PREPARATION, QUALITY EVALUATION AND STORAGE STABILITY OF WOOD APPLE BAR

A THESIS

BY

MD TAFAZZAL HOSSAIN

Roll No. 1305181

Session: 2013-2014

Semester: July- December, 2014

MASTER OF SCIENCE (MS)

IN

FOOD PROCESSING AND PRESERVATION

DEPARTMENT OF FOOD PROCESSING AND PRESERVATION

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR

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DEDICATED
TO MY
BELOVED PARENTS

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The Author

ABSTRACT

Wood apple is the cheaper, highly nutritious and seasonally available fruit and it was decided to preserve for human consumption throughout the year. This study was planned to utilize wood apple by preserving them as fruit bar. Using wood apple preserved products as fruit bar were developed, stored and quality parameters were assessed for a periods of 60 days. Different amounts of wood apple pulp (50g, 75g, 100g) were used to develop bar. Statistically analysis of sensory attributes revealed that sample S2 (75 g pulp) was most delicious. Physico-chemical analysis showed that sample S2 contained moisture 13.55%, ash 4.90%, acidity 1.75%, TSS 71.5 obrix, total sugar 46.15mg/100g, reducing sugar 8.75mg/100g, vitamin C 1.71mg/100g and protein 7.85%. Hence, this study shows that wood apple bar has high nutritional value.

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INTRODUCTION

CHAPTER 1

INTRODUCTION

The wood apple (*A. marmelos* L. *Correa*) belongs to the family *Rutaceae*, occupies an important place among the indigenous, fruits of Bangladesh. It is known by different names viz. Bael, Bel, Bengal Quince, Bil, Bilva, Bilpatre, Shul, Shaiphal, Vilvum, etc. It is a large deciduous tropical tree, found all over Sri Lanka, Pakistan, Bangladesh, Burma, Thailand and most of the southeastern Asian countries (Rakesh *et al.* 2005). The fruit is abundantly available in Rajshahi, Rangpur, Gazipur, Mymensingh, Tangail, and Chittagong districts (Kamaluddin, 1966). However, no statistical data is available regarding its area and production.

The wood apple is highly nutritious. According to Gopalan *et al.* (1971), it contains 61.5 g water, 1.8 g protein, 0.39 g fat, 1.7 g minerals, 31.8 g carbohydrates, 55 mg carotene, 0.13 mg thiamine, 1.19 mg riboflavin, 1.1 mg niaacine, and 8 mg vitamin C per 100 g of edible protein. Wood apple is very rich in riboflavin (Mukherjee and Ahmed, 1957). The wood apple is used for the preparation of a number of products like jam, jelly, morabba, sherbet, pickle, candy, squash, toffee, slab, pulp powder and necter.

Every part of the tree such as root, bark, leaf, flower, fruits, seed and even its latex are important in several traditional system of medicine that is why it is one of the most important trees in India (Purohit *et al.* 2004).

Realizing the importance of fruit, as a cheaper, highly nutritious and because of perishable nature and seasonally available it was decided to make a preserved products for human consumption throughout the year. This study was planned keeping in view the nutritional importance of wood apple, to utilize them by preserving them as fruit bar.

Hence, the study was undertaken with the following specific objectives.

1. To determine the composition of fresh wood apple pulp and developed wood apple bar.
2. To assess the storage stability and overall acceptability of processed product at storage condition.

CHAPTER 2

REVIEW OF LITERATURE

CHAPTER 2

REVIEW LITERATURE

2.1 Wood Apple

Wood-apple (*Aeglemarmelos* Correa.) is an indigenous fruit of Bangladesh and belongs to family Rutaceae consisting of 2 or 3 species. Wood apple tree is a medium-sized deciduous tropical tree common to the dry districts of India as well as the dry and (some of the wet) territories of Sri Lanka. It grows throughout the Indian peninsula as well as Bangladesh, Srilanka, Pakistan, Mayenmar, Thailand and most of the South-east Asian countries. It is also popular as bale in Bnagladesh.

Parmar C and Kaushal MK (1982) reported that the average yield is 300-400 fruits per tree. The quality of fruits is greatly associated with the weight and size of the seed-sacs. The larger and heavier the seed sacs, the greater is the amount of mucilage and poorer the quality.

2.2 Chemical Composition

Sharma PC (2007) studied that the pulp contains 0.46 per cent acidity, 8.36 per cent total sugars, 6.21 per cent reducing sugars, 2.04 per cent non-reducing sugars and 0.21 per cent tannins. The pectin content is 2.52 per cent, which is quite high. The fruit pulp, however, is not a good source of vitamin C which is only 920 mg per 100 g of pulp. The author also studied that this fruit is a very good source of protein which is 5.12 per cent of the edible portion. The total mineral content of the edible portion, as represented by ash, is 2.663 per cent. The percentage content of some of the minerals, viz. phosphorus, potassium, calcium, magnesium and iron is 0.137, 0.746, 0.188, 0.127 and 0.007 respectively.

Roy and Mazumdar (1988) observed that wood apple has high nutritional value; fruit pulp contains 2.66% Pectin on fruit weight bases and moisture 64.2%, protein 7.1%, fat 3.7%, minerals 1.9%, fiber 50%, carbohydrates 18.1%, calcium 0.13%, phosphorus 0.11% and iron 0.048% of fruit weight.

