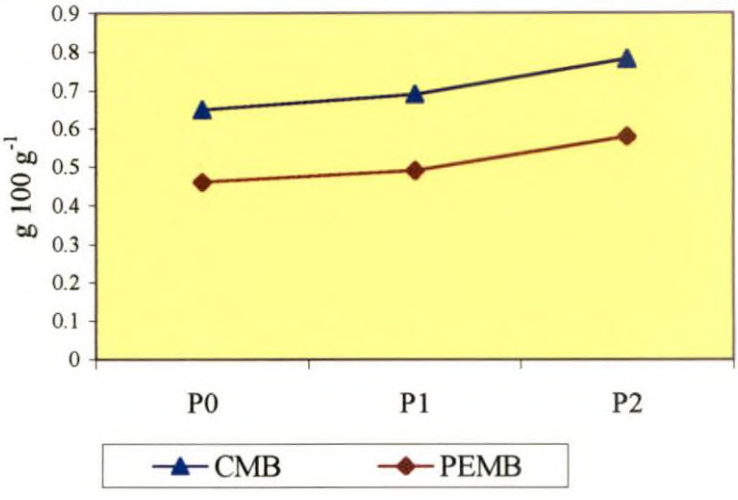

Fig. 10. Effect of storage and packaging materials on the acidity of CMB and PEMB

The initial TSS content of CMB (54.5^0 Bx) increased to 55^0 Bx in sample packed in MPP and increased to 55.75^0 Bx in sample packed in PP, but the increase was not significant. There was no significant variation in the TSS content of control sample packed in MPP and PP after the storage period. In PEMB also the initial TSS content (51.5^0 Bx) increased to 52.5^0 Bx in samples packed in MPP and increased to 53^0 Bx in PP packed sample after the storage period, but there was no significant variation. There was no significant variation in the TSS content of PEMB packed in MPP and PP after three months of storage period. The initial TSS content of CMB (54.5^0 Bx) was significantly higher than the initial TSS content of PEMB (51.5^0 Bx). When CMB and PEMB packed in MPP were compared, the TSS content of CMB was significantly higher (55^0 Bx) than PEMB (52.5^0 Bx) after three months of storage. Similarly CMB packed in PP had significantly higher TSS content (55.75^0 Bx) than PEMB packed in PP (53^0 Bx) after the storage period.

The effect of storage period and packaging materials on the TSS content of CMB and PEMB is illustrated in Fig.11.

There was no significant increase in the reducing sugar content of CMB (13.62%) and mango bar packed in MPP (13.77 %) but there was a significant increase in reducing sugar content of CMB packed in PP (14.21%) after three months of storage period. There was significant variation between the reducing sugar content of CMB packed in MPP and PP after the storage period. In PEMB, initial reducing sugar content (7.54%) was significantly increased to 8.39 per cent and 8.63 per cent in samples packed in MPP and PP respectively after the storage. Significant variation was observed in the reducing sugar content of PEMB packed in MPP and PP after the storage period. The initial reducing sugar content of CMB (13.62%) was significantly high when compared to initial reducing sugar content of PEMB (7.54%). When CMB and PEMB packed in MPP was compared, reducing sugar content of CMB was significantly higher (13.77%) than

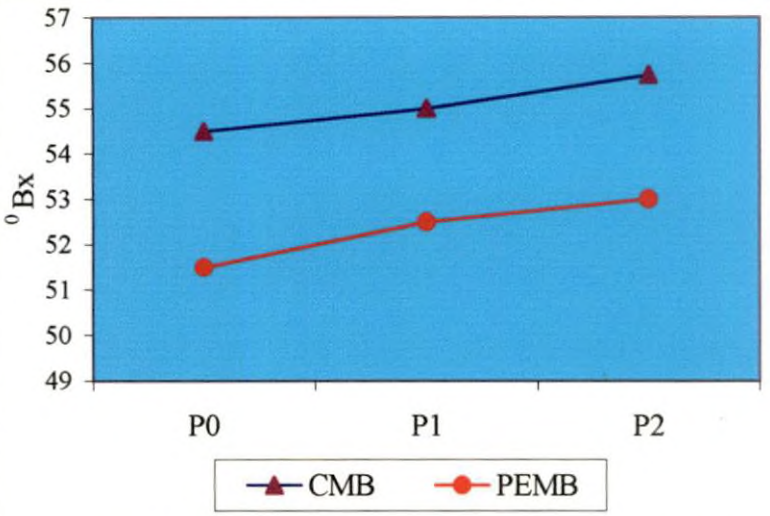

Fig. 11. Effect of storage and packaging materials on the TSS content of CMB and PEMB

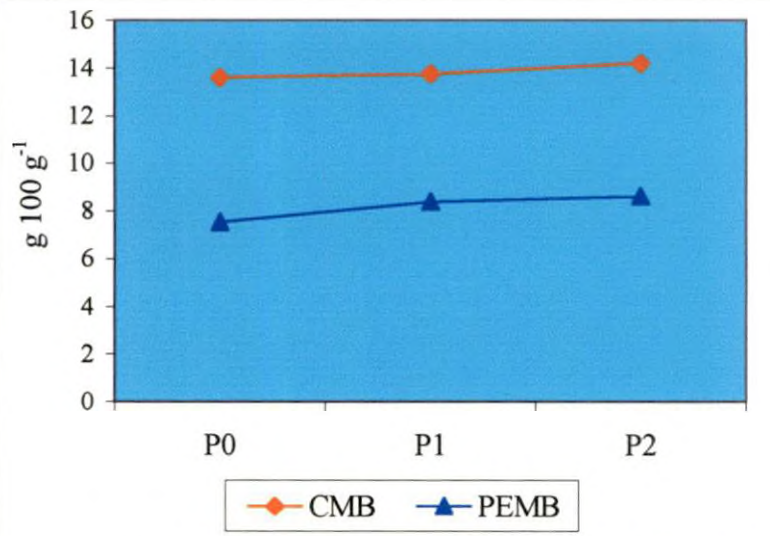

Fig. 12. Effect of storage and packaging materials on the reducing sugar content of CMB and PEMB

PEMB (8.39%). Similarly, CMB packed in PP had significantly higher reducing sugar content (14.21%) than PEMB packed in PP after the storage period.

The initial total sugar content of CMB (60.31%) was significantly reduced to 59.63 per cent in samples packed in MPP and significantly reduced to 59.05 per cent in samples packed in PP after the storage period. But there was no significant variation in the total sugar content of CMB packed in MPP and PP after the storage period. In PEMB, there was no significant variation in the initial total sugar (51.92%) and sugar content of the samples packed in MPP (51.41%) but a significant reduction in total sugar was observed in samples packed in PP (50.87%) after the storage period. There was no significant variation in the total sugar content of PEMB stored in MPP and PP after the storage period. The initial total sugar content of CMB (60.31%) was significantly high when compared to the initial total sugar content of PEMB (51.92%). When control samples and protein enriched samples packed in MPP were compared, the total sugar content of CMB (59.63%) was significantly higher than PEMB (51.41%) after the storage period. Similarly CMB packed in PP had significantly higher total sugar content (59.05%) than PEMB packed in PP after the storage.

The effect of storage and packaging materials on the reducing sugar and total sugar content of CMB and PEMB are illustrated in Fig.12 and 13.

The initial crude fiber content of CMB (2.48 g 100 g^{-1}) was reduced to 2.41 g 100 g^{-1} in samples packed in MPP and was reduced to 2.33 g 100 g^{-1} in PP packed samples after the storage period but the reduction in fiber content of both the samples were not significant. There was no significant variation in the crude fiber content of CMB packed in MPP and PP after the storage. In PEMB, initial crude fiber content (3.38 g 100 g^{-1}) was reduced to 3.37 and 3.25 g 100 g^{-1} in samples packed in MPP and PP respectively after the storage period, but the reduction was not significant. There was no significant variation in the crude fiber content of protein enriched samples packed in MPP and PP after the storage

period. The crude fiber content of PEMB (3.38 g 100 g^{-1}) was significantly higher than CMB (2.48 g 100 g^{-1}). When CMB and PEMB packed in MPP were compared, PEMB had significantly high crude fiber (3.37 g 100 g^{-1}) than control samples. The crude fiber content of PEMB packed in PP (3.25 g 100 g^{-1}) was significantly higher than control samples packed in PP (2.33 g 100 g^{-1}). The effect of storage and packaging materials on the crude fiber content of CMB and PEMB is illustrated in Fig.14.

The changes in the protein, β carotene and vitamin C content of CMB and PEMB during storage using two different packaging materials is presented in the table 6 and the paired comparison of the changes in the protein, β carotene and vitamin C content of CMB and PEMB during storage is presented in table 6a.

