A STUDY ON THE PREPARATION OF MIXED FRUIT BAR FROM MANGO, PINEAPPLE AND PAPAYA

A THESIS

BY

MD. FARIDUL ISLAM
Student No.: 1105040
Session: 2011-12
Semester: January – June, 2012

MASTER OF SCIENCE (MS)
IN
FOOD ENGINEERING AND TECHNOLOGY

DEPARTMENT OF FOOD ENGINEERING AND TECHNOLOGY

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY
UNIVERSITY, DINAJPUR

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Submitted to the Department of Food Engineering and Technology, Hajee Mohammad Danesh Science and Technology University, Dinajpur

In partial fulfillment of the requirements for the degree of

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JUNE, 2012

DEDICATED TO
MY
BELOVED PARENTS

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The Author

ABSTRACT

The study was conducted to develop mixed fruit bar from mango, pineapple and papaya. Fresh mango, pineapple and papaya were analyzed for their composition. The mango fruit contained moisture 80.2%, ash 0.55%, acidity 0.19%, vitamin C 45 mg/100g, TSS 15.9%, protein 0.78% and total sugar 13.7% respectively. The pineapple juice contained vitamin C 8.3 mg/100 g, moisture 83.6%, ash 0.46%, acidity 0.62%, pH 3.70, total soluble solid (TSS) 11.7% and total sugar 12.1%. The whole ripe papaya fruits contained the moisture 89.4%, ash 0.45%, TSS 9.75%, pH 4.30%, vitamin C 38.2 mg/100 g, acidity 0.15% and total sugar 7.6**%.** The mixed fruit bar contained 14.55% moisture, 1.15% ash, 1.07% protein, 1.30% fibre, 52.07% total sugar and 10.40 mg/100 g of vitamin C. Among the four sample S_1 (mango 40%, pineapple 24% and papaya 20%); S_2 (mango 45%, pineapple 19% and papaya 20%); S_3 (mango 50%, pineapple 14% and papaya 20%); S_4 (mango 35%, pineapple 29% and papaya 29%), the sample S_3 secured highest score for overall acceptability and ranked as "Like very much" by a taste testing panel. The sample S_3 had mango pulp 50%, pineapple juice 14%, papaya pulp 20%, starch 1% and sugar 15%. Various proportions of sugar were used to prepare mixed fruit bar. It only increases the weight of final product. Minimum requirement of sugar for fruit bar manufacturing was 7%. Below this level it produces cracker fruit bar. The mixed fruit bar stored in double layer high density polyethylene package coated with aluminium foil rendered higher quality retention than those packed in low density polyethylene bags. The best quality of mixed fruit bar was achieved when stored in double layer high density polyethylene bag coated with aluminium foil during 60 days and best storage temperature is 3°C.

CONTENTS

CONTENTS (Contd.)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

CHAPTER I

INTRODUCTION

Mixed fruit bar is a concentrated fruit product made by evaporating the mixture of different fruit pulp which has a good nutritive value. It is classified as a confectionary product with longer shelf life. Mixed fruit bars are manufactured hygienically, attractively packed, easy to transport and cut in bars can be consumed readily. Mixed fruit bars are cookies containing chopped fruits mixed in the dough or spread between layers of dough then baked.

The mango fruit (*Mangifera indica* L.) is one of the most popular fruit in many countries among millions of people in the world. In the tropical areas, it is considered to be the choicest of all indigenous fruits. It is the most ancient fruits of our country. Mangoes are one of the richest sources of vitamin A. They contain a good amount of niacin and riboflavin and a fair quantity of vitamin C. Unripe mangoes are rich source of vitamin C and iron (Ahmed, 1982).

The statistical data shows that about 79066 acreage of land is under mango cultivation in Bangladesh within an annual production of 1047849 metric tons (BBS, 2010). Due to lack of post harvest handling facilities losses are as high as 18% (Srinivas *et al.,* 1977).

Pineapple (*Ananus comosus)* is another popular and delicious fruit in Bangladesh. It is very much favoured for its attractive color and flavour. The world production of pineapple shows a steady increase over the years, much of the increase due to the expansion of pineapple processing industry in the developing countries of the Far East Africa and Latin America (Bose, 1990). The statistical data shows that about 39583 acreage of land is under pineapple cultivation in Bangladesh with an annual production of 234493 metric tons and the average yield of pineapple is 5.92 metric ton per acre (BBS, 2010).

The pineapple is rich source of vitamins A, B, C, calcium, protein, carbohydrate, iron, carotene etc. The fresh pineapple fruits and juice contain the protein digesting enzyme, bromelin (Collins, 1968). The most popular processing products from pineapple in the world market are canned pineapple. But today various products are prepared from pineapple.

Papaya (*Carrica papaya* L.) is a member of the small family Caricaceae which is an important fruit crop of the tropics and is one of the most versatile fruit. It is also used as vegetables and is available throughout the year in the local markets. It is rich in vitamins and minerals (Ahmed, 1984; Rashid et al., 1987).

Green papayas are in great demand in Bangladesh, particularly for ailing people who suffer from dyspepsia indigestion or stomach disorder. The tropical papaya fruit has effective medicinal properties against disorders of liver and spleen. In Bangladesh, papaya occupies 2790 acreage of land and total production is about 112770 metric tons with an average yield of 40 metric tons per acreage of land (BBS, 2010). Papaya is widely cultivated in the greater district of Pabna, Rajshahi, Jessore, Chittagong, Bandarban, kushtia, Mymensingh, Dhaka, Rangpur, Faridpur, Rangamati etc.

The mango, pineapple and papaya are seasonal in nature and available in large quantity in peak season. The inadequate and improper post-harvest handling, processing and preservation facilities of these fruits often cause a glut during the season and a substantial quantity is wasted every year. The prevention of the losses of the seasonal surplus of these fruits by processing and preservation techniques at farmer's level and as well as industrial scale should, therefore, be warranted. Such efforts will help the growers to preserve the surplus fruits for their home consumption as well as promote the development of processing industries in the growing areas of the country. Moreover this will stimulate an increase in growing areas of the country. Moreover this will stimulate an increase in production and bring better return to the mango, pineapple and papaya growers.

In many countries of the world, fruit bar is a popular confectionery food item. Although fruit bars prepared from single source such as mango, apple, banana etc, are available in the market however, fruit bars prepared from mixed sources are very rare in our country.

There are many ways of preserving fruits and making mixed fruit bars is one such method. Consumption of fruits is very important as they are nutritious and supply vitamins and minerals. Pulpy fruits like mango, pineapple, papaya etc. are best suited for making mixed fruit bars. The mixed fruit bars may be one of the most popular and nutritious confectionery items in the market.

With the above views in consideration, this research work was undertaken to investigate the processing and quality aspects of fruits bar from mixed fruits such as mango, pineapple and papaya, and thus suggested ways and means for production of good quality mixed fruit bars.

The main objective of the proposed study was-

- To prepare mixed fruit bar from mango pulp, pineapple juice and papaya pulp as a preservation method to reduce seasonal surpluses or losses.

The specific objectives of the proposed study are to-

1. Analyze the composition of ripe mango, pineapple and papaya fruits.
2. Analyze the composition of prepared mixed fruit bar from mango, pineapple and papaya.
3. Assess the storage and overall acceptability of the prepared mixed fruit bars.

CHAPTER II
REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

The processing of fruit bar from mixed fruit is very limited. A few literatures are available on the processing of fruit bars. The present review mostly concerns summarization of published information to assess the composition and nutritive value of mango, pineapple and papaya and related fruit bar.

2.1 Mango and its nutrients content

Singh (1968) reported that the main constituents of mango were water 75 to 82%, sugar 8.7-20%, protein 0.51 %, citric acid 0.14-0.71 %, vitamin C 8.5 to 50 mg per 100 gm and ash 0.38 to 0.63%.

Jain (1961) reviewed the chemical composition of mango. It is a rich source of carbohydrate as well as vitamin A and C. The following is the range of chemical constituents present in mango (25 varieties). Sugars constitute the main bulk of the carbohydrates and most of the soluble solids in ripe mango.

The chemical constituents of mango were moisture content 73.9 to 86.7%, carbohydrate 11.6 to 24.3%, protein 0.3 to 1.0%, fat 0.1 to 0.8%, minerals 0.3 to 0.7% vitamin A 650 to 25940 I.U. and vitamin C 3.0 to 83/ 100gm.

The mango can be separated into three parts skin, flesh or pulp and stone. Philippine mangoes have been found to contain 11 to 18% skin, 14-22% seed and 60-73% pulp (Pratt and Del Rosario, 1913), whereas mangoes in Hawaii contain an average of 63-77% of edible matter (Pope, 1929). The flesh content of mango, as reported from various mango growing zones, varies from 58 to 75% (Winton, and Winton, 1935).

Vasquez *et al.,* (2007) observed the effects of thermal mango processing on beta-carotene stability and inactivation of peroxidase (POD) and polyphenol oxidase (PPO) which were systematically evaluated on a laboratory scale, mimicking typical operations in continuous and small-size batch production of mango puree. Maximum vitamin A loss during pasteurisation of mango puree did not exceed 15.4%, owing to total beta-carotene retention of 93%.

PPO was readily inactivated after 1 min, whereas residual POD activities of 4.0-6.3% were detected, even after 16 min, at all pasteurization temperatures.

Ajila *et al.*, (2007) reported that the polyphenol contents in mango peel ranged from 55 to 110 mg/g dry peel. Dietary fibre content ranged from 45% to 78% of peel and was found at a. higher level in ripe peels. Similarly, carotenoid content was higher in ripe fruit peels. Vitamins C and E contents ranged from 188 to 392 and 205 to 509 micro g/g dry peel, respectively; and these were found at a higher level in ripe peels. Both raw and ripe mango peels exhibited significant amount of protease, peroxidase, polyphenol oxidase, xylanase and amylase activities.

Between 1971 and 1993, the production of mango (*Mangifera indica L.),* worldwide, has increased by nearly 50% (F.A.O. 2003). Much of this new production has occurred outside the traditional centers of mango cultures, in South and Central America, Africa and Australia and a significant proportion of the new mango production is for export markets. The high esteem in which this fruit has always been held in Asia, where mango has been cultivated to be the king of fruits (Purseglove, 1969), is now apparently true for much of the world.

2.2 Pineapple and its nutrients content

Mohammed and Wickhom (1995) observed bio-chemical changes and sensory evaluation in pineapple during storage at refrigerated and non-refrigerated temperatures. They studies recently harvested pineapple cv. Deltada fruits were stored at 10, 20 or 30°C and 65-80% RH for up to 12 days. During that storage time they were assessed for quality parameters (weight loss, shell and flesh color, firmness, decay, TSS, pH, acidity, sugars and, vitamin C contents, flesh translucency and taste score) at 4 days interval. The best results were obtained in the 10°C treatment in which all fruits were decay free after 12 days. This treatment resulted in 15.9 and 25.1% more marketable fruits than at 20°C and 30°C treatments, respectively. Significant correlations were found between taste test scores but not between taste test scores and pH, sugars content, vitamin content or acidity.

Achinewhu and Hart (1994) studied the effects of processing and storage on the ascorbic acid (vitamin C) content of 4 pineapple varieties grown in the Rives State of Nigeria. They estimated ascorbic acid content of the juice of the varieties before and after storage of whole pineapple, and processing and storage of the juice for 2 months. They found that ascorbic acid of fresh juice ranged from 22.5 to 33.5 mg/100 g sample, while after storage of whole pineapple at 30to 32°C for 2 weeks. Ascorbic acid was reduced to between 59 and 65% of the fresh juice4. They also found that processing the juice by pasteurization reduced ascorbic acid to between 28 and 46% while storage in plastic bottles for 2 months further reduced the ascorbic acid content to between 10 and 21%.

Botrel *et al.*, (1993) conducted an experiment to determine the effect of fruit weight on internal browning and quality in pineapple cv. Smooth Cayenne. They used fruits in 6 weight grades (700-899, 900-1009, 1100-1299, 1300-1499, 1500-1799 and 1800-2300 g) either at 25°C and 75% RH over 7 days or at 5°C and 90% RH over 1.5 days before assessed for the indices studied. They found that larger fruit (1500-1799 and 1800-2300 g) were more susceptible than smaller ones to internal browning and TSS content also was highest. They also found that ripe fruits held at 5°C had lower amounts of TSS.