Joshi (2004) observed that 100 gm of fruit pulp contains 31 gm of carbohydrate and two gm of protein, which adds up to nearly 140 calories. The ripe fruit is high in beta-

carotene, a precursor of vitamin A. It also contains significant quantities of the B vitamins thiamine and riboflavin, and small amounts of vitamin-C Gopala *et al.* (1974) wood apple contains 61.5 gm water, 1.89 gm protein, 0.39 mg fat, 1.79 mg minerals, 31.8 g carbohydrate, 55 gm carotene, 0.13 mg thiamine, 1.19 mg riboflavin, 1.1 mg niacin and 8 mg vitamin C per 100 gm of edible protein. No other fruit has such a high content of riboflavin. The most therapeutically active principles of wood apple fruit are marmelasin which has been isolated as a colorless crystalline compound.

Shety *et al.* (1999) studied the physic-chemical data on fifteen local strains of wood apple fruit from rahuri. The weight of the fruit, pulp content and rind thickness varied from 173 to 540 gm, 58 to 75.93 cm respectively and the total soluble solid, acidity, total sugar of ripe fruit varied from 14 to 18.5%, 1.04 to 4.5% and 4.7 to 5.0%, 0.46 to 0.63% and 5.37 to 9.04 gm per 100 gm edible protein respectively.

Josly *et al.* (1983) investigated that the effects of length and temperature of storage and relationship of oxygen, light, sugar, pH and ascorbic acid to deteriorative changes in color of these factors. Storage temperature and oxygen content were the most specific for color injury of both juices and isolated pigments. Exposure to light caused little deterioration in color adjustment of acidity within the range of pH 2 to 4.5 or sugar addition had little effect on color retention in fruit juices during storage.

Mita and Bose (1997) studies on post harvest physiology and storage on tropical and subtropical fruits. He showed in his food that tropical and subtropical fruits are becoming increasingly important food items in countries in non-tropical areas. His book deals with the post harvest storage. It should be of particular interest to all horticulture researchers' fruits. It should be particular interest to all horticultural researchers' exports and imports within the interest concerned with tropical and subtropical fruits.

Swamy *et al.* (1993) reported that, he de-shelled the fruit by hand and the pulp with seed are mixed with required quality of water and boiled. Two extractions from the pulp are made. Brix is raised to 13^{O} by addition of sugar from its original brix. The prepared juice after boiling for 30 minutes is filled into cans while it is still hot. The cans are sealed and stored at room temperature for more than 1.5 years.

Barthakur and Arnold (1989) reported that compared orange and grape fruit as reference, the bael fruit contained about 3 times as much TSS and at least 1.5 times as much energy.

The essential and non-essential amino acid contents, bael compared favorably with those in the citrus fruits. Ascorbic acid constituted over 32% of the 17 amino acid analyzed. Out of the 11 minerals studied Fe was found to be 2 times tics as abundant in bael as in either of studied, reference fruits. Zn Cl and Na concentration were also higher in bael. Acid is necessary for the constituent of fruit jam and juices that are deficient in acidity will make food jelly if citric acid is added, provided the proper proportions of pectin and sugar are present.

Rangana and Bajaj (1996) reported that So_2 is widely used throughout the world principally for treating food of plant origin. It is used in the preparation of fruit juices, pulp, beverage and concentrates; concentration used may vary from 350 to 2000 ppm. Soluble sulphite salts (e.g. KMS) are usually used in treating fruits products. The activity is higher at pH below 4.0.

2.3 Medicinal Properties

Ponnachan PTC & Paulose CS (1993) showed that the leaf is used for opthalmia, diabetes, and asthmatic complaints. Unripe fruit is useful for treating diarrhoea, dysentery and stomachalgia. The aqueous extracts of the stem and root bark are used to treat malaria, fever, jaundice, and skin diseases such as ulcers, urticaria, and eczema.

Kar A, Choudhary BK and Bandyopadhyay NG (2003) studied that bael is astringent, cooling, carminative, laxative, restorative and stomachic and is used in dysentery, diarrhoea, flatulence, fever, vomiting and colic. The leaves are astringent, laxative, febrifuge and expectorant and are useful in ophthalmia, deafness, inflammations, diabetes and asthmatic complaints. The tender fruit is bitter, astringent, antilaxative, digestive and promotes digestion and strength, overcomes vata, colics and diarrhoea. The ripe fruits are astringent, sweet, aromatic, cooling, febrifuge, laxative and tonic and are good for the heart and brain. Antidiabetic property, antidiarrhoeal activity, antiulcer activity of seeds, antifungal activity of leaves and antitumour and antimutagenic activity of this plant are clinically evaluated.

Maity P., Hansda D., Bandyopadhyay U. & Mishra D.K (2009) reported that the different parts of Bael are used for various therapeutic purposes, such as for treatment of Asthma, Anaemia, Fractures, Healing of Wounds, Swollen Joints, High Blood Pressure, Jaundice, Diarrhoea Healthy Mind and Brain Typhoid Troubles during Pregnancy.