The initial protein content of CMB (2.04 g 100 g^{-1}) was significantly reduced to 1.87 g 100 g^{-1} in samples packed in MPP and significantly reduced to 1.81 g 100 g^{-1} in PP packed samples after the storage period. But there was no significant variation in the protein content of CMB packed in MPP and PP after the storage period. The initial protein content of PEMB (6.77 g 100 g^{-1}) was significantly reduced to 6.55 and 6.46 g 100 g^{-1} in samples packed in MPP and PP respectively after the storage period. There was significant variation in the protein content of PEMB packed in MPP and PP after the storage period. The initial protein content of PEMB (6.77 g 100 g^{-1}) was significantly high when compared to the initial protein content of CMB. The protein content of PEMB packed in MPP (6.55 g 100 g^{-1}) was significantly high when compared to the protein content of CMB packed in MPP (1.87 g 100 g^{-1}) after three months of storage. Similarly, protein content of PEMB packed in PP (6.46 g 100 g^{-1}) was significantly higher than protein content of CMB packed in PP (1.81 g 100 g^{-1}).

The initial β carotene content of CMB (377 μg 100 g^{-1}) was reduced to 367 and 354 μg 100 g^{-1} in samples packed in MPP and PP respectively after the storage period. There was significant variation in the β carotene content of CMB

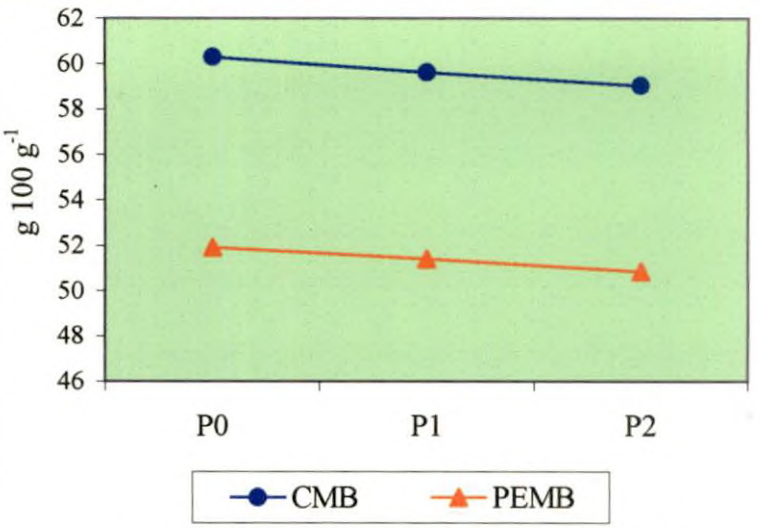

Fig. 13. Effect of storage and packaging materials on the total sugar content of CMB and PEMB

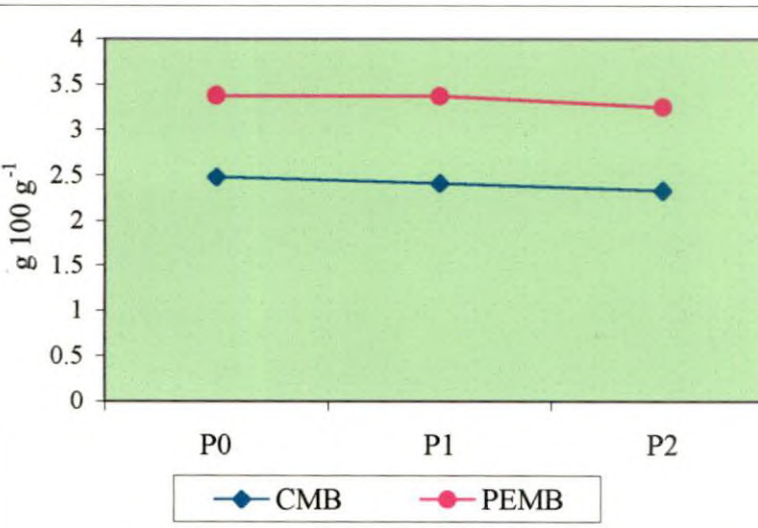

Fig. 14. Effect of storage and packaging materials on the crude fiber content of CMB and PEMB

Table 6. Changes in the protein, β carotene and vitamin C content of CMB and PEMB during storage

	Storage period in months	Packaging material	Protein (g 100 g^{-1})	β carotene (μg 100 g^{-1})	Vitamin C (mg 100 g^{-1})
CMB	0	P_0	2.04	377	24.40
	3	P_1	1.87	367	21.15
		P_2	1.81	354	18.39
PEMB	0	P_0	6.77	283	12.53
	3	P_1	6.55	271	10.94
		P_2	6.46	257	9.69
CD ($P < 0.05$)			0.07	10	0.76

P_0 – Initial (No packaging) P_1 – MPP P_2 – PP

Table 6a. Paired comparison of the changes in the protein, β carotene and vitamin C content of CMB and PEMB during storage

	Pairs	Protein	β carotene	Vitamin C
CMB	P_0 . P_1	0.17*	10	3.25*
	P_0 . P_2	0.23*	23*	6.01*
	P_1 . P_2	0.06	13*	2.76*
PEMB	P_0 . P_1	0.22*	12*	1.59*
	P_0 . P_2	0.31*	26*	2.84*
	P_1 . P_2	0.09*	14*	1.25*
CMB & PEMB	P_0 . P_0	4.73*	94*	11.87*
	P_1 . P_1	4.68*	96*	10.21*
	P_2 . P_2	4.65*	97*	8.70*
CD		0.07	10	0.76

* Significant at 5% level

packed in MPP and PP after the storage period. The initial β carotene content of PEMB (283 μg 100 g^{-1}) was significantly reduced to 271 and 257 μg 100 g^{-1} in samples packed in MPP and PP respectively after the storage time. There was significant variation in the β carotene content of PEMB packed in MPP and PP after the storage period. The initial β carotene content of CMB (377 μg 100 g^{-1}) was significantly high when compared to the initial β carotene content of PEMB (283 μg 100 g^{-1}). When CMB and PEMB packed in MPP was compared, control sample had significantly high β carotene content (367 μg 100 g^{-1}) than protein enriched sample (271 μg 100 g^{-1}) after the storage period. Similarly, CMB packed in PP had significantly higher β carotene (354 μg 100 g^{-1}) than PEMB packed in PP (257 μg 100 g^{-1}).

Initial vitamin C content of CMB (24.4 mg 100 g^{-1}) was significantly reduced to 21.15 and 18.39 mg 100 g^{-1} in MPP packed and PP packed samples respectively after the storage period. Vitamin C content was significantly high in samples packed in MPP than in PP after the storage period. The initial vitamin C content of PEMB (12.53 mg 100 g^{-1}) was significantly reduced to 10.94 and 9.69 mg 100 g^{-1} in MPP and PP packed samples respectively after the storage period. Vitamin C content was significantly high in samples packed in MPP (10.94 mg 100 g^{-1}) when compared to sample packed in PP after the storage period. Initial vitamin C content of CMB (24.40 mg 100 g^{-1}) was significantly higher than initial vitamin C content of protein enriched sample (12.53 mg 100 g^{-1}). When vitamin C content of control and protein enriched sample packed in MPP was compared, control sample had significantly high vitamin C (21.15 mg 100 g^{-1}). Similarly, vitamin C in CMB packed in PP (18.39 mg 100 g^{-1}) was significantly higher than PEMB packed in PP (9.69 mg 100 g^{-1}) after the storage period.

The effect of storage period and packaging materials on the protein, β carotene and vitamin C content of CMB and PEMB are illustrated in Fig.15, 16 and 17.

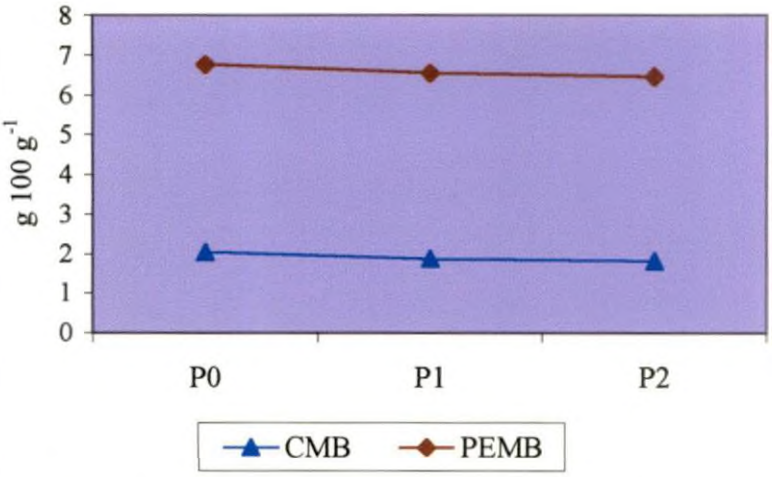

Fig. 15. Effect of storage and packaging materials on the protein content of CMB and PEMB

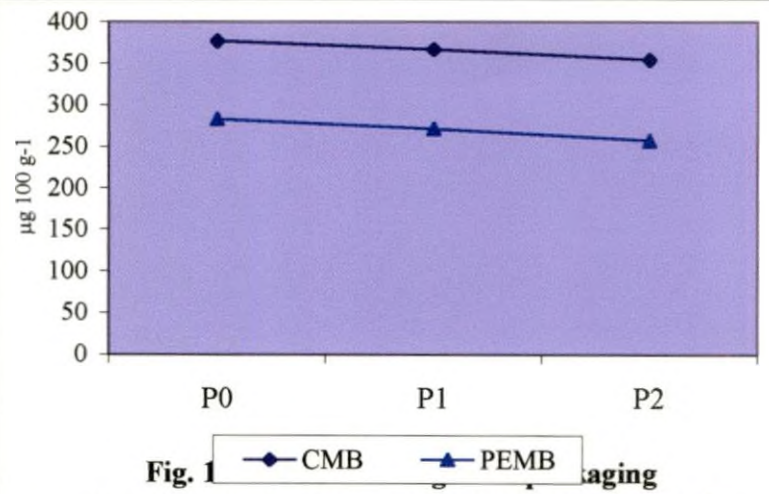

Fig. 1 aging materials on the β carotene content of CMB and PEMB

The changes in the mineral contents of CMB and PEMB during storage in two different packaging materials are presented in table 7 and the paired comparison is given in table 7a. The illustrations of the changes in the mineral contents of CMB and PEMB during storage are presented in Fig18, 19 and 20.