Uddin and Islam (1985) studied the development of shelf-stable pineapple products by mechanical dehydration, sun drying and osmotic dehydration. Sugar syrup of different concentrations were used to study their effectiveness as an agent of osmotic dehydration and higher rate of dehydration observed with higher concentration of syrup. Studies on the influence of time and syrup fruit ratio showed that 6 hour contact time and 4:1 syrup fruit ratio would be optimum.

Anonymous (1960) reported the composition or pineapple, moisture content (75%); reducing sugar (3.06%); non-reducing sugar (6.88%); total sugar (19.94%); ascorbic acid (8.76 mg/100 g); ash (0.56%); acidity (0.64%); pH (2.57) and T.S.S. (13%).

Remarkable works on analysis of pineapple composition was done throughout the world. The composition of pineapple according to FAO (1972) reported that moisture content (87%); Kcal (47%); Ca (17 mg); Fe (0.3 mg); vitamin A (18 mg); vitamin C (22 mg); ash (0.41%); fibre (0.5%) and fat (0.3%).

Akinyele *et al.*, (1990) conducted an experiment to observe nutrient losses during and after processing of pineapple and orange. They analyzed ascorbic acid, pH, total titrable acidity, total solids, ash and contents of calcium, magnesium, sodium and potassium of various products of pineapple and oranges. They estimated sugars in the samples quantitatively and qualitatively and stored the samples of pasteurized pineapple pieces and pasteurized orange juice at room temperature for 3 months followed by chemical analyses. They observed the considerably reduction of ascorbic acid of fresh juice with processing and storage and also observed that both the pasteurized and unpasteurized orange juice were acidic and the pineapple products were less acidic. They showed that the total solids, ash and the selected minerals were present in appreciable amount in the fruit products and were not significantly affected by processing and storage. They showed that pasteurized pineapple juice and pieces contained glucose, fructose and sucrose in appreciable amounts while pasteurized orange juice contained only glucose and fructose with traces of maltose but no sucrose.

Ahmed (1995) conducted an experiment to develop certain processing techniques to preserve the pineapple juice. He suggested that the juice can be preserved by can or bottle and may happily be consumed as drink for its delicious taste and characteristic flavors. His research was mainly conducted to preserve pineapple juice by bottling, reuse bottle, little or no syrup or additive and processing at water bath temperature will certainly result in a low cost processed product. The juice was preserved by various heat treatments with or without KMS (preservative) in different types of containers. He found that the products developed by combined heat treatment and chemical preservative had retained significantly better colour than those developed by heat treatment alone. However, all the products were found equally acceptable in so far as taste and general acceptability are concerned.

Rangana and Bajaj (1966) reported that SO_2 is widely used throughout the world principally in treating food of plant origin. It is used in the preservation of fruit juices, pulps, beverages and concentrate. Concentration used may vary from 350 to 2000 ppm soluble salts (e.g. K.M.S.) are usually used in treating fruits and vegetable products. The activity is higher at pH below 4.0.

Brito *et al.,* (2007) observed that the pineapple pulp had an ascorbic acid content of 21.4 mg/100 g and 15.7 degrees Brix of soluble solids. The pineapple juice peroxidase presented optimum activity at 45-50 degrees C and pH 4.5. The enzyme remained stable at pH 4.0-9.0 and retained >80% of its activity after 24 hours of heat treatment at 50 degrees C. The enzyme remained stable after 30 minutes of treatment at temperatures below 50 degrees C, retaining more than 90% of its activity, and after 30 minutes at 70 degrees C the residual activity was 15%.

Wen and Wrolstad (2002) reported that the phenolic composition of authentic pineapple juice concentrate was analyzed by HPLC. Nine major peaks accounting for 70% of total peak area were characterized and their concentrations measured in 54 commercial samples. Means and standard deviations were as follows (mg/100 ml single strength juice, normalized 12.8 degrees Brix): tyrosine 3.6(1.4); serotonin 1.8(0.8); di-methyl hydroxyl furanone 1.4(0.7); di methyl hydroxyl furanone beta glucoside 6.2(3.0); tryptophan 2.2(0.9); S-sinapyl-L-cysteine 1.1(0.6); N-gamma-L-glutamyl-S-sinapyl-L-cysteine 2.3(1.1); S-sinapyl glutathione 5.4(1.4); and a p-coumaric acid-like phenolic compound (calculated as P-coumaric acid) 0.5(0.4). This information will be useful for evaluation of authenticity and quality.

Askar (1998) investigated the importance and characteristics of tropical fruits. He discussed the properties of tropical fruits and their significance within the overall fruit and fruit juice industry. Aspects considered included: fruit production and consumption; the importance of quality management for successful production of tropical fruit products (Juices, nectars etc); importance of correct harvesting time; compositional aspects; and nutritional and health benefits associated with tropical fruits.

2.3 Papaya and its nutrients content

Papaya is an important fruit in Bangladesh but research works on prospect of processing green and ripe papaya for commercial products are insufficient. Some available research findings in this connection have been reviewed and presented as follows.

Carmen *et al.*, (1978) studied on the papaya and described that papaya is one of the largest tropical fruits; it has pulpy flesh. Its flavour and aroma are controversial, they are not as abundant and exotic as other tropical fruits but are quite characteristics. Papaya is usually eaten alone or in the mixtures of tropical fruits, peeled and cut in segments, cubes or balls. In mixtures it is useful for its texture and well defined organoleptic properties. Fruit pleases or the puree can be dehydrated by different methods. Both types of products, however, are rarely found in commerce, as most of their flavour and aroma is either changed or lost. In order to process papaya it must be at the proper ripening stage. The fruits usually collected green mature and it ripens under storage. Because of its size and fragile skin, transport and handling are critical. The fruit is affected by climate, is injured by chilling and during ripening physical and chemical changes occur. Papaya pulp is one of the best Sources, among fruits, of vitamins, especially vitamin A and C. During fruit maturation and processing changes occurs in these compounds.

Akin et al., (2008) investigated the production of ethanol from Carica papaya (pawpaw) using dried active baker's yeast strain (Saccharomyces cerevisiae) was investigated. The fermented pawpaw fruit waste produced ethanol at 2.82-6.60% (v/v). Proximate analyses of the dry fruit showed that pawpaw waste contained 90.82 g/100 g carbohydrate, 2.60 g/100 g lipid, 1.63 g/100 g crude protein and 4.95 g/100 g ash. These results show that the rate of alcohol production through fermentation of pawpaw fruit waste by baker's yeast increases with fermentation time and peaked at 72 hour. Alcohol production also increased with yeast concentration at a temperature of 30 degrees C. The optimum pH for fermentation is 4.5.

Rodriguez and Iguina-de-George (1975) investigated the evaluation of papaya nectar prepared from unpeeled papaya puree. It was found that the mature green papayas were ripened at room temperature, seeds were removed and unpeeled sections were mashed and pulped. The pulp with 17.5% sugar added was heated at 87.8°C and frozen at -23.3°C. Water to dilute it to 33.3% pulp content, sucrose and citric acid were added. The resulting nectar was pasteurized, canned and stored at 29.4°C for 12 months. The chemical composition of the nectar did not change significantly during storage although there were slight changes in the percentage of reducing sugars. Taste evaluation by a panel showed that the overall quality by of the sample remained acceptable throughout the storage period.

Firmin (1997) investigated the physical and chemical changes during maturation of the local and solo variety of papaya. It was found no change was observed in total acidity, though there was a slight increase in the pH of both types. Starch content decreased while total sugar, reducing sugar and ascorbic acid increased. A sensory panel preferred solo, confirming that it is suitable for the local and international market.

Chan and Kowrk (1975) reported that the total sugars, reducing and non- reducing sugars in papaya to be 5.8% and 0.3%, respectively. Whereas Wilson (1980) analyzed the chemical composition of papaya and stated that reducing, non-reducing and total sugars were 4.0%, 2.9% and 6.8% respectively.

Intermediate moisture foods (IMF) which are practically dehydrated foods with moisture content in the intermediate range i.e. 20 to 50 percent, stabilized by using additives so as to keep water activity low at safe levels (0.6-0.85) from the stand point of microbial spoilage, have attracted attention of many workers recently. The principle behind the development of such foods is that one need not dehydrate foods below percent moisture levels (a>0.6) dictated by microbial stability. There will be substantial reduction in drying and reconstitution time and better retention of original flavour and texture compared to conventional hot air dried or heat processed (canned) foods, if the food is dehydrated to an intermediate moisture level.

Uddin (1991) conducted studies for preparing preserves and candies from pineapples, mango, watermelon, papaya and carrot. Fruits and vegetables cubes were treated with preservatives and vegetables cubes were treated with preservatives and firming agents, blanched and pricked before processing to preserve that mango and pineapple preserves were of excellent quality while those prepared from watermelon and papaya was categorized as "good product". The preserves and candies were shelf stable up to 12 months at ambient temperature (23-38^0C).

Candied fruit is usually coated with a thin transparent layer of heavy syrup containing cane sugar 3 parts, corn syrup 1 part and water 2 parts that dried to a more or less firm texture. The mixture is cooled to boiling point of about 236 to 238^0F. This is cool to about 200^0F and then candied fruit is dipped in it by wire dipping spoon. On cooling the coating will be reasonably free of stickiness. Candied fruit has been coated fairly satisfactorily by dipping in 1.1-1.5% solution and drying at 120°F for 2 hours. The coating is not only glossy but nevertheless is fairly attractive. It is not sticky (Cruces, 1958).

2.4 Processing of fruit bar

Narayana *et al.,* (2007) conducted a study to standardize the recipe and process for the preparation of banana fruit bar. The physicochemical, microbiological and organoleptic properties of the fruit bar were evaluated. The results showed that a tasty and palatable banana fruit bar with good texture and overall acceptability could be prepared by mixing 20% sugar, 0.5% pectin, colour and 350 ppm potassium meta-bi-sulfite with smoothly blended pulp of Karpuravalli banana.

P. Karmoker (2009) The results are showed that formulation F_1 contained moisture 11.92%, ash 1.13%, protein 0.3%, firbre 1.497 mg/100 g and total sugar 54.08%; formulation F_2 contained moisture 12.67%, ash 1.36%, protein 0.48%, fibre 1.15%, total sugar 55.13% and vitamin C 19.44 mg/100 g; formulation F_3 contained moisture 12.48%, ash 1.13%, protein 0.33%, fibre 1.13%, total sugar 55.38% and vitamin C 6.48 mg/100 g; and formulation F_4 contained moisture 12.80%, ash 1.24%, protein 0.31%, fibre 1.206%, total sugar 55.09% and vitamin C 5.4 mg/100 g.

Harsimrat-Kalsi and Dhawan (2001) reported that the quality of guava fruit bar, prepared from newly developed guava hybrids (H-25-25, H-11-7 and H-3-22) and commercial cultivars (Lucknow-49 and Allahabad Safeda) by mixing extracted pulp with sugar, citric acid, potassium meta-bi-sulphate [meta-bi-sulfate] andglucode, heating to 80-85 degrees C for 5 minutes, and drying to approximately 15% moisture level, was evaluated during storage. During storage, sugar and pectin contents, acidity, and browning increased while ascorbic acid and tannin contents and organoleptic rating decreased.

Sawant *et al.*, (2007) conducted a study to determine the effect of different levels of mango pulp inclusion (0, 10 and 20%) on the sensory properties *of kalakand.* Results revealed that the overall acceptability of 0, 10 and 20% mango pulp in *kalakand* were 8.94, 8.88 and 8.46 respectively. The proportion of total solids content increased with increasing level of mango pulp. Fat and protein contents of *the kalakand* significantly decreased with the inclusion of mango pulp. The carbohydrate and ash contents were increased by the addition of mango pulp. Product acidity decreased with increasing levels of mango pulp. The production cost of *kalakand* decreased with increasing levels of mango pulp.

CHAPTER III
MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The study was conducted in the laboratory of the Department of Food Engineering and Technology under the Faculty of Agro-Industrial and Food process Engineering, Hajee Mohammad Danesh Science and Technology University, Dinajpur.