De Carvalho *et al.* (2007) showed that the medicinal value of Bael fruit is enhanced due to presence of Tannin, the evaporating substance in its rind. The rind contains 20% and the pulp has only 9% of Tannin. This substance helps to cure diabetes. Juice blending is one of the best methods to improve the nutritional quality of the juice. It can improve the vitamin and mineral content depending on the kind and quality of fruits and vegetables used.

Anonymous (1994) studied that the delicious drink is prepared by mixing the fruit with sugar and milk medicinally; the pulp is applied externally on snakebite. Ripe fruits are sweet aromatic, cooling, alternative and nutritive. Unripe or half ripe fruit used for astringent, digestive and stomachic, diarrhea, dysentery. The rind of unripe fruit yields a yellow dye.

Mondal *et al.* (2002) stated wood apple has got high medicinal value. Every part of the fruit has got its medicinal property. The fruit is much used in India as a liver and cardiac tonic and when unripe, as a means of halting diarrhea and dysentery and for effective treatment for hiccough, sore throat and disease of the gums.

Teaotia *et al.* (1963) stated that wood apple has high religious, cultural, nutritional and medicinal value. Ripe fruit has been mentioned to be acid bitters, sweet, aromatic cooling tonic, cardiac, restorative appetizer, pleasantly laxative. It is considered good for heart and brain.

2.4 Fruit Bars

Ahmed (1995) conducted an experiment to develop certain processing techniques in 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, this research was mainly conducted to preserve pineapple juice by bottling, reuse bottle, little or no syrup or additive and processing at water bath temp will certainly result in a low cost processed product. The juice was preserved by various heat treatments with or without KMS (preservatives) in different types of containers.

Jain and Nema (2007) carried out a study to evaluate the quality of the leather from five different cultivars (Red Fleshed, Allahabad Safeda, Lucknow-49, Chittidar, and Apple Colour of guava. Leather quality was also observed using three different recipes for its preparation. The study revealed that organoleptic quality (i.e. color, flavor, taste, texture

and overall acceptability) of leather decreased gradually with increase in the quantity of sugar added. The organoleptic quality of the pulp from Allahabad Safeda was found to be the best among all the cultivars followed by Lucknow-49. The maximum loss in weight was recorded in the leather made from apple colour and minimum in Allahabad Safeda. Mean values of moisture content increase significantly with increase in sugar content of leather. The highest moisture content was observed in leather from red fleshed. In the pulp total soluble solids (TSS) increased significantly with amount of sugar. The highest TSS was observed in Allahabad Safeda and apple color. The leather acidity was affected by cultivars significantly. The maximum mean acidity was observed in leather from Allahabad Safeda and lowest in red fleshed. The acidity of the leather also decreased significantly with increase in sugar content. It was observed that the ascorbic acid content of leather of all cultivars showed decreasing trend with recipes when the sugar content was increased. The statistical analysis showed significant difference in the mean ascorbic acid content of leather due to different recipes.

Orrego *et al.* (2012) studied on the developments and trends in fruit bar production and characterization. Fruits serve as a source of energy, vitamins, minerals, and dietary fiber. One of the barriers in increasing fruit and vegetables consumption is time required to prepare them. Overall, fruit bars have a far greater nutritional value than the fresh fruits because all nutrients are concentrated and, therefore, would be a convenience food assortment to benefit from the health benefits of fruits. The consumers prefer fruit bars that are more tasted followed by proper textural features that could be obtained by establishing the equilibrium of ingredients, the proper choosing of manufacturing stages and the control of the product final moisture content. Fruit bar preparations may include a mixture of pulps, fresh or dried fruit, sugar, binders, and a variety of minor ingredients. Additionally to the conventional steps of manufacturing (pulping, homogenizing, heating, concentrating, and drying), there have been proposed the use of gelled fruit matrices, dried gels or sponges, and extruders as new trends for processing fruit bars. Different single-type dehydration or combined methods include, in order of increasing process time, air-infrared, vacuum and vacuum-microwave drying convective-solar drying, convective drying, and freeze drying are also suggested as alternative to exhibited not only higher retention of antioxidants but also better color, texture, and rehydration capacity. Antioxidant activity resulting from the presence of phenolic compounds in the bars is well established. Besides this, fruit bars are also important

sources of carbohydrates and minerals. Given the wide range of bioactive factors in fresh fruits that are preserved in fruit bars, it is plausible that their uptake consumption have a positive effect in reducing the risk of many diseases.

Byrappa *et al.* (2013) studied on the moisture sorption curves of fruit and nut cereal bar prepared with sugar and sugar substitutes. Low sugar, low fat, dry fruit and nut cereal bars without sugar were prepared using cereals, nuts, and sugar substitutes. The sorption characteristics of the bars prepared with sugar substitutes in comparison with that of sugar were studied by keeping the bars at water activity (a_w) from 0.1 to 0.9. The sorption isotherms of low sugar bars were practically identical below a_w of 0.5 but above a_w of 0.5, a clear differentiation in the isotherms could be observed compared to that of sugar counterpart. A sharp increase in moisture content was observed in the bars prepared with alternative sweeteners, above a_w 0.6, whereas a gradual increase in a_w was observed in the case of bar prepared with sugar. The ERH (Equilibrium relative humidity) value for bar with sugar was 50 %, and for bars prepared with alternative sweeteners, it was about 60 %. Low sugar cereal bar prepared with sorbitol + maltitol (SM) syrup scored higher sensory quality compared to other product prepared with sorbitol + nutriose (SN) as the former retained softness and chewiness on storage. Thus, it was observed that bars with alternative sweeteners will be more stable as their ERH is closer to normal ambient conditions compared to that prepared with sugar.