The initial calcium content of CMB (67 mg 100 g^{-1}) was significantly reduced to 61 mg 100 g^{-1} and 57 mg 100 g^{-1} in MPP and PP packed samples respectively after the storage period. There was no significant variation in the calcium content of control sample packed in MPP (61.0 mg 100 g^{-1}) and PP (57 mg 100 g^{-1}) after the storage period. In PEMB, initial calcium content of 85 mg 100 g^{-1} was reduced to 79.5 mg 100 g^{-1} and 75.0 mg 100 g^{-1} in sample packed in MPP and PP respectively after the storage period. There was no significant variation in the calcium content of PEMB packed in MPP (79.5 mg 100 g^{-1}) and PP (75.0 mg 100 g^{-1}) after three months of storage period. The initial calcium content of PEMB (85 mg 100 g^{-1}) was significantly higher than the initial calcium content of CMB (67 mg 100 g^{-1}). When CMB and PEMB packed in MPP was compared, the calcium content of PEMB (79.5 mg 100 g^{-1}) was significantly higher than CMB after the storage period. Similarly PEMB packed in PP had significantly higher calcium content (75 mg 100 g^{-1}) than CMB packed in PP (57 mg 100 g^{-1}) after the storage period.

The initial iron content of CMB (3.84 mg 100 g^{-1}) was reduced significantly to 3.3 mg 100 g^{-1} and 3.03 mg 100 g^{-1} in samples packed in MPP and PP respectively stored for three months. There was no significant variation in the iron content of CMB packed in MPP (3.30 mg 100 g^{-1}) and PP (3.03 mg 100 g^{-1}) after the storage period. In PEMB the initial iron content of 4.68 mg 100 g^{-1} reduced to 4.37 mg 100 g^{-1} in MPP packed sample after three months of storage but the reduction was not significant. But the iron content was significantly reduced to 4.03 mg 100 g^{-1} in sample packed in PP. But there was no significant variation in the iron content of MPP (4.37 mg 100 g^{-1}) and PP (4.03 mg 100 g^{-1})

Table 7. Changes in the mineral content of CMB and PEMB during storage

	Storage period in months	Packaging material	Calcium (mg 100 g^{-1})	Iron (mg 100 g^{-1})	Potassium (mg 100 g^{-1})
CMB	0	P_0	67.0	3.84	100.0
	3	P_1	61.0	3.30	87.5
		P_2	57.0	3.03	100.0
PEMB	0	P_0	85.0	4.68	212.5
	3	P_1	79.5	4.37	187.5
		P_2	75.0	4.03	212.5
CD ($P < 0.05$)			5.75	0.42	29.8

P_0 – Initial (No packaging) P_1 – MPP P_2 – PP

Table 7a. Paired comparison of the changes in the mineral content of CMB and PEMB during storage

	Pairs	Calcium	Iron	Potassium
CMB	P_0 - P_1	6.0*	0.54*	12.5
	P_0 - P_2	10.0*	0.81*	0.0
	P_1 - P_2	4.0	0.27	12.5
PEMB	P_0 - P_1	5.5	0.31	25.0
	P_0 - P_2	10.0*	0.65*	0.0
	P_1 - P_2	4.5	0.34	25.0
CMB & PEMB	P_0 - P_0	18.0*	0.84*	112.5*
	P_1 - P_1	18.5*	1.07*	100.5*
	P_2 - P_2	18.0*	1.00*	112.5*
CD		5.75	0.42	29.8

* Significant at 5% level

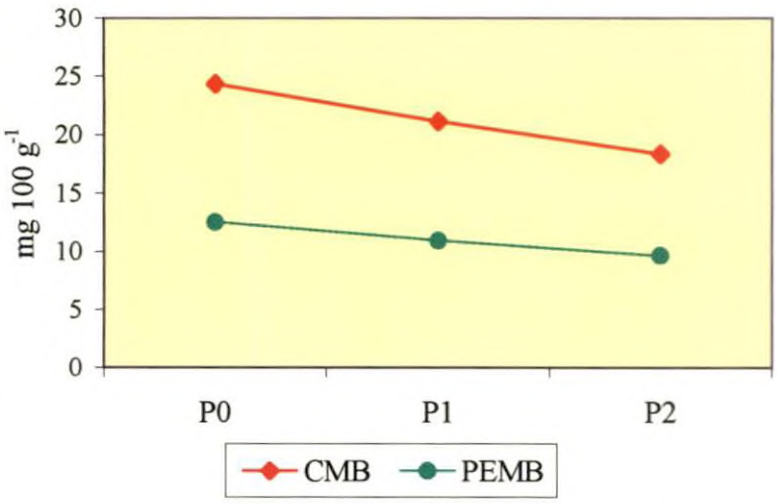

Fig. 17. Effect of storage and packaging materials on the vitamin C content of CMB and PEMB

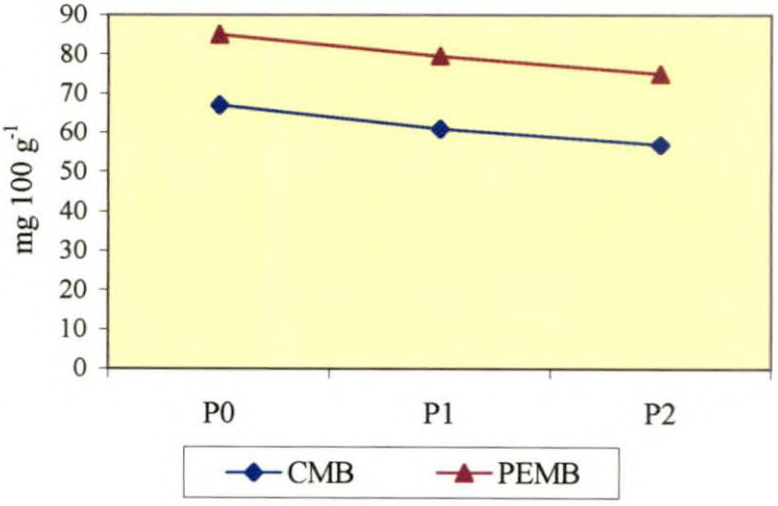

Fig. 18. Effect of storage and packaging materials on the calcium content of CMB and PEMB

packed PEMB after the storage period. The initial iron content of protein enriched sample (4.68 mg 100 g^{-1}) was significantly higher than in the control sample (3.84 mg 100 g^{-1}). When control sample and protein enriched sample packed in MPP was compared, the iron content of PEMB (4.37 mg 100 g^{-1}) was significantly higher than iron content of CMB (3.3 mg 100 g^{-1}) after the storage period. When CMB and PEMB packed in PP was compared, iron content of protein enriched sample (4.03 mg 100 g^{-1}) was significantly higher than in the control sample (3.03 mg 100 g^{-1}).

The initial potassium content of CMB (100 mg 100 g^{-1}) was reduced to 87.5 mg 100 g^{-1} in sample packed in MPP and the reduction was not significant. There was no change in the potassium content of samples packed in PP (100 mg 100 g^{-1}) after the storage period. There was no significant variation in the potassium content of control sample packed in MPP (87.5 mg 100 g^{-1}) and PP (100.0 mg 100 g^{-1}) after the storage period. In protein enriched sample also, the initial potassium content of 212.5 mg 100 g^{-1} was reduced to 187.5 mg 100 g^{-1} in MPP packed sample but the reduction was not significant. There was no change in potassium content of samples packed in PP (212.5 mg 100 g^{-1}) after the storage period. No significant variation was observed in the potassium content of PEMB in MPP (187.5 mg 100 g^{-1}) and PP (212.5 mg 100 g^{-1}) packed samples after the storage period. The initial potassium content of protein enriched sample (212.5 mg 100 g^{-1}) was significantly higher than initial potassium content of CMB (100 mg 100 g^{-1}). The potassium content of PEMB packed in MPP (187.5 mg 100 g^{-1}) was significantly higher than control sample packed in MPP (87.5 mg 100 g^{-1}) after the storage. When control and protein enriched sample packed in PP was compared, potassium content of protein enriched sample (212.5 mg 100 g^{-1}) was significantly higher than the potassium content of control sample (100 mg 100 g^{-1}) after the storage period.