3.1 Materials

Ripe mango (Fazli), pineapple (Giant kew) and papaya (Kashimpuri) were collected from local market of Dinajpur. Other ingredients like sugar, starch, packaging materials etc. were used from the laboratory stock.

3.2 Methods

3.2.1 Preparation of mango pulp

Fresh fully ripe sound mangoes were used for extraction of pulp. After washing thoroughly with clean water, the fruits were peeled by kinfe. The flesh was removed froze seed with the knife and cut into small pieces and then blended in an electrical blender. The pulp was then blanched for 10 minutes at 80^0C and cooled immediately. Then the pulp was stored in a deep freeze at a temperature of -20°C for future use. The schematic diagram for preparation of mango pulp is given in Figure 3.1.

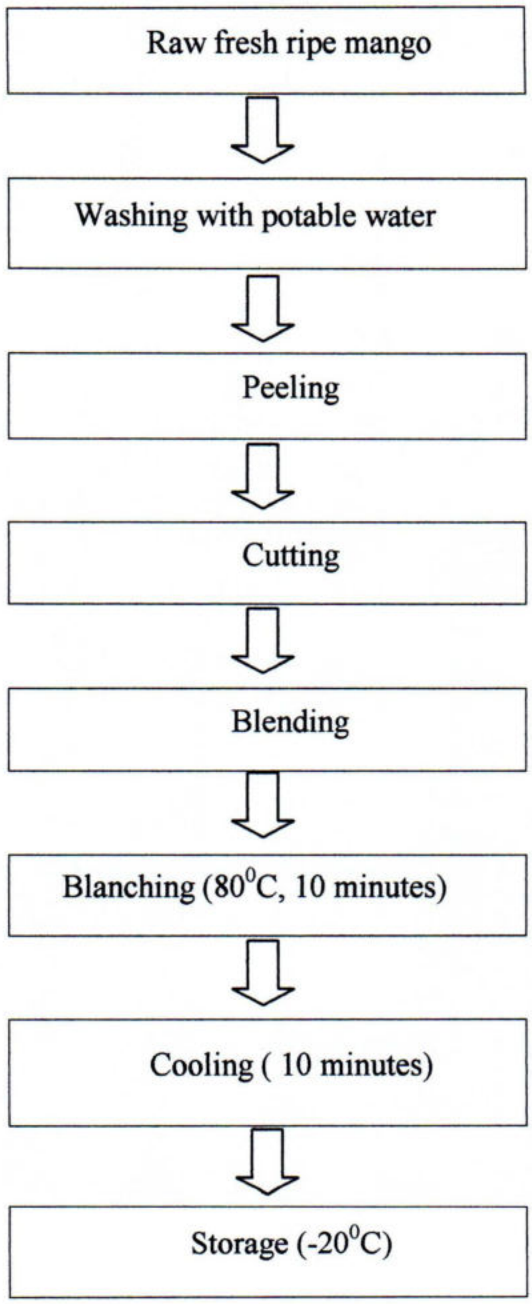

Fig. 3.1 Schematic diagram for preparation of mango pulp

3.2.2 Preparation of pineapple juice

Fresh fully ripe sound pineapples were used for extraction of juice. After washing, they were peeled and cores were removed. The juice was extracted from pineapple by pineapple juicer. The juice was collected and the residue was discarded. The juice was heated at 80°C for 10 minutes and cooled for 10 minutes. Then it was stored in deep freeze at a temperature of -20°C for future use. The schematic diagram for preparation of pineapple juice is given in Figure 3.2.

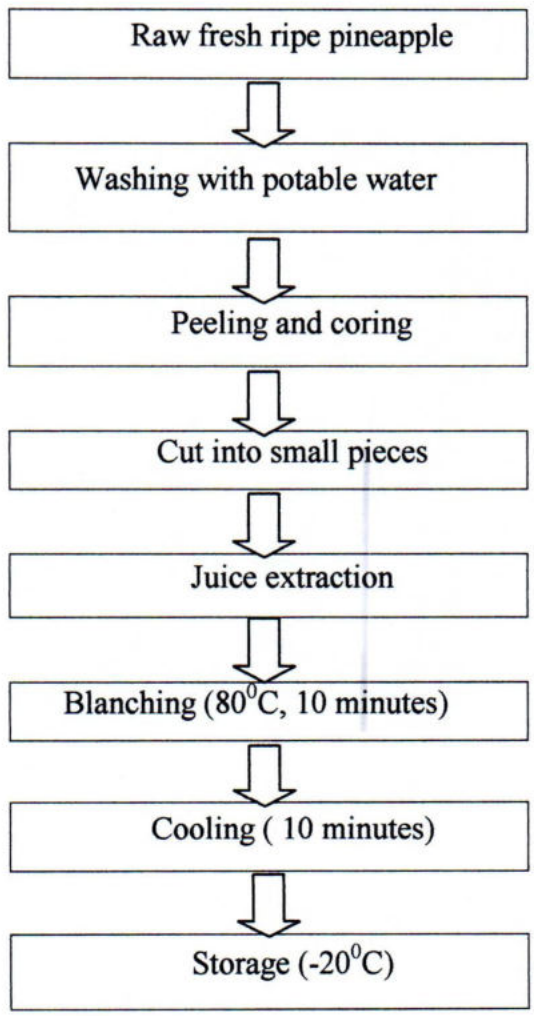

Fig. 3.2 Schematic diagram for preparation of pineapple juice

3.2.3 Preparation papaya pulp

Fresh fully mature papayas were used for the extraction of pulp. After washing with clean water they were peeled and cut into longitudinal section. The cut pieces were blended in electric blender. The pulp was heated at 80°C for 10 minutes and cooling for 10 minutes. Then it was stored in a deep freeze at -20°C for future use. The schematic diagram for preparation of papaya pulp is given in Figure 3.3.

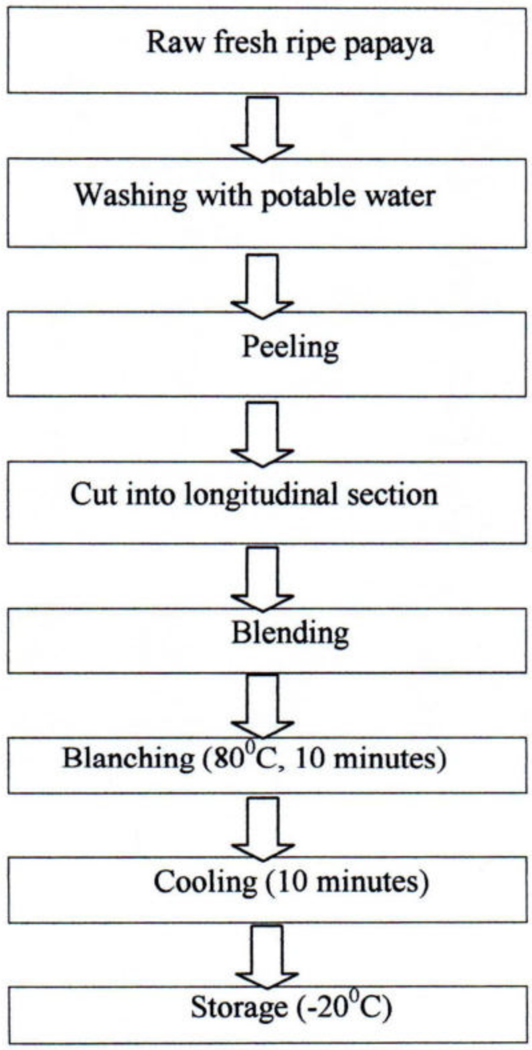

Fig. 3.3 Schematic diagram for preparation of papaya pulp

3.3 Procedure for preparation of mixed fruit bars

3.3.1 Basic sample for preparation of mixed fruit bars

The basic sample for mixed fruit bars is presented in Table 3.1. The sample S_1 contained mango pulp 40%, pineapple juice 24% and papaya pulp 20%. Sample S_2 contained mango pulp 45%, pineapple juice, 19% and papaya pulp 20%. Sample S_3 contained 50% mango pulp, 14% pineapple juice and 20% papaya pulp. Sample S_4 contained 50% mango pulp, 29% pineapple juice and 20% papaya juice pulp. In each type of bar 15% sugar, 1 % starch and 0.25% sodium benzoate were added.

Table 3.1 The basic sample for preparation of mixed fruit bar

Ingredient	Sample			
	S_1	S_2	S_3	S_4
Mango pulp	40%	45%	50%	35%
Pineapple juice	24%	19%	14%	29%
Papaya pulp	20%	20%	20%	20%
Sugar	15%	15%	15%	15%
Starch	1%	1%	1%	1%
Sodium benzoate	0.25%	0.25%	0.25%	0.25%

3.3.2 Preparation of mixed fruit bars from mango pulp, pineapple juice and papaya pulp

At first mango pulp, pineapple juice and papaya pulp were taken and then properly weighed by a balance. All samples commonly contain 15% sugar, 1% starch and 0.25% sodium benzoate. All the ingredients were mixed thoroughly and heated at 80^0C for 5 minutes for gelatinization of starch. The mixture was then placed on a steel plate which was smeared with very thin layer of polythene to prevent the mixed fruit bar from sticking to plate after drying. The mixture was drying dried with constant temperature at 60°C for 21 hours. Then the sheet was cut into (3″x1"x1/4") bar form. The mixed fruit bars were packed in single layer polyethylene bag (thickness of poly bag 0.0254 mm) and stored at room temperature. The schematic diagram for preparation of mixed fruit bar was given in Figure 3.4.

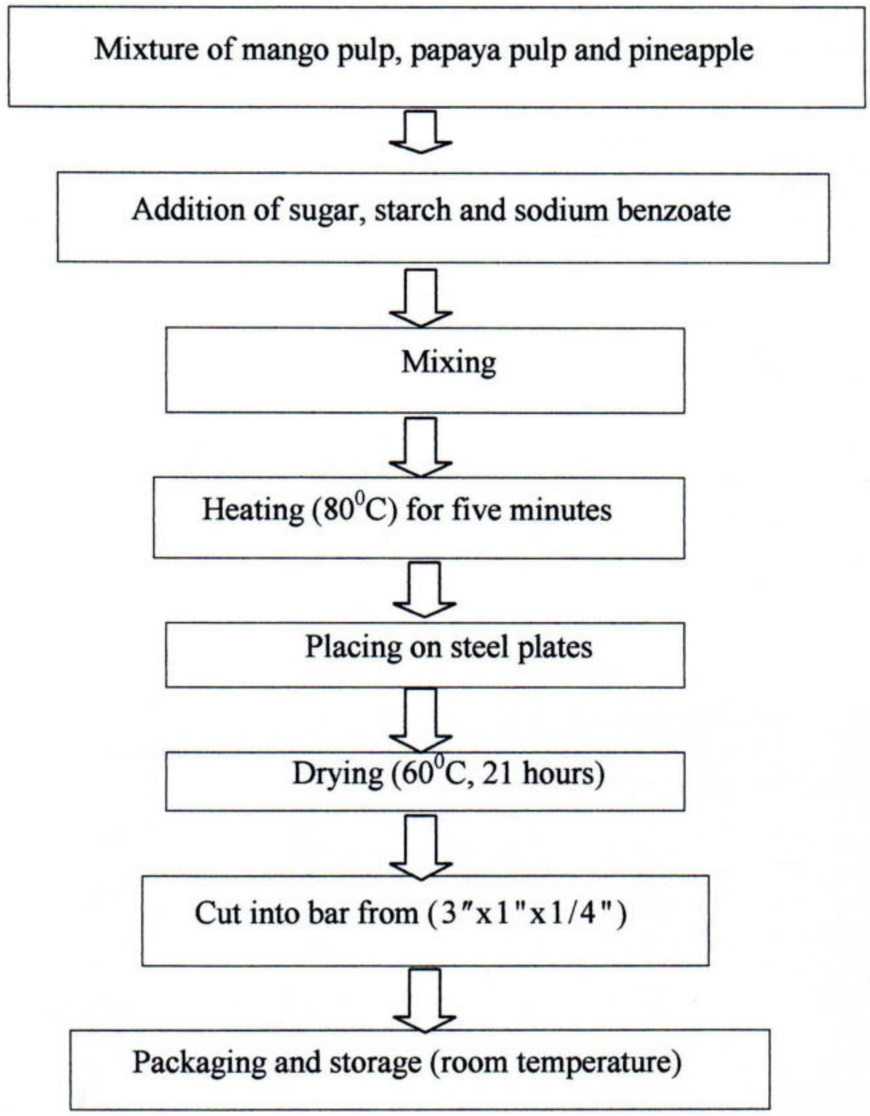

Fig. 3.4 Schematic diagram for preparation of mixed fruit bars

3.4 Chemical Analysis

The ripe mango pulp, pineapple juice and papaya pulp and stored mixed fruit bar were analyzed for their moisture, ash, titrable acidity, pH, total soluble solids, total sugar, fibre content and vitamin C. All the determinations were done in triplicate and the results were expressed as average value.