Jahan and Hossain (2014) reports on the formulation of mixed fruit bar from Mango, Banana and Papaya. The composition of initial all fruits pulp/juice were analysed from moisture, ash, T.S.S. reducing, non reducing sugar, total sugar acidity and ascorbic acid. The pulp and juice of fruits were prepared from ripe and disease free fruits for preparation of bar. We stored the bars for five months. From the study of sensory evaluation, it was observed that there was significant difference in samples of bar. From the results of comparative study, it also observed that the mango rich bars were much better than Papaya and banana rich bars.

CHAPTER 3

MATERIALS AND METHOD

CHAPTER 3

MATERIALS AND METHOD

This chapter deals with materials and methods that were used to conduct the present research work. The materials and methods used to develop wood apple bar are described under the following sub-titles.

3.1 Experimental site

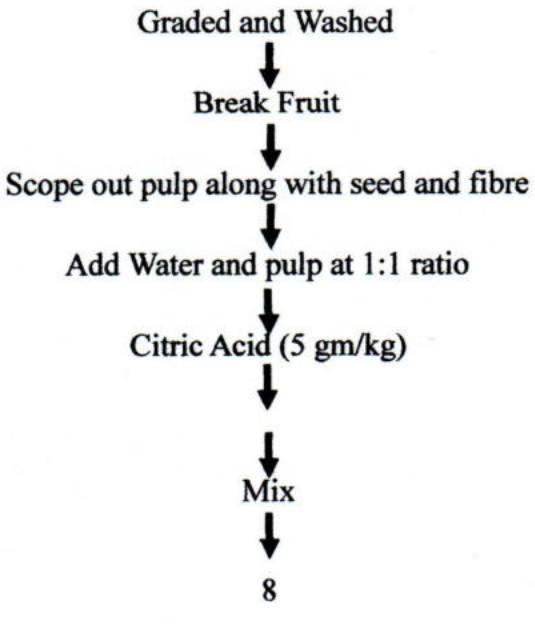
This study was conducted in the laboratories under the Faculty of Engineering, Hajee Mohammad Danesh Science and Technology University. Some physic-chemical analyses were accomplished in the laboratories under the department of Agricultural Chemistry, Hajee Mohammad Danesh Science and Technology University.

3.2 Sample collection

Raw sample wood apple was collected from local market. The wood apples were cleaned with water to remove adhering dirt and soil. The cleaned and washed wood apples were stored at ambient condition for further uses.

3.3 Extraction of wood apple pulp

The cleaned wood apples were broken to collect pulp. The pulp was taken with seed and fibre. Then the pulp was blanched with steam at 70-80°C for 5 minutes. Then the material is sieved through stainless steel sieve and seeds and fibre are removed. The pulp thus obtained is preserved by deep freezing at a temperature of -20°C for future use.



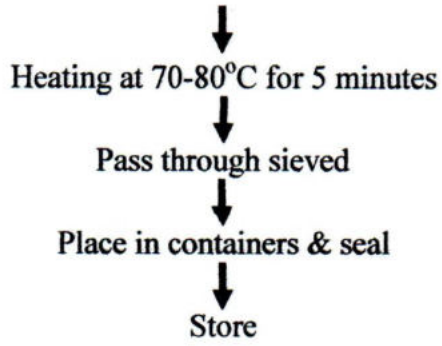


Figure 3.1: Preparation of wood apple Pulp

3.4 Preparation of Wood Apple Bar

The major ingredients of wood apple bar are pulp, sugar and milk. Here is the working flow chart of preparation of wood apple bar.