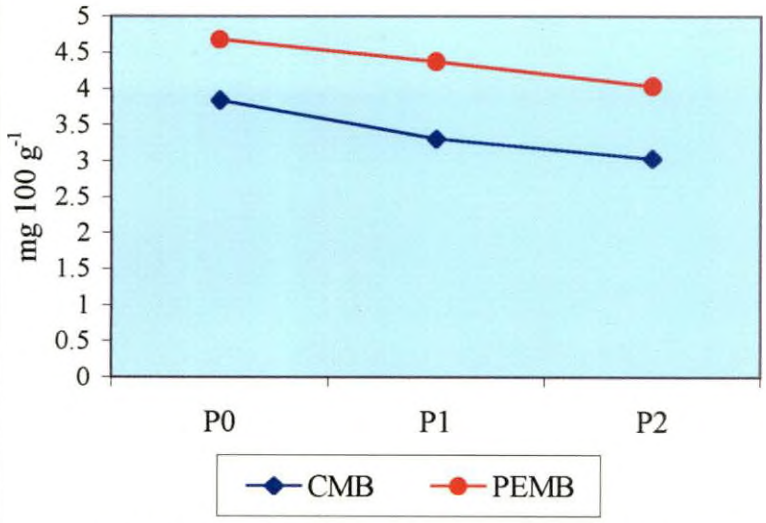

Fig. 19. Effect of storage and packaging materials on the iron content of CMB and PEMB

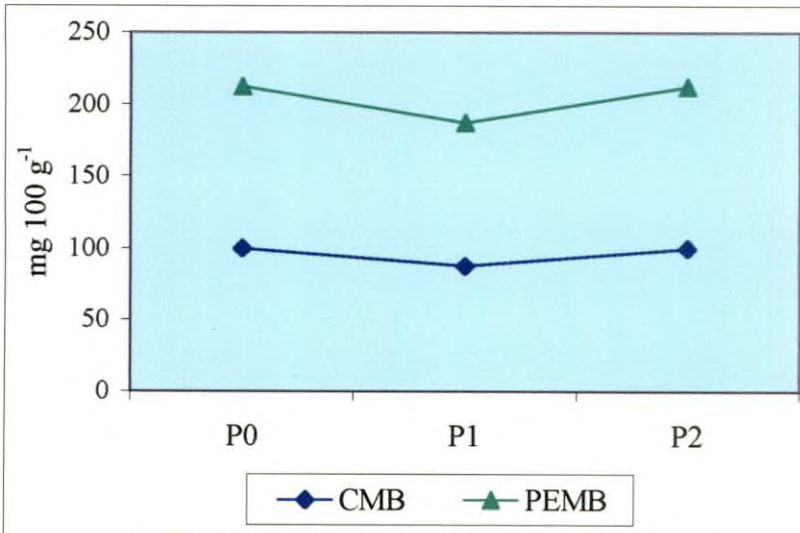

Fig. 20. Effect of storage and packaging materials on the potassium content of CMB and PEMB

4.2 ORGANOLEPTIC STUDIES

Results of the organoleptic evaluation of CMB and PEMB during storage in two different packaging materials are presented in table 8 and the paired comparison is given in table 8a.

The initial mean scores for appearance of CMB (4.27) was significantly reduced to 4.0 in sample packed in MPP and was significantly reduced to 3.93 in PP packed sample after storage. But no significant variation was observed in the appearance of control samples packed in MPP and PP after the storage. Initial scores for appearance of PEMB (4.0) was significantly reduced to 3.67 and 3.60 in MPP and PP packed samples respectively after the storage period. But there was no significant variation in the appearance of protein enriched product packed in MPP and PP after the storage. Initial scores for appearance of CMB (4.27) was significantly higher than scores for appearance of PEMB (4.0). Control bar packed in MPP had significantly higher scores for appearance (4.0) than PEMB packed in MPP (3.67) after the storage period. The mean score for appearance of CMB packed in PP was significantly higher (3.93) than the mean score of PEMB in PP.

The mean score for colour of CMB (4.27) was significantly reduced to 4.0 and 3.93 in MPP and PP packed samples respectively after the storage period. No significant variation was observed in the score for colour of CMB packed in MPP (4.0) and PP (3.93) after the storage. In PEMB also the initial score for colour (3.87) reduced significantly to 3.60 in MPP packed sample and 3.40 in PP packed sample after the storage period. There was significant variation in the score for colour of PEMB packed in MPP (3.60) and PP (3.40) after the storage period. The initial score for colour of CMB (4.27) was significantly higher than initial score for colour of PEMB (3.87). The score for colour of CMB packed in MPP (4.0) was significantly higher than colour of PEMB packed in MPP (3.60). Similarly

Table 8. Changes in the organoleptic qualities of CMB and PEMB during storage (Mean scores)

	Storage period in months	Packaging material	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
CMB	0	P_0	4.27	4.27	4.07	4.00	4.00	4.12
	3	P_1	4.00	4.00	3.87	3.87	3.93	3.93
		P_2	3.93	3.93	3.93	3.73	3.87	3.88
PEMB	0	P_0	4.00	3.87	3.80	3.87	3.80	3.87
	3	P_1	3.67	3.60	3.67	3.60	3.53	3.60
		P_2	3.60	3.40	3.47	3.53	3.73	3.55
CD (P<0.05)			0.19	0.14	0.17	0.14	0.14	0.14

P_0 – Initial (No packaging) P_1 – MPP P_2 – PP

Table 8a. Paired comparison of the changes in the organoleptic qualities of CMB and PEMB during storage (Mean scores)

	Pairs	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
CMB	P_0 - P_1	0.27*	0.27*	0.20*	0.13	0.07	0.19*
	P_0 - P_2	0.34*	0.34*	0.14	0.27*	0.13	0.24*
	P_1 - P_2	0.07	0.07	0.06	0.14	0.06	0.05
PEMB	P_0 - P_1	0.33*	0.27*	0.13	0.27*	0.27*	0.27*
	P_0 - P_2	0.40*	0.47*	0.33*	0.34*	0.07	0.32*
	P_1 - P_2	0.07	0.20*	0.20*	0.07	0.20*	0.05
CMB & PEMB	P_0 - P_0	0.27*	0.40*	0.27*	0.13	0.20*	0.25*
	P_1 - P_1	0.33*	0.40*	0.20*	0.27*	0.40*	0.33*
	P_2 - P_2	0.33*	0.53*	0.46*	0.20*	0.14	0.33*
CD		0.19	0.14	0.17	0.14	0.14	0.14

* Significant at 5% level

CMB packed in PP had significantly higher score for colour (3.93) than PEMB packed in PP (3.40).

The initial mean score for flavour of CMB (4.07) reduced significantly to 3.87 in MPP packed sample and reduced to 3.93 in PP packed sample but the reduction in the mean score for flavour in the PP packed sample was not significant after the storage period. No significant variation was observed in the score for flavour of CMB packed in MPP and PP. In PEMB, initial score for flavour (3.80) was reduced to 3.67 in MPP packed sample, which was not a significant reduction. But the mean score was significantly reduced to 3.47 in PP packed sample. There was a significant variation in the score for flavour of PEMB packed in MPP (3.67) and PP (3.47) after the storage but not in CMB. Significantly higher score for flavour was observed in CMB initially (4.07) than initial score for flavour of PEMB (3.80). Control bar packed in MPP had significantly higher score for flavour (3.87) than PEMB packed in MPP (3.67). Score for flavour of CMB packed in PP (3.93) was significantly higher than score for flavour of PP packed PEMB (3.47).

The mean score for texture of CMB (4.0) was reduced to 3.87 in MPP packed sample but the difference was not significant. But significant reduction in the mean score was observed in PP packed sample (3.73). There was no significant variation in the score for texture of CMB packed in MPP and PP after the storage period. Initial mean score for texture of PEMB (3.87) was significantly reduced to 3.60 and 3.53 in MPP and PP packed samples respectively. No significant variation was observed in the scores for texture of PEMB packed in MPP and PP. The initial score for texture of CMB (4.0) was higher than score for texture of PEMB (3.87) but the difference was not significant. When CMB packed in MPP and PEMB packed in MPP was compared, CMB had significantly higher score for texture (3.87) than PEMB in MPP. Similarly, CMB packed in PP had significantly higher score for texture (3.73) than PEMB packed in PP (3.60).