3.4.1. Moisture content

Moisture content was determined adopting AOAC (2000) method.

Procedure

At first weight of empty previously dried (1 hr at 100°C) crucible with cover was taken and 5 gm of sample was placed on it. Then the crucible was placed in an air oven (thermostatically controlled) and dried at temperature of 100 to 105°C for 24 hrs. After drying, the crucible was removed from the oven and cooled in desicator. It was then weighed with cover glass. The crucible was again placed in the oven, dried for 30 minutes, took out of the dryer, cooled in desicator and weighed. Drying, cooling, and weighing were repeated until the two consecutive weights were the same. From these weights the percentage of moisture in food samples was calculated as follows:

$$\% \text{ Moisture} = \frac{\text{Loss of weight}}{\text{Weight of sample}} \times 100$$

3.4.2 Ash content

Ash content of a foodstuff represents inorganic residue remaining after destruction of organic matter. The oven dried sample was taken in a muffle furnace at 600^0C for 4 hrs after charring over an electric heater. The difference between oven dried matter and final weight represented the ash, which was expressed in percentage. It was calculated using the following formula:

$$\% \text{ Ash content} = \frac{F}{I} \times 100$$

Where,

F= Weight of ash

I= Initial weight of dry matter.

3.4.3 Acidity

Acidity was determined following the methods of Jacob (1959) and Rangana (1977). Known volume of the fruit pulp was measured in graduated cylinders and then they were transferred to beakers and sufficiently. The juices were then cooled and poured back to the same graduated measuring cylinder and made up to the lost volume with distilled water.

Titration

10ml pulp/juice was taken in a 100ml conical flask. A few drops of 1% phenolphthalein solution (indicator) was added to the flask and titrated with 0.1N NaOH solution from a burette until a light pink colour appeared and persist for 15 seconds.

The titration was done for several times for accuracy. Percent titrable acidity was calculated using the following formula:

$$\% \text{ Titrable acidity} = \frac{T \times N \times V_1 \times E}{V_2 \times W \times 1000} \times 100$$

Where,

T= Titre

N= Normality

V_1=Volume made up

E= Equivalent weight of acid

V_2=Volume of sample taken for estimation

W= Weight of sample

3.4.4 Reducing sugar

The reagents used for the estimation of reducing, non-reducing and total sugar were follows:

1. Fehling's solution (A)
2. Fehling's solution (B)
3. Methylene blue indicator
4. 45% Neutral lead acetate solution
5. 22% Potassium oxalate solution

Standardization of Fehling's solution

10 ml of both Fehling's solution A and Fehling's solution B were mixed together in a beaker. 10 ml of mixed solution was pipetted into a 250 ml conical flask and 25 ml distilled water was added to it. Standard sugar solution was taken in a

burette. The conical flask containing mixed solution was heated on a hot plate. When the solution began to boil, three drops of methylene blue indicator solution was added to it. Mixed solution was titrated by standard sugar solution. The end point was indicated by decolorization of the indicator. Fehling's factor was calculated by using the following formula:

$$\text{Fehling's factor} = \frac{\text{Titre} \times 2.5}{1000}$$

Preparation of the sample

10 gm of filtered juice and 100 ml of distilled water were mixed in homogenizer and transferred to 250 ml volumetric flask. The mixture was neutralized with 0.1N NaOH and 2 ml of lead acetate solution was added and followed to stand for 10 minutes. 5 ml potassium oxalate solution was added and made to a volume of 250 ml. Then the mixture was filtered and made the dilution.

Titration for reducing sugar

10 ml of mixed Fehling's solution was taken in a conical flask and 25 ml of distilled water was added to it. Purified juice was taken in a burette. Conical flask containing mixed Fehling's solution was added to the flask when boiling started and titrated with solution taken in the burette at the same time. The end point was indicated by decolorization of indicator. Percent reducing sugar was calculated by using the following formula:

$$\%\ \text{Reducing sugar} = \frac{I \times D \times 100}{T \times W \times 100}$$

Where,

I = mg of invert sugar required to reduce known volume of Fehling's solution

D = dilution factor

T = titration

W = weight of sample

3.4.5 Non-reducing sugar

50 ml purified solution was taken in conical flask 50 ml distilled water and 5 gm of citric acid were added to it. Then the conical flask was heated for 10

minutes for addition of sucrose and finally cooled. The sample was then neutralized by 0.1 N NaOH solution using phenolphthalein as indicator. The volume was made up to 100 ml with distilled water. The mixed Fehling's solution was titrated using similar procedure followed as that for reducing sugar. The percent invert sugar was then calculated by the similar procedure as for reducing sugar from which the percent non-reducing sugar is calculated as follows:

% Non-reducing sugar =% Invert sugar-%Reducing sugar

3.4.6 Estimation of total sugar

Total sugar can be calculated as follows:

% Total sugar = %Reducing sugar +%Non-reducing sugar.

3.4.7 Total soluble solids (TSS)

Two drops prepared pulp was taken in a refractometer (Model no. HI 96801) plate and the total soluble solids of the juice was read directly from the refractometer.

3.4.8 pH

An electrolytic cell composed of two electrodes (caramel and glass electrode) was standardized with buffer solution of pH 4.0. Then the electrodes were dipped into the test sample. A voltage corresponding to the pH of the solution was developed and directly one can read the P^H of the solution indicated by the instrument (potentiometer).

3.4.9 Vitamin-C content (Ascorbic acid)

Ascorbic acid was determined following the method of Rangana (1977). The equations used for the estimation of vitamin-C were follows:

$$\text{Mg of vitamin C per 100g sample} = \frac{T \times D \times V_1}{V_2 \times W} \times 100$$

Where,

T = Titre

D = Dye factor

V_1 = Volume made up

V_2 = Aliquot of extract taken for estimation

W = Weight of sample taken for estimation

1. 3% Meta phosphoric acid (HPO_3): Prepare by dissolving the sticks or pellets of HPO_3 in glass-distilled water.

2. Ascorbic acid standard: Weigh accurately 100 mg of L ascorbic acid and make up to 100 ml with 3% $HP0_3$. Dilute 10 ml to 100 ml with 3% HPO_3 mg =0.3 mg of ascorbic acid.

3. Dye solution: Dissolve 50 mg of the sodium salt of 2, 6 dichlorophenol indophenol in approximately 150 ml of hot glass distilled water containing 42 mg of sodium bicarbonate. Cool and dilute with glass-distilled water to 200 ml. Store in a refrigerator and standardize everyday.

The dye 2, 6 Dichlorophenol-indophenols is blue in alkaline solution and reduced to light red colour by an ascorbic acid at pH range of 1-3.5

Standardization of Dye

Take 5 ml of standard ascorbic acid solution and add 5 ml of HPO_3. Fill a micro burette with the dye. Titrate with the dye solution to a pink colour, which should persist for 15 seconds. Determine the dye factor i.e. mg of ascorbic acid per ml of the dye, using the following formula:

$$\text{Dye factor} = \frac{0.5}{\text{Titre}}$$

Preparation of the samples

10 ml of the pulp/juice was taken and made up to 100 ml with 3% $HP0_3$ and then filtered. Now 10 ml of the aliquot was taken in a 150 ml conical flask. 1ml of 40% formaldehyde and 0.1N of HCI were added to it and kept for 10 minutes. This was titrated with standard dye to a pink colour (end point) when persisted for 15 seconds.

Calculation:

$$\text{Mg of ascorbic acid per 100 ml} = \frac{\text{Titre} \times \text{Dye factor} \times \text{Volume made up ml}}{\text{Aliquot of extract} \times \text{weight of the sample}} \times 100$$

3.4.10 Crude fibre

Crude fibre content was determined using AOAC (1989). Method the accepted method is as follows:

Reagents

1. 0.255 N sulphuric acid solution (1.25gm H_2SO_4/100ml).
2. 0.313 N sodium hydroxide solutions: 1.25 gm NaOH/100ml, free or nearly so sodium carbonate.

   Check the concentration of the solution 1 and 2 by titration and adjust (if necessary) accurately to the stated concentration.

3. Asbestos: Gooch grade, medium fibre, acid-washed and ignited.
4. 10% Potassium sulphate (K_2SO_4) Solution: Dissolve 10 gm in water made up to 100 ml.

Apparatus

1. Liebig condenser.
2. Filtering cloth: Use filtering cloth of such character that no solid material passes through when filtering. (Retention may be tested by passing the filtrate through Gooch.) Bucher's film or dressed lilen with approximately 45 Threads per inch may be used.

Determination

Extract 2 gm of dry material with either or use the residue from crude fat determination. Transfer the residue and approximately 0.5 gm of asbestos, to the digestion flask. Add 200 ml of the boiling sulphuric acid solution, immediately connect the digestion flask with condenser, and heat. (Contents of the flask must come to boiling within 1 min and boiling must continue briskly for exactly 30 min.) Rotate the flask frequently until the sample is thoroughly wetted. During digestion take care to keep the material from remaining on the side the digestion of flask without contact with the solution.

After 30 minutes remove the flask and filter through filtering cloth in a fluted funnel. Wash with boiling water until the washing is no longer acid.

Heat sodium hydroxide solution to boiling under reflex condenser. Wash the residue from acid digestion back.

Into the flask with 200 ml of boiling sodium hydroxide solution connect the flask with reflex condenser and boil for exactly 30 min.

After 30 min of boiling remove the flask and immediately filter through filtering cloth in a fluted funnel. Wash with water. For materials, difficult to filter, filter through filtering cloth in a fluted funnel using vacuum and wash with 10% potassium sulphate solution. The potassium sulphate solution may be added during filtration, whenever it becomes difficult. Return the residue to the digestion flask thorough washing all residues from cloth with hot water. Filter into the Gooch crucible prepare with thin but a packed layer of ignited asbestos. After thorough washing of the residue in the Gooch crucible with holing water, wash with approximately 15 ml of alcohol. Dry the crucible and the contents at 110^0C to constant weight. Cool in a desiccator and weigh. Ignite the contents of crucible in an electric muffle furnace or over a burner at dull red heat until carbonaceous matter is destroyed (approximately 20 min). Cool in a desiccator and weigh. The loss in weight represents crude fibre.

Calculation:

$$\%\ \text{Crude fibre} = \frac{\text{Loss in weight noted}}{\text{Weight of sample taken}} \times 100$$

2.4.11 Protein

The accepted method as follows. The reagents used for the estimation of protein were as follows:

1. Concentrated H_2SO_4
2. Digestion mixture:

Potassium sulphate= 100gm

Copper sulphate= 10gm

Selenium dioxide=2.5 gm

3 Boric Acid Solution

4 Alkali solution

5 Mixed indicator solution

6 Standard HCI (0.1N)

For estimation of protein, the steps were followed:

Digestion: Two gram sample, 2gm digestion mixture and 25 ml H_2SO_4 were taken in a kjeldahl digestion flask. It was heated for 4 hours in a kjeldal digestion and distillation apparatus. If the colour of the substance is pale yellow the digestion is complete.

Distillation: After digestion 100ml water, 100 ml 40% NaOH and glass blltz were added in the kjeldahl flask which containing about 10 ml 2% boric acid and 2-3 drops mixed indicator. About 100ml distillate was collected just before the distillation was stopped the receiving flask was moved. So, that the tip of the distilling tube was out the distillate. Some distillate was collected in this way to make sure the condenser tube was free from traces of ammonia.