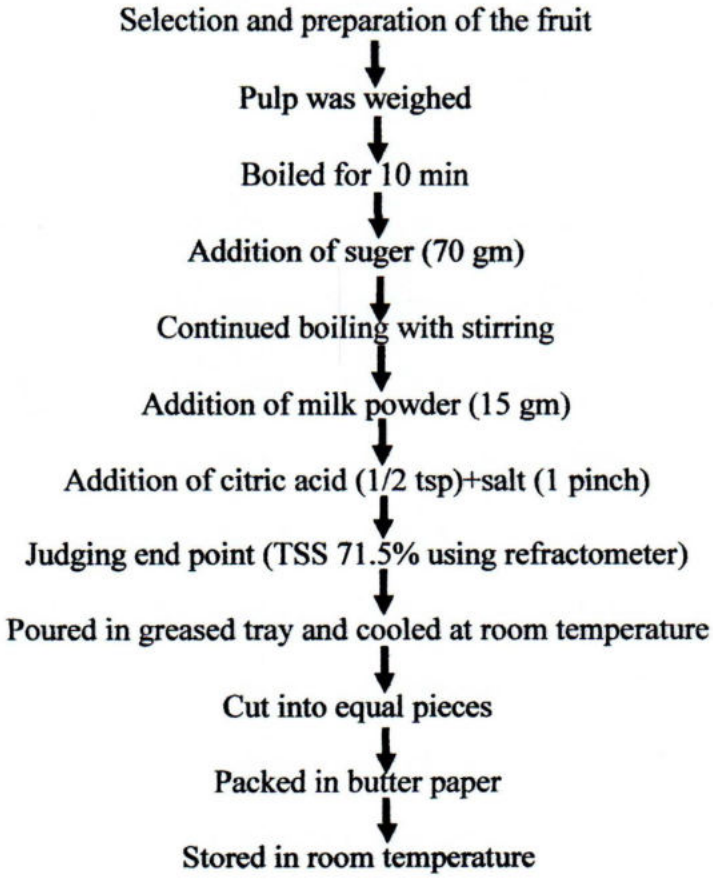


Figure 3.2: Preparation of wood apple bar

Table 3.1 Basic Formulation for Preparation of Wood Apple Bar

Ingredient Used	Number of Combination		
	S1	S2	S3
Wood Apple Pulp			
Sugar	70 g	70 g	70 g
Powder Milk	20 g	20 g	20 g
Hydrogenated Fat	10 g	10 g	10 g
Citric Acid	½ tsp	½ tsp	½ tsp
Salt	1 pinch	1 pinch	1 pinch
CMC	0.1 g	0.1 g	0.1 g

3.5 Physico-chemical characteristics of fruit bar

In the present investigation certain physico-chemical properties of the developed wood apple fruit bar were analysed, to ensure the quality of the products.

3.5.1 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°C 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.

3.5.2Acidity

Titration

10ml pulp/juice was taken in a 100m1 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

3.5.3 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 were read directly from the refractometer.

3.5.4 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 PH of the solution indicated by the instrument (potentiometer).

3.5.5 Vitamin-C content (Ascorbic acid)

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

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

Ascorbic acid standard: Weigh accurately 100 mg of L ascorbic acid and make up to 100 ml with 3% HP03. Dilute 10 ml to 100 ml with 3% HPO3 mg =0.3 mg of ascorbic acid.

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 every day. 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 HPO3. 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% HP03 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:

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

3.5.6 Protein

For estimation of protein, the steps were followed:

Digestion: Two gram sample, 2gm digestion mixture and 25 ml H2SO4 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 blltzwere 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

3.5.7 Reducing sugar

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

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:

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

Where,

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

D = dilution factor

T = titration

W = weight of sample

3.5.8 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

3.5.9 Estimation of total sugar

Total sugar can be calculated as follows:

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

3.6 Sensory Evaluation

A panel of 30 members consisting of teachers, staff and students of university evaluated the products. Prior to sensory evaluation the samples were coded using random three-digit numbers and each sample was served, with the order of presentation counter balanced. Panellists were provided with a glass of water and, instructed to rinse their palate with water and drink water between samples.

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.

3.7 Studies on storage stability of wood apple bar

The mixed fruit bar samples were packed in sealed high density polythene coated with aluminium foil. The samples were stored at two temperature such as room temperature (21-32°C) and refrigerated temperature (30C) for 60 days. Moisture uptakes by samples in the above packaging systems were determined at every 15 days interval gravimetrically.

3.8 Statistical analysis

In the experiment, data obtained from various treatments were statistically analyzed using SPSS 20 software. One-way analysis of variance (ANOVA) was used to determine the significance of difference between the means of data obtained from panellists. Least significant difference (LSD) test at 1% and 5% levels of probability and Duncan Multiple Range Test (DMRT) were used to compare the significance of difference between pair of means.

CHAPTER 4

RESULTS AND DISCUSSION

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4.1 Composition of Fresh Wood Apple

Fresh wood apple was analyzed for its proximate composition. The result is tabulated below in Table 4.1.

Table 4.1 Composition of Wood Apple

Parameter	Wood Apple
Moisture (%)	65
Ash (%)	0.2
Protein (%)	6.57
TSS (%)	19
Total Sugar (%)	12.65
Reducing Sugar (%)	2.15
Vitamin C (mg/100g)	3.2
Acidity (%)	2.94

The above chemical composition shows that wood apple contain 65.00 % moisture, 2.15 % reducing sugar, 6.57 % Protein, 12.65 % total sugar, 0.20 % total ash, 2.94 % acidity, 3.2 mg per 100 gm vitamin C.

These chemical components of fresh wood apple are more or less similar to that reported by Sharma PC (2007). He reported that wood apple contained 64.20% moisture, 3.5% pectin, 2.1% reducing sugar, 7.10% Protein, 5.10% non-reducing sugar, 7.20% total sugar, 0.30% total ash, 2.30% acidity, 3mg per 100gm vitamin C. This study may be due to the varietals difference, soil nutrients and composition of the growing area.

4.2 Composition of Wood Apple Bar

The composition of Wood Apple bars prepared from of Wood Apple was analyzed for moisture, ash, acidity vitamin C, total sugar, protein. The results are presented in Table 4.2.