The mean score for taste of CMB (4.0) was reduced to 3.93 in MPP packed sample and reduced to 3.87 in PP packed sample after three months of storage period, but the variation was not significant. Similarly, no significant variation was observed in control sample packed in MPP and PP after the storage period. The initial score for taste of PEMB (3.80) was significantly reduced to 3.53 in MPP packed sample after the storage period and reduced to 3.73 in PP packed sample but this reduction in the mean score for taste was not significant. Significant variation was observed in the score for taste of protein enriched sample packed in MPP and PP after the storage period. Initially, the score for taste of CMB (4.0) was significantly higher than score for taste of PEMB (3.80). Control bar packed in MPP had significantly higher score for taste (3.93) than PEMB packed in MPP (3.53) after the storage period of three months. Control bar packed in PP had higher score for taste (3.87) than PEMB packed in PP (3.73) but the variation was not significant.

The score for overall acceptability of CMB (4.12) was significantly reduced to 3.93 and 3.88 in samples packed in MPP and PP respectively after the storage period. No significant variation was observed in the score for overall acceptability of CMB packed in MPP (3.93) and PP (3.88). The mean scores for overall acceptability of PEMB (3.87) was reduced significantly to 3.60 in MPP packed sample and reduced to 3.55 in PP packed sample after three months and the variation was found to be significant. There was no significant variation in the score for overall acceptability of PEMB packed in MPP (3.60) and PP (3.55). Initially, mean score for overall acceptability of CMB (4.12) was significantly higher than score for PEMB (3.87). Control bar packed in MPP had significantly higher score for overall acceptability (3.93) than PEMB packed in MPP (3.60). Significantly higher score for overall acceptability was found in CMB packed in PP (3.88) than PEMB packed in PP (3.55).

The changes in the overall acceptability of CMB and PEMB in two packaging materials are illustrated in Fig.21.

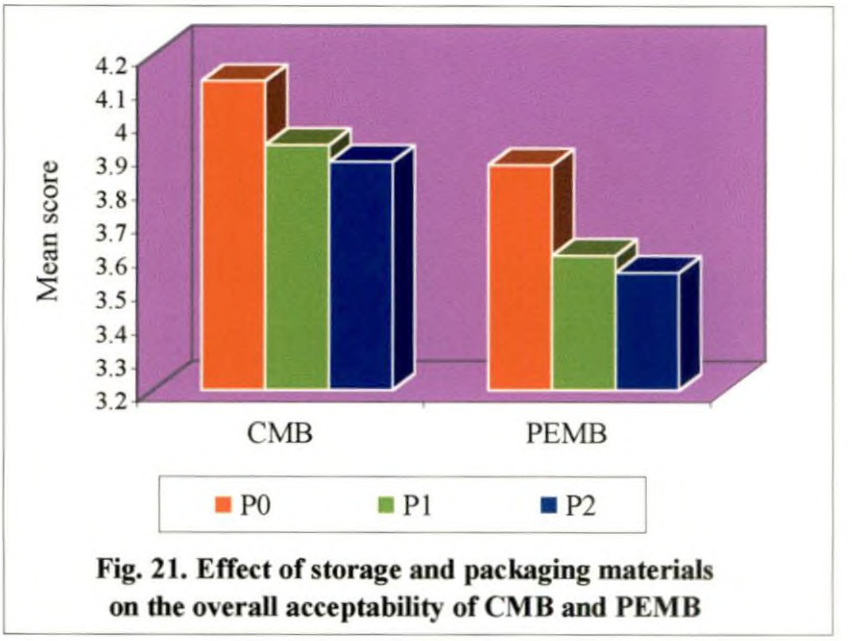

Fig. 21. Effect of storage and packaging materials on the overall acceptability of CMB and PEMB

4.3 MICROBIAL POPULATION AND STORAGE INSECT PESTS

Total microbial population of CMB and PEMB in different packaging materials is given in table 9.

The CMB had a bacterial population of 0.13 x 10^5 cfu g^{-1} initially and it increased to 1.2 x 10^5 cfu g^{-1} in MPP and 1.6 x 10^5 cfu g^{-1} in PP bags after three months.

The bacterial population of PEMB was found to be 0.05 x 10^5 cfu g^{-1} initially. After three months of storage it increased to 0.75 x 10^5 cfu g^{-1} in MPP and 0.98 x 10^5 cfu g^{-1} in PP bags.

Table 9. Microbial population of CMB and PEMB during storage

	CMB			PEMB		
	P_0	P_1	P_2	P_0	P_1	P_2
Bacteria (x 10^5 cfu g^{-1})	0.13	1.2	1.6	0.05	0.75	0.98
Fungi (x 10^3 cfu g^{-1})	ND	0.15	0.18	ND	0.28	0.33
Yeast (x 10^3 cfu g^{-1})	ND	ND	0.08	ND	0.05	0.13

ND – Not detected

P_0 – Fresh sample

P_1 – MPP

P_2 – PP

There was no fungal growth initially in both CMB and PEMB. After three months of storage, fungal population was 0.15 x 10^3 cfu g^{-1} in CMB packed in MPP. In PP bags, it was 0.18 x 10^3 cfu g^{-1}. The fungal population of PEMB was 0.28 x 10^3 cfu g^{-1} in MPP and 0.33 x 10^3 cfu g^{-1} in PP bags.

There was no yeast growth in CMB and PEMB initially. After three months of storage, yeast growth was not observed in CMB packed in MPP and 0.08 x 10^3 cfu g^{-1} was observed in samples in PP. A yeast population of 0.05 x10^3 cfu g^{-1} and 0.13 x 10^3 cfu $g^{-1}$was observed in PEMB packed in MPP and PP respectively.

The most common storage insects in dried fruits were reported to be flour beetles, Indian meal moths, dermestid beetles, saw toothed grain beetles. But there was no storage insect pest infestation in both CMB and PEMB during the entire period of storage.

4.4 BENEFIT COST ANALYSIS

Yield and Benefit Cost (BC) ratio of products were worked out and is given in table 10.

The highest yield was observed in PEMB (0.40 kg per kg of mango) and lowest yield in CMB (0.32 kg per kg of mango).

The cost was highest for PEMB packed in MPP (Rs.71.25/ kg) and lowest for CMB packed in PP (Rs.56.50/ kg).

Table 10. Yield and BC ratio of products

SI NO	Product	Yield/ kg of mango (kg)	Cost/ kg of products (Rs)	BC ratio
1	CMB MPP	0.32	66	3.63
2	CMB PP	0.32	56.50	4.24
3	PEMB MPP	0.40	71.25	4.07
4	PEMB PP	0.40	61.75	4.69

All the products had BC ratio greater than one. The highest BC ratio was observed in PEMB packed in PP (4.69) and lowest BC ratio in CMB packed in MPP.

DISCUSSION

5. DISCUSSION

The discussion pertaining to the study is presented under the following heads.

1. Chemical composition of mango bars
2. Organoleptic studies
3. Microbial enumeration and storage insect pests in mango bar
4. Benefit cost analysis

5.1 CHEMICAL COMPOSITION OF MANGO BAR

A. The moisture content of CMB was 13.51 per cent. When compared to the results observed by Nadanasabapathi *et al.* (1993) where the moisture content of commercially available mango bar was 15.86 per cent, the moisture content of mango bar in the present study (13.51%) is very low. But Hemakar *et al.* (2000) reported a moisture content of 11 per cent in mango bars. The PEMB had a moisture content of 16.09 per cent in the present study. Mir and Nath (2000) reported a moisture content of 18.7 and 18.4 per cent in mango – desiccated coconut bar and mango – soy protein concentrate bar respectively. Shanthi (2000) reported a moisture content of 15 per cent in PEMB. Protein enriched mango bar had significantly high moisture content.

The acid content of CMB was found to be 0.65 g 100 g^{-1} which was in accordance with the results of Shanthi (2000) who reported an acid content of 0.64 g per cent in mango bars. Hemakar *et al.* (2000) reported an acid content of 0.58 per cent in mango bar. The PEMB had a significantly low acid content of 0.46 per cent which was in accordance with Shanthi (2000) who reported an acid content of 0.43 per cent in green gram enriched mango bar. But Mir and Nath (2000) reported high acidity (1.41 – 1.78 %) in PEMB.

TSS content of CMB was 54.50^0 Bx and PEMB had significantly low TSS of 51.50^0 Bx. Sandhu *et al.* (2001) reported a TSS content of 50.60^0 Bx in guava bar. Shanthi (2000) reported a TSS content of 55^0 Bx in soy protein enriched mango bar.

The reducing sugar content of CMB was 13.62 per cent. Hemakar *et al.* (2000) reported the reducing sugar content to be 10.51 per cent in plain mango bar. But Mir and Nath (2000) reported a higher reducing sugar content of 21.8 per cent in CMB. Protein enriched mango bar had significantly low reducing sugar content of 7.54 per cent. Shanthi (2000) also reported a reducing sugar content of 7.90 per cent in mango – soy bar.