Titration

The calculation of the percent of protein in the sample using protein factor 6.25.

$$\%\ \text{Nitrogen} = \frac{(T_S - T_B) \times \text{Nomality of acid} \times \text{meq.}N_2}{\text{Weight of sample (gm)}} \times 100$$

Where,

T_s= Titre value of the sample (ml)

T_B= Titre value of the Bank (ml)

Meq. of N_2=0.014

% Protein = % Nitrogen × 6.25

3.5 Sensory Evaluation

Sensory evaluations of all the samples mixed fruit bar were done by taste testing panel. The taste testing panel was made up with of 10 test panelists. They were asked to evaluate colour, flavour, texture, taste and overall acceptability by a scoring rate on a 9 point hedonic scale. 9= Like extremely, 8= Like very much, 7= Like moderately, 6= Like slightly, 5= Neither like nor dislike, 4= Dislike slightly, 3= Dislike moderately, 2= Dislike very much and 1= Dislike extremely. The preference differences were evaluated by statistical analysis of the data for variance and consequently Duncan's Multiple Range Test (DMRT). Procedures of the Statistical Analysis System (SAS, 1985) were used for statistical analysis.

The sensory evaluation of all types of fruit bar containing various proportions of sugar was evaluated for color, flavour and texture by a panel of 10 tasters. The tasters were asked to rate the mixed fruit bars of different samples presented to them on a 5 point hedonic scale: excellent=5, very good=4, good=3, acceptable=2, poor = 1.

3.6 Studies on storage stability of mixed fruit bar

3.6.1 Packaging and storage

The mixed fruit bar samples were packed in sealed single layer polythene bag and high density polythene coated with aluminum foil. The samples were stored at two temperature such as room temperature (21-32°C) and refrigerated temperature (3^0C). Single layer low density polythene permits easy passage of moisture and gasses in or out of the bag, while high density polythene (HDPE) inhibit passage of moisture and is poor gas barrier (Goddard, 1980). Moisture uptakes by samples in the above packaging systems were determined at every 15 days interval gravimetrically. The treatments for storage studies are shown in Table 3.2.

Table 3.2 Treatments applied in the storage studies of mixed fruit bar

Sample	Packing method	Storage temperature (^{0}C)	Period of storage (Days)
Mixed fruit bar	Single layer low density polythene	Ambient (21-32 ^{0}C) and 3^{0}C	60
	Double layer high density polythene	Ambient (21-32 ^{0}C) and 3^{0}C	60

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Composition of fresh mango pulp

The mango pulp was prepared as per the method described in section 3.2.1. The mango pulp was analyzed for moisture, ash, acidity, vitamin C, total soluble solid, protein and sugar. The results are shown in Table 4.1. The mango pulp contained 80.2% moisture, 0.55% ash and 0.19% acidity, vitamin C 45 mg per 100g, TSS 15.9%, protein 0.78% and total sugar 13.7%. The results were more or less similar to those reported by Singh, (1986) who showed that mango contained moisture 75 to 82%, sugar 8.7 to 20%, protein 0.51 %, citric acid 0.14 to 0.71, vitamin C 8.5 to 50 mg per 100 g and ash 0.38 to 0.63%.

4.2 Composition of fresh pineapple juice

The pineapple juice was prepared as per the method described Section 3.2.2. The pineapple juice was analyzed for moisture, ash, acidity, vitamin C, total soluble solid, protein and sugar. The results are shown in Table 4.1 which represent that pineapple juice contained moisture content 83.6%, ash 0.46%, acidity 0.62%, pH 3.70, total soluble solid (TSS) 11.7%, vitamin C 8.30 mg/100g and total sugar 12.1%.

This study is nearly in agreement with the findings of Anonymous (1960) who reported that the pineapple contained moisture content 75%, vitamin C 8.76 mg/100g, ash 0.56%, acidity 0.64%, pH 2.57, TSS 13%, reducing sugar 3.06%, non-reducing sugar 6.88% and total sugar 9.94%. The composition of two juices varies due to use of different variety.

4.3 Composition of fresh papaya pulp

The papaya pulp was prepared as per the method described in Section 3.2.3. The pulp was analyzed for proximate composition. The results are shown in Table 4.1. The papaya pulp contained moisture 89.4%, ash 0.45%, TSS 9.75%, pH 4.30, vitamin C 38.2 mg/100g, acidity 0.15% and total sugar 7.6%.

The results are more or less similar to Akin *et al.*, (2008) reported that papaya contained moisture 92.1%, ash 0.66%, fat 0.10%, protein 1% and total carbohydrate

6.2%. Kuth and Spore (1974) studied on the 15-20 varieties papaya which contained protein 0.6% and carbohydrate 9%.

Table 4.1 Composition of mango pulp, pineapple juice and papaya pulp

Parameter	Mango	Pineapple	Papaya
Moisture (%)	80.2	83.6	89.4
Vitamin C (mg/100 g)	45	8.30	38.2
Ash (%)	0.55	0.46	0.43
Total soluble solid (TSS, %)	15.9	11.7	9.75
Acidity (%)	0.19	0.62	0.15
Total sugar (%)	13.7	12.1	7.6

4.4 Composition of mixed fruit bar prepared from mango pulp, pineapple juice and papaya pulp

The composition of mixed fruit bars prepared from mango pulp, pineapple juice and papaya pulp were analyzed for moisture, ash, acidity vitamin C, total sugar, protein and fibre. The results are presented in Table 4.2. It can be seen from Table 4.2 that Sample S_1 contained moisture 13.80%, ash 1.09%, protein 0.70%, fibre 1.10% and total sugar 52.34%; Sample S_2 contained moisture 14.25%, ash 1.05%, protein 1.10%, fibre 1.20%, total sugar 52.40% and vitamin C 9.40 mg/100g; Sample S_3 contained moisture 14.55%, ash 1.15%, protein 1.07%, fibre 1.30%, total sugar 52.07% and vitamin C 10.40 mg/100 g; and Sample S_4 contained moisture 15.30%, ash 1.10%, protein 0.80%, fibre 1.09%, total sugar 52.60% and vitamin C 7.35 mg/100g. It is found that Sample S_4 contained highest amount of moisture and Sample S_1 had the lowest level of moisture. In case of protein, Sample S_2 contained the highest amount of protein and all other sample contained more or less similar amount. Sample S_2 and S_3 retained higher amount of vitamin C. Sample S_4 contained the highest amount of sugar and Sample S_3 contained lowest level. In case of fibre, Sample S_3 posed the highest amount and other sample had similar levels.

The results are more or less similar to P. Karmoker (2009) showed that formulation F_1 contained moisture 11.92%, ash 1.13%, protein 0.3%, firbre 1.497 mg/100 g and total sugar 54.08%; formulation F_2 (mango, pineapple and papaya) contained moisture 12.67%, ash 1.36%, protein 0.48%, fibre 1.15%, total sugar 55.13% and vitamin C 19.44 mg/100 g; formulation F_3 (mango, pineapple and papaya) contained moisture 12.48%, ash 1.13%, protein 0.33%, fibre 1.13%, total sugar 55.38% and vitamin C 6.48 mg/100 g; and formulation F_4 (mango, pineapple and papaya) contained moisture 12.80%, ash 1.24%, protein 0.31%, fibre 1.206%, total sugar 55.09% and vitamin C 5.4 mg/100g. The composition of two juices varies due to use of different variety.

Table 4.2 Composition of mixed fruit bar from mango, pineapple and papaya

Parameter	Sample			
	S_1	S_2	S_3	S_4
Moisture (%)	13.80	14.25	14.55	15.30
Vitamin C (mg/100 g)	8.80	9.40	10.40	7.35
Ash (%)	1.09	1.05	1.15	1.10
Acidity (%)	0.30	0.19	0.15	0.25
Total Sugar (%)	52.34	52.40	52.07	52.60
Protein	0.70	1.10	1.07	0.80
Fibre	1.10	1.20	1.30	1.09

Sample S_1; Mango (40%) + Pineapple (24%) + Papaya (20%)
Sample S_2; Mango (45%) + Pineapple (19%) + Papaya (20%)
Sample S_3; Mango (50%) + Pineapple (14%) + Papaya (20%)
Sample S_4; Mango (35%) + Pineapple (29%) + Papaya (20%)

4.5 Sensory evaluation

A panel of 10 judges tested the colour, flavour, texture and overall acceptability of fruit bar made from mango, pineapple and papaya in various ration. The mean scores for colour, flavour, texture, taste and overall acceptability of different types of bar sample such as S_1, S_2, S_3 and S_4 are presented in Table 4.3.

A two way analysis of variance ANOVA (Appendix 3.1 and Appendix 3.2) was carried out for colour preference and results revealed that there was significant ($P<0.05$) difference in colour acceptability among the fruit bars. The results of DMRT showed that there was no significant difference for colour difference among the formulation S_1 and S_4 (Table 4.3).

Table 4.3 Mean score for colour, flavour, texture and overall acceptability of mixed fruit bars

Sample Code	Sensory attributes				
	Colour	Flavour	Texture	Taste	Overall Acceptability
S_1	5.5^c	5.7^c	7.3^b	6.1^c	6.1^c
S_2	6.8^b	7.0^b	6.1^c	6.4^c	7.1^b
S_3	7.7^a	8.1^a	8.2^a	8.4^a	8.1^a
S_4	5.4^c	6.1^c	5.8^c	7.5^b	5.6^c
LSD ($P<0.05$)	0.375	0.577	0.547	0.533	0.569

Sample S_1; Mango (40%) + Pineapple (24%) + Papaya (20%)
Sample S_2; Mango (45%) + Pineapple (19%) + Papaya (20%)
Sample S_3; Mango (50%) + Pineapple (14%) + Papaya (20%)
Sample S_4; Mango (35%) + Pineapple (29%) + Papaya (20%)

In case of colour preference among the sample, the sample S_3 was more acceptable than sample S_1, S_2 and S_4. Sample S_3 secured the highest score 7.7 and ranked as "Like very much". Sample S_1 and S_4 are ranked as "Like slightly" and securing score 5.5 and 5.4 respectively. The mixing ratio of mango, pineapple and papaya pulp in sample S_3 was composed of 50%, 14% and 20% respectively.

In case of flavour preference among the sample ANOVA analysis (Appendix 4.1 and Appendix 4.2) showed that there was significant ($p<0.05$) difference in flavour acceptability among the fruit bars. From Table 4.3 it is seen that sample S_3 secured highest score 8.1 for flavour and was ranked as "Like very much" and followed by the sample S_2 and S_4 securing score 7.0 and 6.1. The sample S_1 secured score 5.7 and rank as "Like slightly".

In case of texture preference among the sample (Appendix 5.1 and Appendix 5.2) showed that there was significant ($p<0.05$) difference in texture as shown in Table 4.3. Sample S_3 secure the highest score 8.2 for texture and ranked "Like very much". Sample S_4 secure score 5.8 and posed lowest score.

In case of taste preference among the sample (Appendix 6.1 and Appendix 6.2) showed that there was significant ($p<0.05$) difference in texture as shown in Table 4.3. Sample S_3 secure the highest score 8.4 for texture and ranked "Like very much". Sample S_1 secure score 6.1 and posed lowest score.

It was apparent from the results of the ANOVA (Appendix 7.1 and Appendix 7.2) there was significant ($p<0.05$) difference in overall acceptability of the sample tested as the calculated F (31.988) is greater than the tabulated F value (2.960). This indicates that so far as overall acceptability is concern the samples were not equally acceptable. It can be seen from Table 4.3 that the sample S_3 is the most acceptable product receiving 8.1 out of 9.0 compared to the other sample and ranked as "Like very much". The sample S_2 securing 7.1 and was ranked as "like moderately ". However S_1 and S_4 securing 6.1 and 5.6 respectively and ranked as "Like slightly ".

Mixed fruit bar (S_3) containing 50% mango pulp, 14% pineapple juice and 20% papaya pulp secured the highest score for colour, flavour, texture, taste and overall acceptability among all the samples and was closely followed by fruit bar S_2 having 45% mango pulp, 19% pineapple juice and 20% papaya pulp. So, sample S_3 product may be regarded as the best product.