Table 4.2 Composition of Wood Apple Bar

Parameter	Sample		
	S_1	S_2	S_3
Moisture (%)	13.25	13.55	14.03
Ash (%)	4.85	4.90	4.70
Acidity (%)	1.80	1.75	1.85
TSS (^{o} Brix)	71.6	71.5	71.6
Total Sugar (mg/100g)	45.60	46.15	45.85
Reducing Sugar (mg/100g)	8.55	8.75	8.60
Vitamin C (mg/100g)	1.75	1.71	1.81
Protein	7.75	7.85	7.86

Table 4.2 revealed that moisture content 13.25%, 13.55% and 14.03% were found in sample S_1, S_2, and S_3 respectively. The moisture content is important consideration for bar storage and shelf-life. These results were more or less similar to results carried out by P. Karmoker (2009) who found highest moisture content (11.92%) in mixed fruit bar.

In case of protein, sample S_3 contained the highest amount of protein (7.86) and sampleS_1 contained lowest level of protein (7.75). Protein content in this study was in contrast to result found by P. Karmoker (2009). He found protein content (0.3%) in mixed fruit bar made with mango, pineapple and papaya. It might be resulted because wood apple bar contained milk powder.

Data showed that sample S_3 was scored with highest amount of vitamin C (1.81mg/100g) and sample S_2 was scored with lowest value of vitamin C (1.71mg/100g). Vitamin C content in wood apple bar was very less than the result (19.44mg/100g) observed by P. Karmoker (2009). One of the possible reasons of this result is less vitamin c content in wood apple pulp and processing lost.

Result showed in Table 4.2 indicated that sample S_2 posed the highest amount (4.90%) and sample S_3 had lowest level (4.70%) of ash, whereas sample S_1 contained ash (4.85%). Ash content in developed bar was higher than the ash content (1.13%) in mixed fruit bar found by P. Karmoker (2009).

Sample S_2 contained the highest amount of total sugar (46.15) and Sample S_1 contained lowest level (45.60). However, sample S_3contained the highest amount of reducing sugar (8.60) and sample S_1 contained lowest level (8.55). Sample S_3 contained highest amount of acidity (1.85) and sample S_2 had the lowest level (1.75).

4.3 Storage studies of Wood Apple 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.

4.3.1 Effect of storage time and temperature on the moisture content of Wood Apple bar

This study was conducted to assess the effect of storage time (60 days) and temperature (room temperature 21-32°C and refrigeration temperature 3°C). As we can be seen from Appendix 1 (Table 1.1) that the initial moisture content of wood apple bar were 13.25%, 13.55% and 14.03%in sample S_1, S_2 and S_3 respectively. The moisture content in wood apple bar at ambient temperature (21-32°C) were increased from 13.25% to 17.03%, 13.55% to 17.20% and 14.03% to 18.29% for sample S_1, S_2 and S_3 respectively during 60 days. The increase in moisture content was also reported by Anju *et al.* (2014) who observed highest moisture content (25.21%) and lowest moisture content (20.66%) in peach-soy leather after four months of storage study at ambient condition. The increase in moisture content was due to high humidity in room condition.

On the other hand the moisture content of wood apple bar at refrigeration temperature (3°C) were also increased from 13.25% to 14.20%, 13.55% to 15.50% and 14.03% to 15.20% for sample S_1, S_2 and S_3 respectively during 60 days. The results are shown in Appendix 1 (Table 1.2). The increase rate of moisture content in bar samples stored at refrigeration condition was less than the rate observed in ambient condition because of less humidity in refrigeration condition.

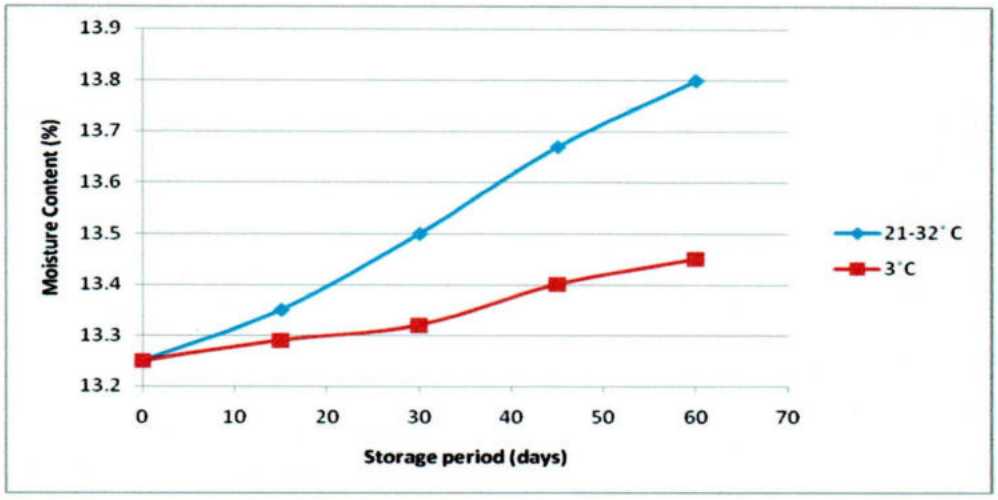

Figure 4.1: Effect of storage time and temperature on the moisture content of Wood Apple bar (S_1)