The total sugar content of CMB was 60.31 per cent. This result is in line with the results of Hemakar *et al.* (2000) who reported the total sugar to be 60 per cent in plain mango bar. Rao and Roy (1980b) reported a higher total sugar content of 65.74 per cent in mango bar. Protein enriched mango bar was found to have a significantly low total sugar content of 51.92 per cent which was in line with the results of Shanthi (2000) who reported 51 per cent total sugar in mango soy bar.

The crude fiber content of CMB was 2.48 g 100 g^{-1} and that of PEMB was 3.38 g 100 g^{-1}. Crude fiber content of PEMB was significantly high when compared to CMB. This agrees with the results of Shanthi (2000) who reported a crude fiber content of 2.4 g per cent in CMB and 4.0 g 100 g^{-1} in mango – soy bar.

In CMB protein content was 2.04 per cent. According to Pramanik and Sengupta (1978) the protein content of mango bar ranged from 1.05 to 2.20 per cent. Protein content of PEMB was found to be 6.77 per cent which was in accordance with the results of Kaushal and Bhat (1999) who reported a protein content of 6.54 in plum soy bar.

The β carotene content of CMB was 377 μg 100 g^{-1}. Mir and Nath (2000) reported 5.4 mg 100 g^{-1} of β carotene content in mango bar of Langra variety. In the present study, the β carotene content of PEMB was found to be 283 μg 100g^{-1}. Shanthi (2000) also reported a β carotene content of 280.85 μg 100 g^{-1} in mango green gram bar.

The CMB had 24.4 mg 100 g^{-1} of vitamin C which was in accordance with the results of Hemakar *et al.* (2000) who reported the ascorbic acid content to be 25 mg in plain mango bar. The vitamin C content in PEMB was significantly low i.e. 12.53 mg 100 g^{-1}. Shanthi (2000) also reported the vitamin C content to be 13.02 mg per cent in mango green gram bar.

The calcium content of PEMB (85 mg 100 g^{-1}) was significantly higher than the CMB (67 mg 100 g^{-1}) but Mir and Nath (2000) reported the calcium content to be 72 mg 100 g^{-1} in plain mango bar. This high calcium in PEMB is mainly contributed by the green gram flour.

Iron and potassium were also significantly high in PEMB (4.68 and 212.5 mg 100 g^{-1} respectively) due to enrichment with green gram flour.

B. Changes in the chemical constituents of CMB and PEMB packed in MPP and PP were studied for a period of three months.

The moisture content of both the CMB and PEMB were significantly reduced during the storage period indicating moisture loss during storage. The decrease in moisture content can be attributed to the evaporation of water from product due to high storage temperature and loss of sulphur dioxide (Rao and Roy, 1980b). Nanjundaswamy *et al.* (1976) found that below 50 per cent relative humidity, the mango bar looses its moisture content progressively and becomes hard in texture. The moisture retention of CMB and PEMB was significantly high in MPP packed sample than in PP packed sample after the storage period.

Nadanasabapathi *et al.* (1993) observed a higher moisture loss in mango bar packed in thinner foil (12 μ) than in PET/HDLD, PEP and nylon/ ionomer which might be due to the pinholes in the foil. According to Shanthi (2000) retention of moisture content of plain and PEMB was high in MPP than in PP. Similar trend was observed in the present investigation. But Manimegalai *et al.* (2001) reported that moisture content of jack fruit bar was slightly high in PP packed sample than MPP packed sample after six months of storage period.

There was an increase in the acidity of CMB and PEMB during storage. Gowda *et al.* (1995) also reported an increase in the acidity of mango bars after six months of storage. Significant increase in the acidity of PEMB in the present study is also supported by the reports of Chauhan *et al.* (1997) who also observed an increase in the acidity of PEMB on storage. According to Cruess (1958), an increase in the acidity of fruit products during storage can be attributed to the formation of sulphurous acid from sulphur dioxide, ascorbic acid degradation or hydrolysis of pectin. A significant increase in total acids can also be attributed to loss of moisture resulting in the concentration of the product during storage (Nanjundaswamy *et al.*, 1976, Rao and Roy, 1980b and Mir and Nath, 1993). A significant increase in acidity in both CMB and PEMB was found in PP than in MPP after the storage period of three months. This is in line with the findings of Shanthi (2000) who also reported higher acidity of CMB and PEMB stored in PP than in MPP after six months of storage. But Manimegalai *et al.* (2001) reported that acidity of jack fruit bar was high in MPP than in PP after the storage period of six months. A significant increase in acidity was observed with packaging materials during storage of CMB and PEMB.

The TSS content of CMB and PEMB were slightly increased during storage but the increase was not significant. No significant variation was observed in TSS content of CMB and PEMB with respect to packaging materials also. But the TSS of CMB was significantly high initially (54.50^0 Bx) than the PEMB (51.50^0 Bx). And due to storage significant difference in TSS was observed

between the CMB and PEMB. High TSS was observed in control samples in MPP (55^0 Bx) and PP (55.75^0 Bx) than in PEMB in MPP (52.50^0 Bx) and PP (53.0^0 Bx). In the present study treatment had a significant effect on the TSS content of mango bars. The increased TSS in CMB may be due to more moisture loss from the control samples during storage.

The reducing sugar content of both CMB and PEMB was increased during the storage period. Chauhan *et al.* (1997) also observed an increase in reducing sugar content of mango bar and mango soy bar during storage. An increasing trend in reducing sugar content of mango, papaya, guava and sapota bars were also observed by Rao and Roy, (1980a), Aruna *et al.* (1999), Sandhu *et al.* (2001) and Kumar and Manimegalai (2002) respectively during storage. The increase in reducing sugar observed during storage may be mainly due to the acid hydrolysis of sucrose (Labuza *et al.*, 1970) and since the inversion is temperature dependent, the inversion rate being higher at higher temperature. The increase in reducing sugar content of CMB and PEMB was found to be significantly high in PP bags than in MPP pouches after the storage. In control sample the increase in reducing sugar was not significant in MPP pouches. This is in line with Shanthi (2000) and Manimegalai *et al.* (2001) who reported a higher increase of reducing sugar content in PP bags than MPP pouches of plain and PEMB and jack fruit bar respectively after the storage period. Thus statistical analysis of the present study revealed that, an increase in the reducing sugar content among the samples was found to be significant between treatments, packaging materials and storage period except in CMB, stored in MPP which showed no significant variation in reducing sugar content.

The total sugar content of both CMB and PEMB was found to decrease during storage. According to Aruna *et al.* (1999) the total and non reducing sugars in papaya fruit bar decreased significantly on storage. According to Mir and Nath (1993) the reduction in total sugar might be due to significant increase in reducing sugars by acid hydrolysis of total and non reducing sugars and thereby inversion

of total and non reducing sugars to reducing sugars (Rao and Roy, 1980a). In CMB significant reduction in total sugar was observed in both MPP (59.63 g 100 g^{-1}) and PP (59.05 g 100 g^{-1}) packed samples but showed no significant variation in total sugar content with respect to packaging materials. But in PEMB no significant reduction in total sugar was observed with MPP (51.41 g 100 g^{-1}) but reduction was observed with PP packed sample (50.87 g 100 g^{-1}). This is in accordance with Manimegalai *et al.* (2001) who reported that total sugar content of jack fruit bar was better retained in MPP than in PP bags after the storage period. In the present study also total sugar was better retained in MPP packages for PEMB. But Nadanasabapathi *et al.* (1993) reported that the mango bar packed in different packaging materials did not show any change in total sugar content even after 9 months at different temperatures.

The crude fiber content of CMB and PEMB had decreased during storage, but the reduction was not significant. The crude fiber content of both CMB and PEMB showed no significant variation in MPP pouches and PP bags. This is in line with Shanthi (2000) who reported that there was not much change in crude fiber content of mango bar packed in MPP and PP during the storage period. She also reported that crude fiber content of PEMB samples were higher than control samples due to incorporation of pulse flour. In this study also crude fiber was significantly high in PEMB (3.38 g 100 g^{-1}).

Protein content of both CMB and PEMB showed a declining trend on storage. In control samples protein content did not vary with the packaging materials during storage but PEMB retained significantly high amount of protein in MPP (6.55 g) during storage. Shanthi (2000) also reported that protein content of mango bar, mango soy bar and mango green gram bar showed a declining trend on storage. She also reported that protein content of CMB and PEMB was better retained in MPP than in PP bags after the storage period of six months.

The β carotene content of CMB and PEMB showed a decreasing trend on storage. Mir and Nath (1993) observed greater losses of total carotenoids and β carotene in the fortified mango bars during storage at high temperature. They reported that losses could be due to non oxidative changes (cis-trans isomerisation, epoxide formation or thermal degradation) or oxidative changes. Such changes altered the colour of the product and lowered the flavour and nutritive value of the product (Land, 1962; Eskin, 1979). In the present study significant retention of β carotene in CMB and PEMB was observed in MPP pouches after three months of storage. This is in line with the results of Manimegalai *et al.* (2001) who reported maximum retention of β carotene in the jack fruit bars in MPP pouches. According to Gahilod *et al.* (1982) mango leather packed in polyethylene bags showed reduction in carotenoid contents after storing for 70 days at 10 ± 1^0 C.