4.6 The effects of various levels of sugar on the quality of mixed fruit bar

In order to evaluate the effects of sugar on the organoleptic properties of mixed fruit bars one sample such as S_3 was chosen. Since sample S_3 was found to be better for its overall acceptability as determined by DMRT. Initially all samples (S_1, S_2, S_3 and S_4) contained 15% sugar. But the selected sample S_3 contained various levels of sugar ranging from 7-20% and investigated the effects of the colour, flavor and texture on mixed fruit bars. A panel of 10 tasters evaluated the color, flavour, texture and total score of mixed fruit bars. The mean score for color flavour, texture and total scores were presented in Table 4.4

Table 4.4 The effects of sugar at various substitution levels for sample S_3 on the organoleptic properties of mixed fruit bar

Sample	Sugar (%)	Score on			
		Colour	Flavour	Texture	Total
S_3	7	4.15	2.90	3.20	10.25
	11	4.30	4.15	3.90	12.35
	15	4.60	4.45	4.75	13.80
	20	4.10	3.50	3.00	10.60

Score: 5= Excellent; 4= Very good; 3= Good; 2= Acceptable; 1= poor
Mean score from a panel of 10 panelists.

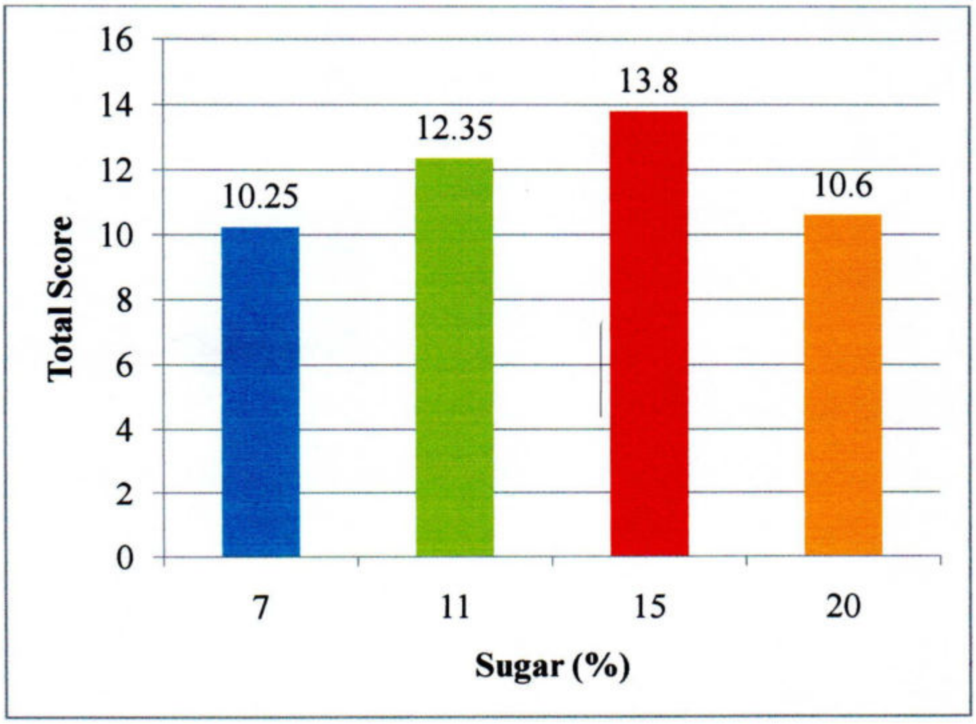

Fig 4.1 The effects of sugar at various substitution levels for sample S_3 on the organoleptic properties of mixed fruit bar

It was observed from Table 4.4 and Figure 4.1 that the highest scores obtained at 15% addition of sugar where as lowest total score for obtained at 7% addition of sugar. The addition of lowest amount of sugar offered the brittle characteristics of mixed fruit bar. So, 15% addition of sugar produced the best product.

4.7 Storage studies of mixed fruit bar

The moisture absorption and moisture removal are the two important parameters required to be studied for all types of dried and high-sugar products in order to assess the shelf life of the finished products.

4.7.1 Effect of storage time and temperature on the moisture content of mixed fruit bar in single layer low density polyethylene

This study was conducted to assess the effect of storage time (60 days), room temperature (21-32^{0}C) and refrigeration temperature (3^{0}C), packaging materials (low density polythene and double layer high density polythene coated with aluminium foil) on the moisture content of mixed fruit bar samples S_1, S_2, S_3 and S_4. As can be seen from Figures 4.2 that the initial moisture content of mixed fruit bar were 13.80(S_1), 14.25(S_2), 14.55(S_3) and 15.30(S_4) The moisture content of mixed fruit bar at ambient temperature (21-32^{0}C) were increased in single layer low density poly ethylene bag from 13.80% to 17.66%; 14.25% to 18.07%, 14.55% to 18.89% and 15.30% to 19.41% for sample S_1, S_2, S_3 and S_4 respectively during 60 days.

On the other hand the moisture content of mixed from bar at refrigeration temperature (3°C) were also increased in single layer low density polyethylene from 13.80% to 14.83%, 14.25% to 15.38%, 14.55% to 15.45% and 15.30% to 16.19% for sample S_1, S_2, S_3 and S_4 respectively during 60 days.

4.7.2 Effect of storage time and temperature on the moisture content of mixed fruit bar in double layer high density polyethylene coated with aluminum foil

There was no significant difference in weight gain or loss of the product noted in high density polyethylene coated with aluminum foil. The results are shown in Table 4.5 and Table 4.6

Table 4.5 Moisture content (% wet basis) of mixed fruit bar stored in double layer high density polyethylene coated with aluminum foil at 21-32^{0}C temperature

Days	Moisture Content (%)			
	S_1	S_2	S_3	S_4
0	13.8	14.25	14.55	15.3
15	13.88	14.35	14.63	15.38
30	13.97	14.43	14.71	15.48
45	14.02	14.55	14.85	15.6
60	14.09	14.66	14.92	15.73

Table 4.6 Moisture content (% wet basis) of mixed fruit bar stored in double layer high density polyethylene coated with aluminum foil at 3^{0}C temperature

Days	Moisture Content (%)			
	S_1	S_2	S_3	S_4
0	13.8	14.25	14.55	15.3
15	13.83	14.29	14.56	15.33
30	13.86	14.32	14.58	15.38
45	13.91	14.39	14.61	15.43
60	13.98	14.45	14.65	15.51

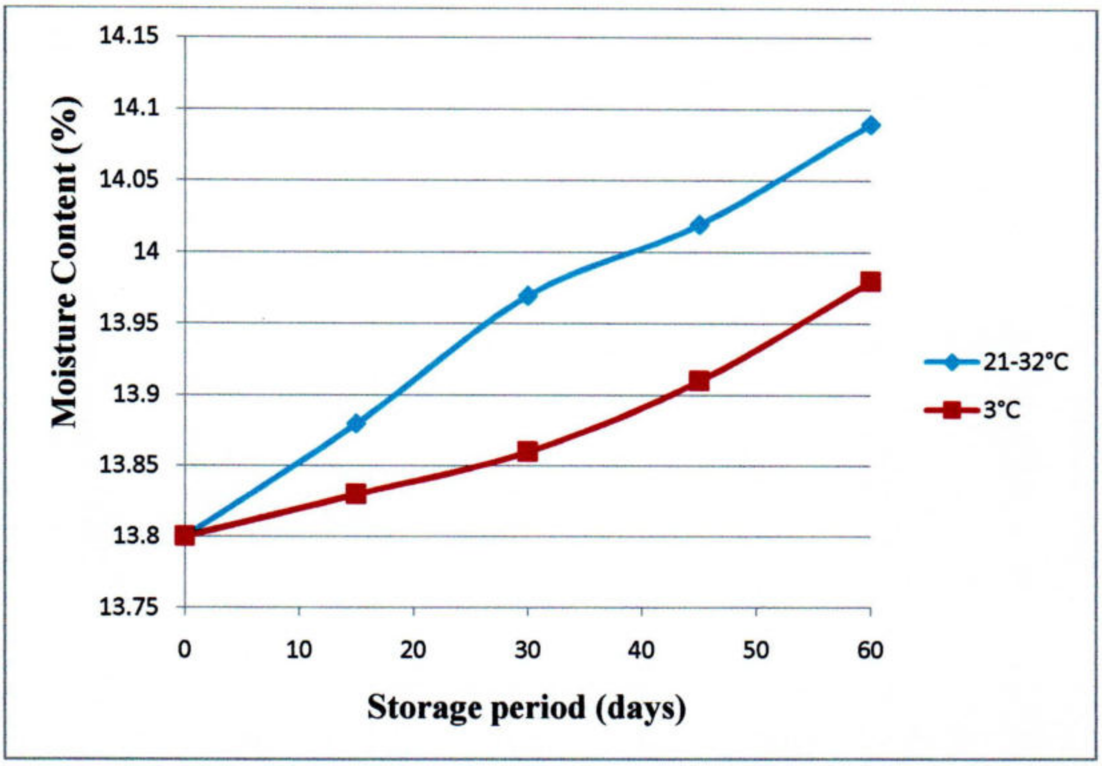

Fig. 4.2 Effect of storage time and temperature on the moisture content of mixed fruit bar in double layer density polyethylene coated with aluminum foil (S_1)

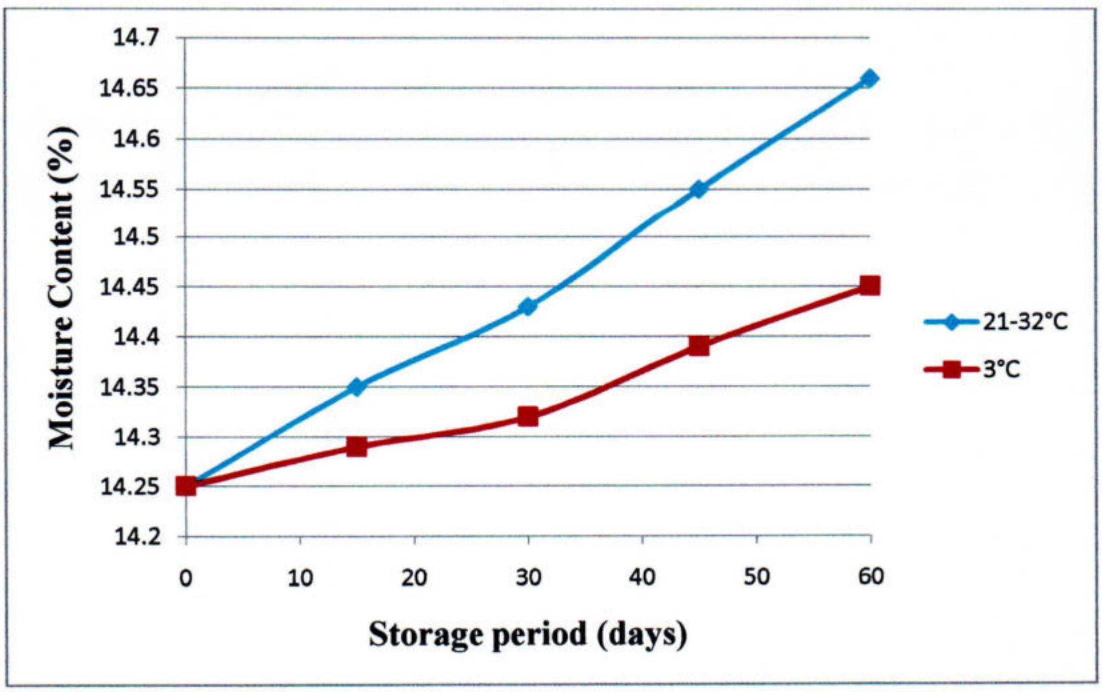

Fig. 4.3 Effect of storage time and temperature on the moisture content of mixed fruit bar in double layer density polyethylene coated with aluminum foil (S_2)