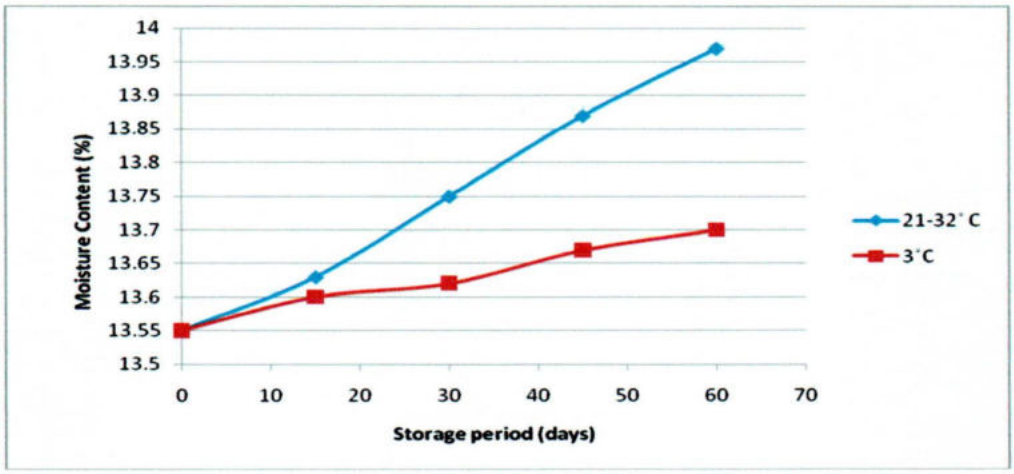

Figure 4.2: Effect of storage time and temperature on the moisture content of Wood Apple bar (S_2)

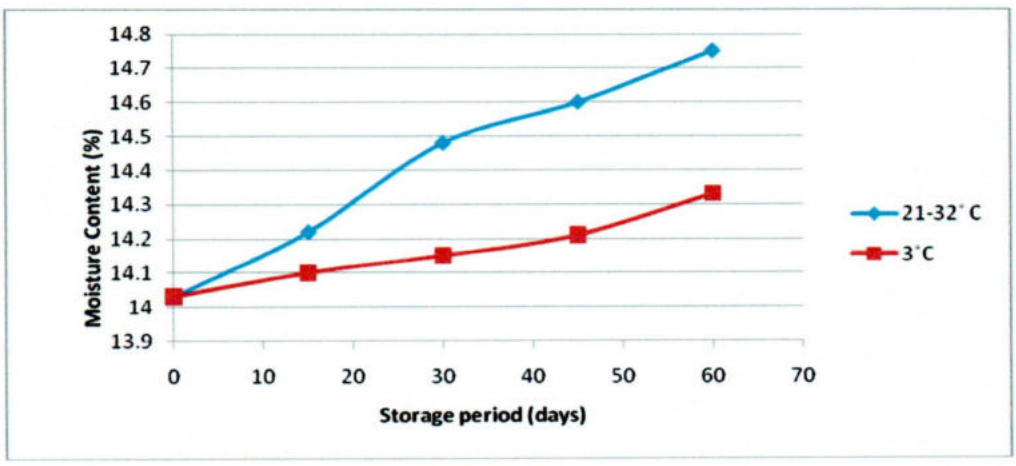

Figure 4.3: Effect of storage time and temperature on the moisture content of Wood Apple bar (S_3)

4.4 Sensory Analysis

Presented data in Table in 4.3 revealed that highest score of 7.61 for colour was found in sample S_2 and sample S_3 was marked with lowest score of 6.15, whereas S_1 was scored with 6.38.This variation in colour indicated that S_2 sample was most appealing.

Results also revealed that there was no significant difference in flavour of wood apple bar samples. In case of flavour, sample S_1 and S_3 contained the highest score (6.46) and lowest score in (6.15) in sample S_2.

Significant difference in taste was not found in wood apple bar samples. However, sample S_1 scored with highest value (6.54) in case of taste and lowest score (6.38) was found in sample S_3.

Texture of bar is greatly depends on the fruit pulp. Highest score (7.00) for texture is for sample S_2 and lowest score (5.53) is for sample S_3 where sample S_3 contained maximum amount wood apple pulp. This result indicates that using high amount of fruit pulp would not result consistent texture of fruit bar.

However, data for overall acceptability indicated that there was no significant difference among three samples of wood apple bar. All three samples were equally accepted but highest score 7.07 were recorded for sample S_2 and lowest value 6.15 was found in sample S_3.