The vitamin C content of CMB and PEMB decreased significantly during storage due to its thermo labile nature. Rao and Roy (1980b) reported that ascorbic acid content of mango bar was completely lost during storage at higher temperature. According to Chauhan *et al.* (1997) the initial vitamin C content of control and mango soy bar reduced significantly after six months of storage at room temperature. Aruna *et al.* (1999) also noted a decrease in vitamin C content of papaya bar from 53.90 (initial) to 43.12, 35.36 and 24.75 mg per cent after 3, 6 and 9 months of storage respectively. They reported that retention of vitamin C was fairly good up to three months storage due to adequate amounts of sulphur dioxide in the product, but after three months of storage, higher loss of vitamin C with concomitant loss of sulphur dioxide was observed. Similar reduction in ascorbic acid in jack fruit bar (7.3 to 4.75 mg %), guava leather (55 to 35 mg %) and sapota bar (5.2 to 2.94 mg %) during storage was reported by Krishnaveni *et al.* (1999), Sandhu *et al.* (2001) and Kumar and Manimegalai (2002) respectively.

The retention of vitamin C in CMB and PEMB was found to be significantly high in MPP packed sample than PP packed sample after the storage

period. This is in line with the results of Shanthi (2000) and Manimegalai *et al.* (2001) who reported that MPP exhibited higher retention of vitamin C than PP bags for CMB and PEMB and jack fruit bar respectively during storage. Through out the storage period vitamin C retention was significantly high in CMB than PEMB.

The calcium content of CMB was significantly reduced during storage in both MPP and PP packed samples but the variation between these two packaging materials was not significant. But in PEMB the sample stored in MPP did not show significant reduction in calcium content after storage. The calcium content of PEMB was significantly higher than the CMB during entire storage period. The results showed that the high calcium content in PEMB can be retained well in MPP pouch during storage.

The initial iron content of CMB was significantly reduced in both MPP and PP after three months of storage. Retention of iron in PEMB was high in MPP packed samples after storage. The iron content of PEMB was significantly higher than iron content of CMB through out the storage period in both the packaging materials.

The potassium content of both CMB and PEMB was reduced in MPP packed sample after three months of storage but the reduction was not significant. Potassium content of both CMB and PEMB showed no significant variation with the packaging materials during storage. But the potassium content of PEMB was significantly high when compared to CMB in both the packaging materials through out the storage period.

5.2 ORGANOLEPTIC STUDIES

Changes in the organoleptic qualities of CMB and PEMB packed in MPP and PP were evaluated for a storage period of three months.

Appearance of any product is of primary importance in its acceptability. The overall eye appeal of a final product is more important than dependence on taste and odour and may determine acceptance or rejection without a trial testing. Appearance therefore deserves much consideration in fruit processing. In the present study appearance of CMB was significantly high than PEMB through out the storage period in both the packaging materials and appearance of both the samples reduced significantly on storage. Aruna *et al.* (1999) also observed significant difference in the appearance and colour of papaya fruit bar during storage. In the present study appearance of the products did not vary with the packaging materials within samples but significant variation between samples observed may be due to the high initial score for the CMB.

Colour is the first quality attribute in which the consumer perceives in food. In this study colour of both CMB and PEMB were significantly reduced during storage in both the packaging materials. Chauhan *et al.* (1997) also observed a significant decrease in the colour and texture of mango leather during storage. The significant reduction in the colour of PEMB during storage when compared to CMB can be attributed to their high protein content which might have lead to browning reactions during storage. The high acceptability of colour in CMB can also be due to its better β carotene content. But better colour retention was observed in MPP packed sample in PEMB during storage indicating less oxidation and also better retention of β carotene in MPP packed samples than PP.

Flavour is an important factor which enriches the consumer's preference to a particular product. In this study flavour of the CMB was highly acceptable than the PEMB through out the storage period in both the packaging materials. But maximum flavour retention in PEMB was found to be in MPP packed sample during storage. This flavour retention in MPP packed samples may be due to less oxidation in chemical constituents during storage.

The acceptability of the texture of the products were also found to be less during storage in both CMB and PEMB. But the texture of CMB was found to be more acceptable than the PEMB. There was no change in the texture of the products with regard to the packaging materials.

Taste is not only a sensory response but also an aesthetic appreciation of the mouth feel towards soluble materials. In this study there was no significant change in the taste of the control samples during storage in both the packaging materials. But in PEMB there was no significant variation in the taste of the product packed in MPP.

The overall acceptability depends on the different sensory attributes of a product. In the present study the overall acceptability of both CMB and PEMB reduced significantly on storage in both the packaging materials. But the acceptability of CMB was high in both the packaging materials through out the storage period. Chauhan *et al.* (1997) also observed that there was a significant change in the sensory scores of CMB and PEMB during storage for six months.

In effect, the acceptability of CMB and PEMB decreased during storage. This is in line with Sandhu *et al.* (2001) who reported that overall acceptability of guava bar decreased (8.33 to 7.13) during storage. Significant differences were observed in the appearance and colour of papaya fruit bar, when stored at 25^0 C and above due to increase in the non enzymatic browning (Chan and Cavaletto, 1978). Nadanasabapathi *et al.* (1993) reported that at 40^0 C, after five months of storage, commercially available mango bar was not acceptable due to the development of undesirable colour. This might be due to caramelization of sugar content of mango bar stored at accelerated condition. According to Mir and Nath (1995) the change in colour was due to the reduction in β carotene and total carotenoids in fortified bars and texture loss was due to reduction in their equilibrium moisture content. Aruna *et al.* (1999) reported significant deteriorative changes in papaya fruit bar texture due to stickiness developed

during storage at 5 to 8^0 C and 25^0 C and above. The increase in stickiness might be due to increase in acidity and absorption of moisture on storage.

In the present study after three months of storage, the quality attributes of CMB didn't show any variation between two packaging materials. The quality attributes of PEMB namely flavour, taste and colour showed significant variation between the packaging materials after the storage period. Both the CMB and PEMB packed in MPP had better quality attributes than bars packed in PP. This is in accordance with the results of Shanthi (2000) who reported that all the quality attributes of CMB and PEMB was significantly high in MPP than in PP. Jack fruit bar samples packed in MPP also had better quality attributes than PP packed sample. (Manimegalai *et al.*, 2001).

Control bar had better acceptability in both the packaging materials throughout the storage.

5.3 MICROBIAL POPULATION AND STORAGE INSECT PESTS

The shelf life quality of the processed product is of much importance because the need for improving different processing techniques is influenced by shelf life quality. The microbial damage of a product is dependent upon certain factors both chemical and physical, which are favourable for their growth.

The shelf life of mango bar was assessed by measuring the microbial population.

In this study the bacterial population in PEMB was comparatively less than CMB during storage in both packaging materials. But in both cases sample packed in MPP showed less microbial count. Fungal growth was not observed in the initial samples of both CMB and PEMB. But during storage PEMB showed more fungal growth than CMB. Here also samples packed in MPP showed less

fungal growth. Yeast growth was not detected in CMB initially and after storage in MPP. But in PEMB, traces of yeast growth were observed in MPP (0.05×10^3 cfu g^{-1}). Thus the bacteria, fungi and yeast growth of both CMB and PEMB were comparatively more in PP bags than in MPP pouches.

Here the microbial count obtained for the stored products were found to be very low when compared to the microbial load reported by other authors. Garg *et al.* (1993) observed a higher bacterial count of 8×10^{-1} cfu/ g and fungal count of 6.6×10^{-1} cfu/ g in market sample of mango leather. Higher microbial load is an indication of improper handling and storage conditions of commercial samples. The bacterial flora, fungal and yeast population noted in the papaya based fruit bars after 180 days of storage ranged from 3.0 to 5.0×10^6/ g, 3.0 to 4.0×10^4/ g and 2.0 to 3.0×10^3/ g respectively (Sobana, 1998). Microbial count was not observed in papaya bar up to three months. But on six months storage, yeast and mold count were noticed and these increased further on 9 months storage (Aruna *et al.*, 1999). The microbial analysis of sapota bar (180 days) indicated the presence of 4×10^{-6}/ g bacteria, 2×10^4/ g yeast which are negligible in number and safe to consume. The jack fruit bar samples in MPP pouches showed minimum of microbial count than samples in PP bags (Manimegalai *et al.*, 2001).

Storage insect pests were not observed in both CMB and PEMB through out the entire storage period. But Garg *et al.* (1993) detected insect larvae and adult insects in commercially available mango leather.

5.4 BENEFIT COST ANALYSIS

The highest yield was observed in PEMB and lowest in CMB. Cost analysis showed that CMB packed in PP is the cheapest.