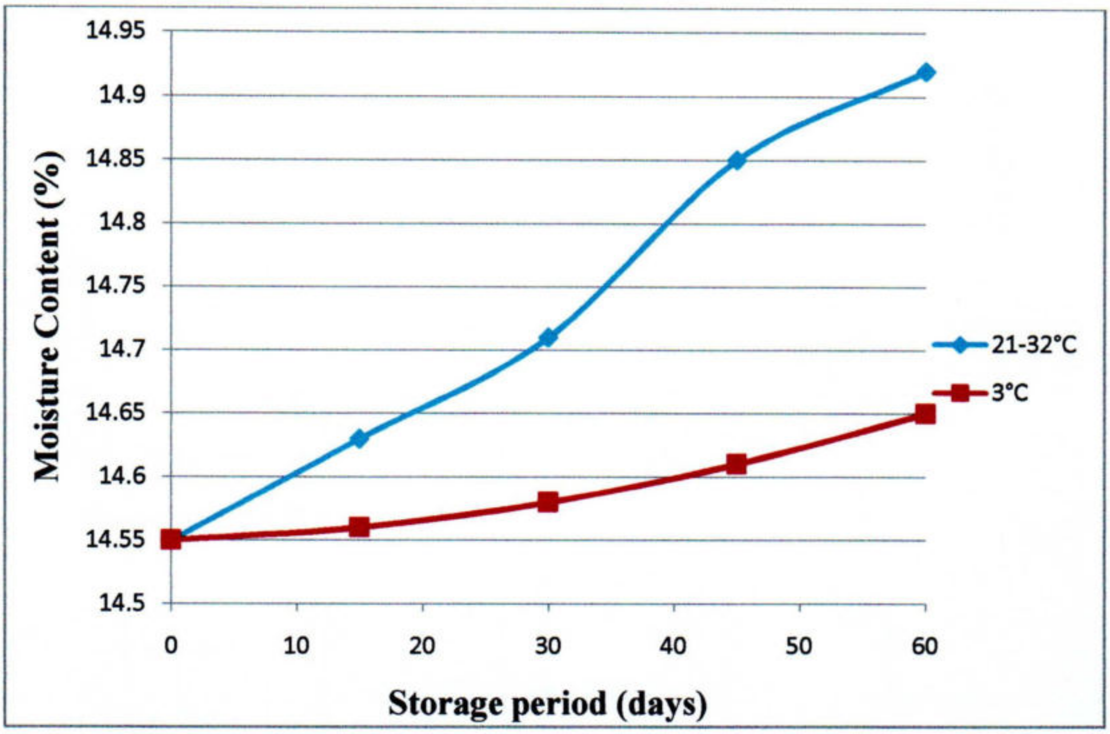

Fig. 4.4 Effect of storage time and temperature on the moisture content of mixed fruit bar in double layer density polyethylene coated with aluminum foil (S_3)

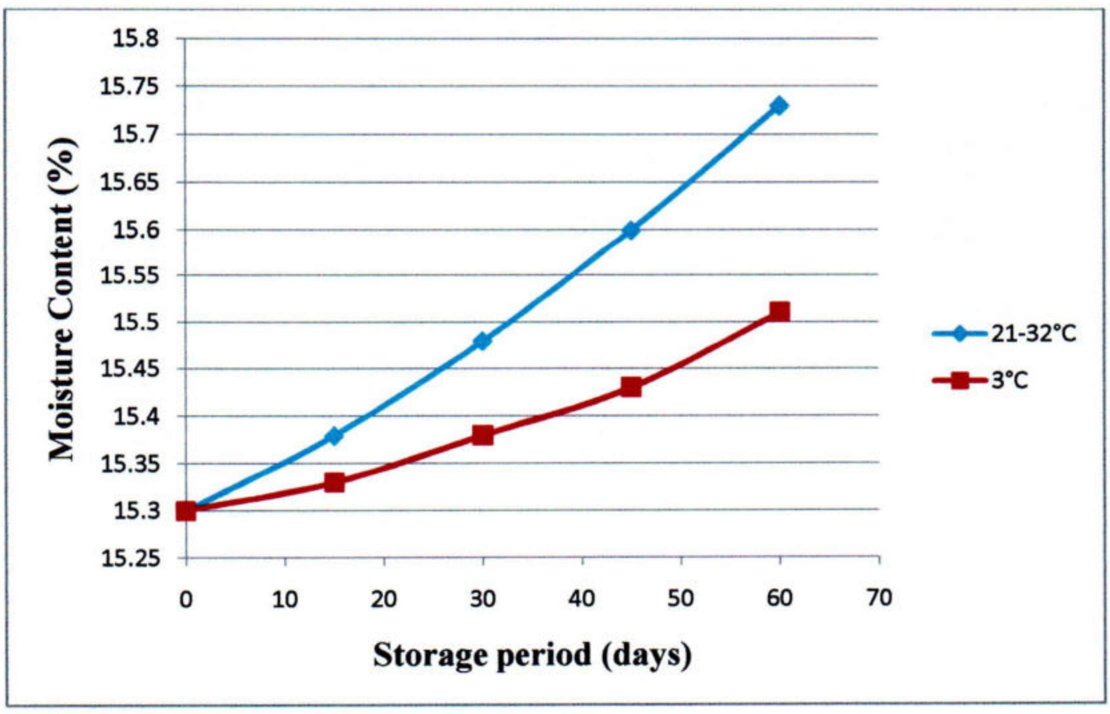

Fig. 4.5 Effect of storage time and temperature on the moisture content of mixed fruit bar in double layer density polyethylene coated with aluminum foil (S_4)

4.7.3 Comparison between two packaging systems

The different between initial moisture content and final moisture content of samples S_1, S_2, S_3 and S_4 after storage period of 60 days for different packaging system are presented in Table 4.7 and Table 4.8

Table: 4.7 Moisture uptakes in two packaging systems in storage period of 60 days at 21^0C-32^0C

Moisture Content	Single layer low density polyethylene				Double layer high density polyethylene coated with aluminium foil			
	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4
Initial moisture Content (%)	13.80	14.25	14.55	15.30	13.8	14.25	14.55	15.3
Final moisture Content (%)	17.66	18.07	18.89	19.41	14.09	14.66	14.92	15.73
Difference	3.86	3.82	4.34	4.11	0.29	0.41	0.37	0.43

Table: 4.8 Moisture uptakes in two packaging systems in storage period of 60 days at 3^0C

Moisture Content	Single layer low density polyethylene				Double layer high density polyethylene coated with aluminium foil			
	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4
Initial moisture Content (%)	13.80	14.25	14.55	15.30	13.8	14.25	14.55	15.3
Final moisture Content (%)	14.83	15.38	15.45	16.19	13.98	14.45	14.65	15.51
Difference	1.03	1.13	0.90	0.89	0.11	0.14	0.06	0.13

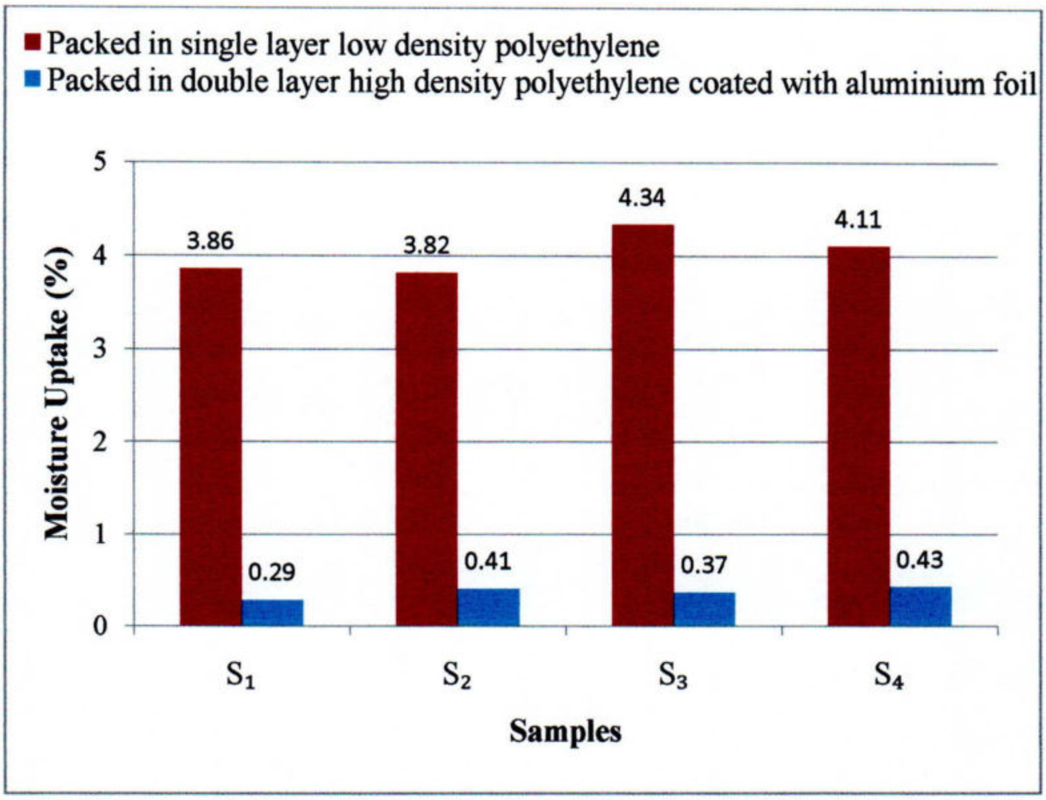

Fig.4.6 Comparison between two packaging system stored at 21⁰C-32⁰C

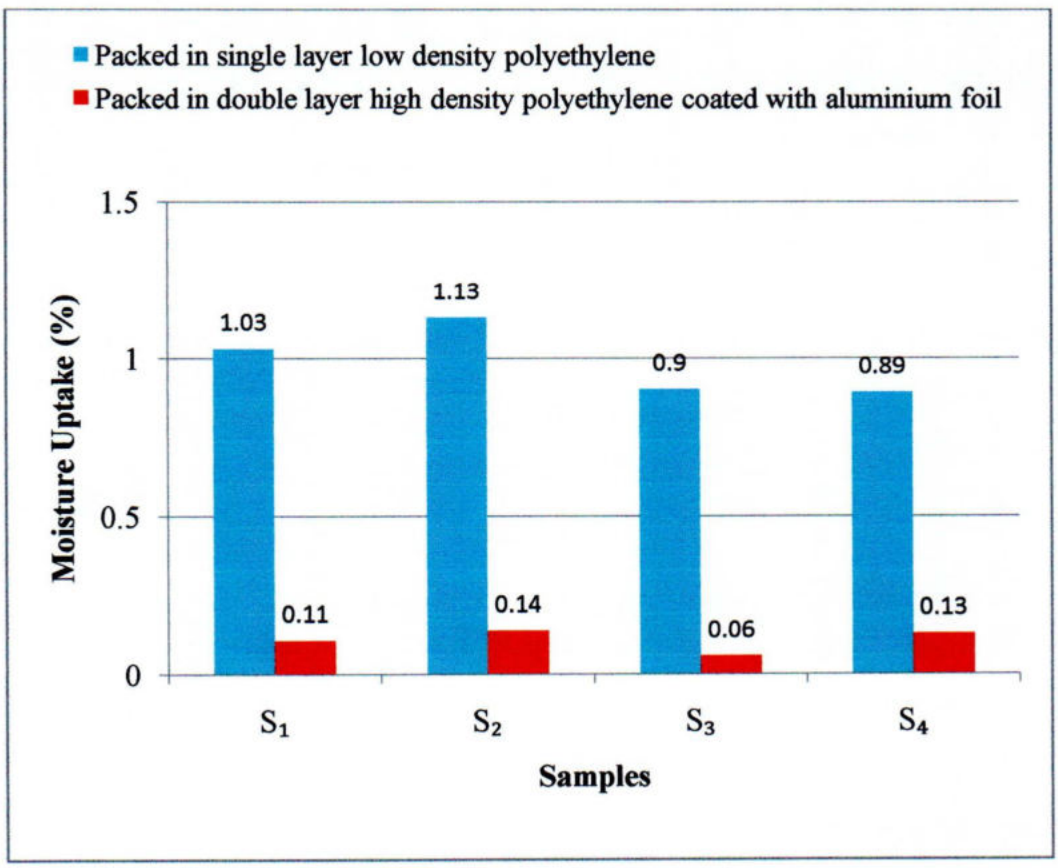

Fig. 4.7 Comparison between two packaging system stored at 3⁰C

It is seen from figure 4.6 and 4.7 that mixed fruit bar packed in double layer high density polyethylene coated with aluminium foil has lower moisture content in comparison with single layer low density polythene. So, double layer high density polyethylene coated with aluminium foil is the best as packaging material for mixed fruit bar.