Table 4.3 Sensory analysis of developed bar

Sample	Color	Flavor	Taste	Texture	Overall acceptability
S_1	6.38 ± 1.32^b	6.46 ± 0.43^a	6.54 ± 1.13^a	6.61 ± 0.96^a	6.61 ± 1.26^a
S_2	7.61 ± 0.96^a	6.15 ± 0.45^a	6.53 ± 1.20^a	7.00 ± 1.08^a	7.07 ± 0.95^a
S_3	6.15 ± 1.28^b	6.46 ± 0.43^a	6.38 ± 1.39^a	5.53 ± 1.61^b	6.15 ± 1.21^a

* S_1= Bar with 50 gm pulp

S_2= Bar with 75 gm pulp

S_3= Bar with 100 gm pulp

CHAPTER 5

SUMMARY AND CONCLUSION

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SUMMARY AND CONCLUSION

The result of the study indicates the possibility of production of wood apple bar based confection with standard quality. It was observe that there was satisfactory consumer acceptability for the wood apple bar. From the point of nutritional composition, this product can be considered as a functional food for healthy life. According to the moisture adsorption properties, this product should be packed in moisture proof packaging materials at ambient temperature conditions which will help to extend the product's shelf life to more than two months.

Further study can be carried out to increase the self- life of wood apple bar. Wood apple is seasonal fruit but its production is increase day by day in Bangladesh. Anyone can create the income source by starting small business with wood apple bar.

However, it can be concluded that making bar would be possible use of wood apple that may greatly contribute to enhance socio-economic of Bangladesh.

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APPENDIX

APPENDIX

Appendix 1 Moisture content uptake during storage

Table 1.1 Moisture content (% wet basis) of Wood Apple bar stored in double layer high density polythene coated with aluminum foil at 21-320C temperature

Days	Moisture Content (%)		
	S_1	S_2	S_3
0	13.25	13.55	14.03
15	13.35	13.63	14.22
30	13.50	13.75	14.48
45	13.67	13.87	14.60
60	13.80	13.97	14.75

Table 1.2 Moisture content (% wet basis) of Wood Apple bar stored in double layer high density polythene coated with Aluminum foil at 3^0C temperature

Days	Moisture Content (%)		
	S_1	S_2	S_3
0	13.25	13.55	14.03
15	13.29	13.60	14.10
30	13.32	13.62	14.15
45	13.40	13.67	14.21
60	13.45	13.70	14.33

Appendix 2 Statistical Analysis for sensory evaluation

Table 2.1 Analysis of Variance (ANOVA) of Color

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	16.462[a]	3	5.487	4.196	.010
Intercept	2382.769	1	2382.769	1822.118	.000
Sample	16.462	3	5.487	4.196	.010
Error	62.769	48	1.308		
Total	2462.000	52			
Corrected Total	79.231	51			

Table 2.2 Duncan's Multiple Range Test (DMRT) Value for Color

	Sample	N	Subset	
			1	2
Duncan[a,b]	S_3	13	6.1538	
	S_1	13	6.3846	
	S_2	13		7.6154
	Sig.		.111	.129

LSD = 0.23; P<0.05

Table 2.3 Analysis of Variance (ANOVA) for Flavor

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.923[a]	3	1.308	.555	.647
Intercept	2197.000	1	2197.000	932.604	.000
Sample	3.923	3	1.308	.555	.647
Error	113.077	48	2.356		
Total	2314.000	52			
Corrected Total	117.000	51			

Table 2.4 Duncan's Multiple Range Test (DMRT) Value for Flavor

	Sample	N	Subset
			1
Duncan[a,b]	S_2	13	6.1538
	S_1	13	6.4615
	S_3	13	6.4615
	Sig.		.252

LSD = 0.00; P<0.05

Table 2.5 Analysis of Variance (ANOVA) for Taste

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.846[a]	3	1.282	.784	.509
Intercept	2275.692	1	2275.692	1392.188	.000
Sample	3.846	3	1.282	.784	.509
Error	78.462	48	1.635		
Total	2358.000	52			
Corrected Total	82.308	51			

Table 2.6 Duncan's Multiple Range Test (DMRT) Value for Taste

Taste			
	Sample	N	Subset
			1
Duncan[a,b]	S_3	13	6.3846
	S_2	13	6.4615
	S_1	13	6.5385
	Sig.		.216

LSD = 0.07; P<0.05

Table 2.7 Analysis of Variance (ANOVA) for Texture

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	19.596[a]	3	6.532	4.402	.008
Intercept	2236.173	1	2236.173	1506.881	.000
Sample	19.596	3	6.532	4.402	.008
Error	71.231	48	1.484		
Total	2327.000	52			
Corrected Total	90.827	51			

Table 2.8 Duncan's Multiple Range Test (DMRT) Value for Texture

	Sample	N	Subset	
			1	2
Duncan[a,b]	S_3	13	5.5385	
	S_1	13		6.6154
	S_2	13		7.0000
	Sig.		1.000	.369

LSD = 0.38; P<0.05

Table 2.9 Analysis of Variance (ANOVA) for Overall Acceptability

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6.981[a]	3	2.327	1.650	.190
Intercept	2342.327	1	2342.327	1660.923	.000
Sample	6.981	3	2.327	1.650	.190
Error	67.692	48	1.410		
Total	2417.000	52			
Corrected Total	74.673	51			

Table 2.10 Duncan's Multiple Range Test (DMRT) Value for Overall Acceptability

	Sample	N	Subset
			1
Duncan[a,b]	S_3	13	6.1538
	S_1	13	6.6154
	S_2	13	7.0769
	Sig.		.075

LSD = 0.46; P<0.05