All the products had benefit cost ratio above one and could be recommended for commercial popularization. The PEMB packed in PP had the highest BC ratio (4.69) but nutrients and other organoleptic qualities were better retained in MPP. So PEMB stored in MPP can be recommended which had a BC ratio 4.07.

SUMMARY

6. SUMMARY

The present study entitled 'Standardization and quality evaluation of protein enriched mango bars' was attempted to standardize protein enriched mango bars and to evaluate the nutritional and organoleptic qualities and shelf life of the products.

The nutritional evaluation revealed that the moisture content was high for PEMB (16.10 %) than CMB (13.51 %). The acidity was high in CMB (0.66 %) than in PEMB (0.46 %).. The TSS content of CMB and PEMB was found to be 54.5 and 51.5^0 Bx respectively.

The reducing sugar (13.62 g 100 g^{-1}) and total sugar (60.31 g 100 g^{-1}) was also high in CMB. The PEMB had high crude fiber content (3.38 g 100 g^{-1}) than CMB (2.48 g 100 g^{-1}).

The CMB contained 2.04 g 100 g^{-1} protein and PEMB had a protein content of 6.77 g 100 g^{-1}. The β carotene content of CMB and PEMB was 377 and 283 µg 100 g^{-1} respectively. The vitamin C was comparatively high in CMB (24.40 mg 100 g^{-1}) than PEMB (12.53 mg 100 g^{-1}). Protein enriched mango bar also had comparatively better value for calcium (85 mg 100 g^{-1}), iron (4.68 mg 100 g^{-1}) and potassium (212.5 mg 100 g^{-1}).

The CMB and PEMB were packed in two packaging materials namely metallised polyester polyethylene laminate pouches (MPP) and polypropylene (PP) and were stored for a period of three months. The nutritional composition, organoleptic qualities and microbial load were analysed initially and after three months of storage.

The moisture content of CMB and PEMB reduced significantly on storage. The moisture retention of CMB and PEMB was significantly high in MPP (11.96 and 14.98 g 100 g^{-1} respectively) than in PP after the storage.

The acidity of CMB and PEMB showed an increasing trend on storage. There was significant increase in the acidity of CMB and PEMB packed in PP than in MPP after the storage of three months.

The TSS content of CMB was significantly higher than PEMB. The TSS content of CMB and PEMB showed a slight increase on storage, which was not significant. The TSS content of both CMB and PEMB was slightly high in PP than in MPP after the storage period.

The reducing sugar content of CMB and PEMB was increased during storage. The increase in reducing sugar content of PEMB was significantly high in PP bags (8.63 g 100 g^{-1}) after the storage but the increase was not significant in CMB.

In CMB there was significant reduction in total sugar content in both MPP (59.63 g 100 g^{-1}) and PP (59.05 g 100 g^{-1}) during storage. But there was no significant variation in total sugar content with respect to packaging materials. In PEMB total sugar content was significantly reduced in PP (50.87 g 100 g^{-1}) after the storage period.

Crude fiber was significantly high in PEMB and there was no significant change in the crude fiber content of samples during storage in different packaging materials.

The protein content of both CMB and PEMB was significantly reduced during storage. In CMB no significant variation was observed in protein content

with respect to packaging materials during storage. In PEMB protein content was significantly high in MPP (6.55 g 100 g^{-1}) than PP bags (6.46 g 100 g^{-1}).

The β carotene content of both CMB and PEMB showed a declining trend on storage. In CMB and PEMB β carotene content was significantly high in MPP pouches (367 and 271 μg respectively) than PP bags after the storage period.

The vitamin C content of CMB and PEMB decreased significantly during storage. The retention of vitamin C in CMB and PEMB was significantly high in MPP packed sample than PP packed sample after the storage period. The vitamin C retention was significantly high in CMB than in PEMB.

The calcium content of CMB was significantly reduced during storage in both MPP and PP. In PEMB the sample stored in MPP didn't show significant reduction in calcium content after storage.

The iron content of CMB was significantly reduced in both MPP and PP after the storage period. The retention of iron in PEMB was high in MPP (4.37 mg 100 g^{-1}) than in PP (4.03 mg 100 g^{-1}) after the storage.

Potassium content of both CMB and PEMB showed no significant variation with the packaging materials during storage.

The organoleptic evaluation revealed that appearance of the CMB was significantly high than the PEMB in both the packaging materials. The appearance of both CMB and PEMB reduced significantly on storage. The colour of both CMB and PEMB was significantly reduced during storage. The colour retention of CMB and PEMB was better in MPP pouches than PP bags. The flavour of the CMB was highly acceptable than PEMB through out the storage period. In PEMB flavour was better retained in MPP packed sample than in PP. The texture of the CMB was found to be more acceptable than the PEMB. There was no change in

the texture of the products with regard to the packaging materials. The taste of the CMB was not significantly reduced during storage in both the packaging materials. In PEMB the taste was found to be better in MPP packed sample.

The overall acceptability of both CMB and PEMB reduced significantly on storage. The acceptability of CMB was high in both the packaging materials than PEMB.

Regarding the microbial count, the bacterial growth in PEMB was less than CMB. The CMB and PEMB packed in MPP showed less bacterial growth than PP packed sample. Initially fungal growth was not observed in both CMB and PEMB. The PEMB showed more fungal growth than CMB. The CMB and PEMB packed in MPP showed less fungal growth. Yeast growth was not detected in CMB initially and after storage in MPP. In PEMB packed in MPP yeast growth was found to be 0.05×10^3 cfu g^{-1}. The bacteria, fungi and yeast growth of both CMB and PEMB were comparatively more in PP bags.

The yield and BC ratio was found to be highest for PEMB than CMB. Protein enriched mango bar packed in PP had highest BC ratio.

Even though the overall acceptability of PEMB was less when compared to CMB, nutrients such as crude fiber, protein, calcium, iron and potassium were high in PEMB. Better retention of the nutrients, sensory qualities and less microbial contamination was observed in MPP packed sample than PP packed sample after three months of storage. The yield and BC ratio was highest for PEMB than CMB. Hence, good quality PEMB can be obtained by packing and storing in MPP. The overall acceptability of PEMB can be improved by trials with other commonly used pulses or pulse protein concentrates or a combination of both.

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APPENDIX

APPENDIX - I

SCORE CARD FOR ORGANOLEPTIC EVALUATION OF CMB AND PEMB

NO	Character	Description	Score	1	2	3	4	5
1	Appearance	Excellent	5					
		Very good	4					
		Good	3					
		Fair	2					
		Poor	1					
2	Colour	Excellent	5					
		Very good	4					
		Good	3					
		Fair	2					
		Poor	1					
3	Flavour	Excellent	5					
		Very good	4					
		Good	3					
		Fair	2					
		Poor	1					
4	Texture	Excellent	5					
		Very good	4					
		Good	3					
		Fair	2					
		Poor	1					
5	Taste	Excellent	5					
		Very good	4					
		Good	3					
		Fair	2					
		Poor	1					

Name

Date

Signature

STANDARDIZATION AND QUALITY EVALUATION OF PROTEIN ENRICHED MANGO BARS

By

SHERIN N. A.

ABSTRACT OF THE THESIS

submitted in partial fulfilment of the requirements for the degree of

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2005

ABSTRACT

The present study on "Standardization and quality evaluation of protein enriched mango bars" was aimed to standardize protein enriched mango bars with pulse protein and to improve the storage life of fruit bars with suitable packaging materials.

The CMB was prepared using standard procedure and PEMB was standardized with green gram as a source of protein and were analysed for moisture, acidity, TSS, reducing sugar, total sugar, crude fiber, protein, β carotene, vitamin C, calcium, iron and potassium. There was significant variation in the nutrient content of CMB and PEMB. The moisture, crude fiber, protein, calcium, iron and potassium were significantly high in PEMB than CMB.

The CMB and PEMB packed in two packaging materials namely metallised polyester polyethylene laminate pouches (MPP) and polypropylene (PP) bags were stored for three months under ambient conditions. The chemical constituents, organoleptic qualities and the microbial load were analysed initially and after three months of storage. The acidity, TSS and reducing sugar had increased whereas the moisture, total sugar, crude fiber, protein, β carotene, vitamin C, calcium, iron and potassium had decreased after the storage period. The CMB and PEMB packed in MPP had better retention of nutrients than PP packed sample.

The organoleptic evaluation revealed that there was significant reduction in the sensory qualities of mango bar such as appearance, colour, texture and taste on storage but there was no significant reduction in the flavour of PEMB due to storage. Both the fruit bars had better acceptability in MPP stored samples after storage. The overall acceptability of CMB was high in both the packaging materials than PEMB. A gradual increase in the bacterial, fungal and yeast count

was observed during storage of CMB and PEMB. The CMB and PEMB packed in MPP showed less bacterial, fungal and yeast growth.

The PEMB packed in PP had highest BC ratio. But nutrient retention and acceptability was more in MPP and it had BC ratio above one hence, economically beneficial also.