Sample S_1

Sample S_2

Sample S_3

Sample S_4

Fig. 4.8 Appearance of mixed fruit bars

CHAPTER V

SUMMARY AND CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSION

The investigation was carried out in the laboratory of the Department of Food Engineering and Technology, Hajee Mohammad Danesh Science and Technology University, Dinajpur to explore the acceptable sample of mixed fruit bars incorporating mango, pineapple and papaya fruits.

The fresh ripe mango, pineapple and papaya were collected from the local market and analyzed for their composition. The mango contained moisture 80.2%, ash 0.55%, acidity 0.19%, vitamin C 45mg/100g, TSS 15.9%, protein 0.51% and total Sugar 13.7%, respectively. Pineapple contained vitamin C 8.30mg/100g, moisture content 83.6%, ash 0.46%, acidity 0.62 %, pH 3.50, total soluble solid (TSS) 11.7% and total sugar 12.1 %. The whole ripe papaya fruit contained the moisture content 89.4%, ash 0.43%, TSS 9.75%, pH 4.50, vitamin C 38.2mg/100 g, acidity 0.15% and total sugar 7.6%.

The pulps from mango, pineapple and papaya were prepared and used for production of mixed fruit bar using different proportions along with other ingredients in the Sample. The Sample S_1 contained mango pulp 40%, pineapple juice 24% and papaya pulp 20%; Sample S_2 contained mango pulp 45%, pineapple juice 19% and papaya pulp 20%; Sample S_3 contained 50% mango pulp, 14% pineapple juice and 20% papaya pulp and the Sample S_4 contained 35% mango pulp, 29% pineapple juice and 20% papaya juice pulp. All the sample contained 15% sugar, 1% starch and 0.25% sodium benzoate.

The mixed fruit bars were prepared as per standard procedures and were analyzed for proximate composition. The sample S_1 contained moisture 13.80%, ash 1.09%, protein 0.70%, fibre 1.10%, vitamin C 8.80 mg/100g and total sugar 52.34%, sample S_2 contained moisture 14.25%, ash 1.05%, protein 1.10%, fibre 1.20%, total sugar 52.40% and vitamin C 9.40 mg/100g, sample S_3 contained moisture 14.55%, ash 1.15%, protein 1.07%, fibre 1.30%, total sugar 52.07% and vitamin C 10.40 mg/100g, sample S_4 contained moisture 15.30%, ash 1.10%, protein 0.80%, fibre 1.09%, total sugar 52.60% and vitamin C 7.35 mg/100 g.

The statistical analysis showed that color, flavour, texture, taste and overall acceptability of mixed fruit bar of Sample S_3 (mango 50%, pineapple 14%, papaya 20%) was more acceptable that Sample S_1, S_2 and S_4. It indicates that higher proportions of mango pulp with low level of pineapple juice rendered the most acceptable mixed fruit bar.

Various proportions of sugar were used to prepare mixed fruit bar. It only increases the weight of final product. Minimum requirement of sugar for fruit bar manufacturing was 7%. Below this level it produce cracker fruit bar.

The moisture content of mixed fruit bar both at room temperature (21-32°C) and at refrigeration temperature (3°C) were increased in single layer low density polyethylene. The increase in moisture content of mixed fruit bar was lower at refrigeration temperature (3°C) than at room temperature (21-32°C) during storage period in single layer low density polyethylene bag. The increase in moisture content was very much lower in HDPF that can he ignored. Thus it observed that the mixed bar stored in double layer high density polythene and storage temperature of refrigeration temperature (3°C) was more stable in terms of water absorption.

Every year in Bangladesh a large amount of mango, pineapple and papaya are spoiled due to inadequate processing and preservation facilities. The fruit bar preparation is a simple technique for preservation and suitable for cottage and small scale enterprises. Inadequate and improper processing and preservation facilities for many important fruits like mango, pineapple and papaya are responsible for increasing post harvest losses of these commodities. Proper utilization and value addition of these important fruits through preparation of mixed fruit bars may help encourage development of cottage and small scale industries in the country.

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APPENDICES

APPENDICES

Appendix 3.1 Rating score for Colour of mixed fruit bar from mango, pineapple and papaya

Panelist No.	Sample No.				Total
	S_1	S_2	S_3	S_4	
1	6	7	8	5	26
2	4	6	7	5	22
3	6	7	8	6	27
4	5	6	7	5	23
5	6	7	8	5	26
6	5	6	7	5	23
7	6	7	8	5	26
8	6	8	9	7	30
9	6	7	7	5	25
10	5	7	8	6	26
Total	55	68	77	54	254
Mean	5.5	6.8	7.7	5.4	

Hedonic scale used: 9 = Like extremely; 8 = Like very much; 7 = Like moderately; 6 = Like slightly; 5 = Neither like nor dislike; 4 = Dislike slightly; 3 = Dislike moderately; 2 = Dislike very much; 1 = Dislike extremely.

Appendix 3.2 Analysis of variance (ANOVA) for colour

Source	Degree of freedom	Sum of squares	Mean squares	F- value	
				Calculated	Tabulated
Judges	9	12.1	1.344	8.067	2.250
Products	3	36.5	12.167	73	2.960
Error	27	4.5	0.167		
Total	39	53.1			

Appendix 3.3 Duncan's Multiple Range Test (DMRT) for colour

LSD value =0.375, P<0.05

Sample Code	Original order of means	Sample Code	Ranked order of means
S_1	5.5^c	S_3	7.7^a
S_2	6.8^b	S_2	6.8^b
S_3	7.7^a	S_1	5.5^c
S_4	5.4^c	S_4	5.4^c

Appendix 4.1 Rating score for Flavour of mixed fruit bar from mango, pineapple and papaya

Panelist No.	Sample No.				Total
	S_1	S_2	S_3	S_4	
1	7	8	9	6	30
2	6	7	8	5	26
3	5	7	7	6	25
4	5	6	8	7	26
5	7	8	9	6	30
6	6	6	7	5	24
7	5	6	8	7	26
8	6	8	9	7	30
9	6	8	9	7	30
10	4	6	7	5	22
Total	57	70	81	61	269
Mean	5.7	7	8.1	6.1	

Hedonic scale used: 9 = Like extremely; 8 = Like very much; 7 = Like moderately; 6 = Like slightly; 5 = Neither like nor dislike; 4 = Dislike slightly; 3 = Dislike moderately; 2 = Dislike very much; 1 = Dislike extremely.

Appendix 4.2 Analysis of variance (ANOVA) for flavor

Source	Degree of freedom	Sum of squares	Mean squares	F- value	
				Calculated	Tabulated
Judges	9	19.225	2.136	5.402	2.250
Products	3	34.075	11.358	28.728	2.960
Error	27	10.675	0.395		
Total	39	63.975			

Appendix 4.3 Duncan's Multiple Range Test (DMRT) for flavour
LSD value =0.577, P<0.05

Sample Code	Original order of means	Sample Code	Ranked order of means
S_1	5.7^c	S_3	8.1^a
S_2	7^b	S_2	7^b
S_3	8.1^a	S_4	6.1^c
S_4	6.1^c	S_1	5.7^c

Appendix 5.1 Rating score for Texture of mixed fruit bar from mango, pineapple and papaya

Panelist No.	Sample No.				Total
	S_1	S_2	S_3	S_4	
1	7	5	8	6	26
2	7	6	8	5	26
3	8	7	9	6	30
4	8	6	8	7	29
5	8	7	9	6	30
6	7	5	7	4	23
7	7	6	8	5	26
8	6	7	8	5	26
9	8	6	9	7	30
10	7	6	8	7	28
Total	73	61	82	58	274
Mean	7.3	6.1	8.2	5.8	

Hedonic scale used: 9 = Like extremely; 8 = Like very much; 7 = Like moderately; 6 = Like slightly; 5 = Neither like nor dislike; 4 = Dislike slightly; 3 = Dislike moderately; 2 = Dislike very much; 1 = Dislike extremely.

Appendix 5.2 Analysis of variance (ANOVA) for texture

Source	Degree of freedom	Sum of squares	Mean squares	F- value	
				Calculated	Tabulated
Judges	9	12.60	1.40	3.937	2.250
Products	3	36.9	12.3	34.594	2.960
Error	27	9.6	0.356		
Total	39	59.1			

Appendix 5.3 Duncan's Multiple Range Test (DMRT) for texture LSD value =0.547, P<0.05

Sample Code	Original order of means	Sample Code	Ranked order of means
S_1	7.3^b	S_3	8.2^a
S_2	6.1^c	S_1	7.3^b
S_3	8.2^a	S_2	6.1^c
S_4	5.8^c	S_4	5.8^c

Appendix 6.1 Rating score for Taste of mixed fruit bar from mango, pineapple and papaya

Panelist No.	Sample No.				Total
	S_1	S_2	S_3	S_4	
1	6	7	9	8	30
2	8	6	8	7	29
3	7	6	9	8	30
4	6	7	8	8	29
5	6	7	8	7	28
6	7	6	9	8	30
7	5	6	8	7	26
8	4	5	7	6	22
9	6	7	9	8	30
10	6	7	9	8	30
Total	61	64	84	75	284
Mean	6.1	6.4	8.4	7.5	

Hedonic scale used: 9 = Like extremely; 8 = Like very much; 7 = Like moderately; 6 = Like slightly; 5 = Neither like nor dislike; 4 = Dislike slightly; 3 = Dislike moderately; 2 = Dislike very much; 1 = Dislike extremely.

Appendix 6.2 Analysis of variance (ANOVA) for taste

Source	Degree of freedom	Sum of squares	Mean squares	F- value	
				Calculated	Tabulated
Judges	9	15.1	1.678	4.978	2.250
Products	3	33.4	11.133	33.033	2.960
Error	27	9.1	0.337		
Total	39	57.6			

Appendix 6.3 Duncan's Multiple Range Test (DMRT) for taste
LSD value =0.532, P<0.05

Sample Code	Original order of means	Sample Code	Ranked order of means
S_1	6.1^c	S_3	8.4^a
S_2	6.4^c	S_4	7.5^b
S_3	8.4^a	S_2	6.4^c
S_4	7.5^b	S_1	6.1^c

Appendix 7.1 Rating score for Overall Acceptability of mixed fruit bar from mango, pineapple and papaya

Panelist No.	Sample No.				Total
	S_1	S_2	S_3	S_4	
1	6	7	8	5	26
2	5	6	7	4	22
3	7	8	9	6	30
4	5	8	8	6	27
5	5	6	7	5	23
6	5	6	8	7	26
7	6	7	8	5	26
8	7	8	9	6	30
9	8	7	8	6	29
10	7	8	9	6	30
Total	61	71	81	56	269
Mean	6.1	7.1	8.1	5.6	

Hedonic scale used: 9 = Like extremely; 8 = Like very much; 7 = Like moderately; 6 = Like slightly; 5 = Neither like nor dislike; 4 = Dislike slightly; 3 = Dislike moderately; 2 = Dislike very much; 1 = Dislike extremely.

Total	39	65.975			

Appendix 7.3 Duncan's Multiple Range Test (DMRT) for Overall Acceptability

LSD value =0.569, P<0.05

Sample Code	Original order of means	Sample Code	Ranked order of means
S_1	6.1^c	S_3	8.1^a
S_2	7.1^b	S_2	7.1^b
S_3	8.1^a	S_1	6.1^c
S_4	5.6^c	S_4	5.6^c

Appendix 8

TASTE TESTING OF MIXED FRUIT BAR

Name of Tester: …………………………… Date: …

Please taste these samples and check how much you like or dislike each one on four sensory attributes such as Colour, Flavour, Texture and
Use the appropriate scale to show your attitude by checking at the point that best describes your feeling about the sample. Please give a re
Remember you are the only one who can tell what you like. An honest expression of your personal feeling will help me.

HEDONIC SCALE	COLOUR				FLAVOUR				TEXTURE				A
	Sample				Sample				Sample				
	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4	S_1
Like extremely													
Like very much													
Like moderately													
Like Slightly													
Neither like nor dislike													
Dislike slightly													
Dislike moderately													
Dislike very much													
Dislike extremely													

Extra comments on each sample if any:
N.B. Overall Evaluation:
Hedonic scale used: 9 = like extremely; 8 = like very much; 7 = like moderately;
6 = like slightly; 5 = neither like nor dislike; 4 = dislike slightly;
3 = dislike moderately; 2 = dislike very much; 1 = dislike extremely.

………………
Signature of Ju