A STUDY ON PREPARATION AND PRESERVATION OF JACKFRUIT JUICE

A THESIS

BY

TONMOY KUMAR DEY
Student No. 1105035
Session: 2011-2012
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 requirement for the degree of

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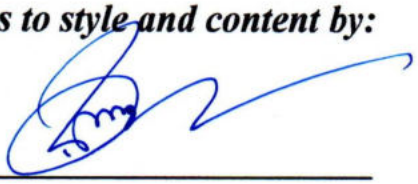

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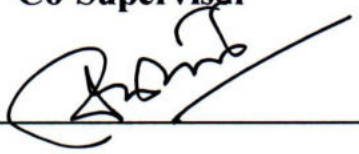

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DEPARTMENT OF FOOD ENGINEERING AND TECHNOLOGY
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR

JUNE, 2012


DEDICATED TO
MY BELOVED PARENTS

ACKNOWLEDGEMENT

I would like to thank the "Almighty Allah" Who has enabled me to complete the research work and to prepare this research in partial fulfillment of the requirements for the degree of master of science in food engineering and technology and as well as to submit this research work in due time by keeping me fit.

I would like to express my gratitude, regard and indebtedness to the supervisor Prof. Md. Ruhul Amin Department of Agricultural and Industrial Engineering , Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur for his scholastic guidance, restless inspiration, valuable advice and untiring assistance in all phases of the research work and in the preparation of the thesis paper.

I would like to express my cordial gratitude, regard and deep appreciation to the Co–supervisor Prof. Dr. Mohammad.Shiddiqur Rahman, Department of Agricultural and Industrial Engineering, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur for his scholastic guidance, restless inspiration, valuable advice and untiring assistance.

I am grateful to my beloved teachers Dr.Maruf Ahmed Prof. Department of Food processing and preservation, Md.Mojaffor Hosain Lecturer Department of Food processing and preservation, Md.Raihanul Haque Lecturer Department of Food Engineering and Technology, Md. Aslam Ali Assistant prof. Department of Food Science and Nutrition, Habiba Khatun Lecturer Department of Food Science and Nutrition and all the teachers and staff of Agro-Industrial and Food Process Engineering Faculty, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur for their valuable cooperation and help during conducting the research work.

Finally, I express my heartily gratitude and indebtedness to my parents, brothers, sisters and relatives for their patience and sacrifice and also to friends who helped us directly or indirectly in the preparation of the thesis paper.

JUNE, 2012 ***The Author***

ABSTRACT

The study was conducted to find out the processing and preservation techniques and to evaluate the sensory attributes of the prepared jackfruit juice to have a good quality jackfruit juice and to make the availability of jackfruit products all the year round. The pulp was prepared from mature, sound and ripe jackfruit. Calculated amount of sugar and citric acid were mixed with required amount of fresh water and boiled for 3 to 5 minutes to make the syrup. To prepare juice, the syrup was mixed with the required amount of pulp and cooled down to about 28^0C to 30^0C temperature and potassium metabisulphite (KMS) at the rate of 0.6 gm was added to it and mixed thoroughly. The finished products were kept into clean, dry and sterilized glass bottles and then they were seamed properly. The seamed bottles were stored in cool and dry places. The samples were analyzed for proximate composition and sensory evaluation was done to detect the best sample and sample differences. The colour, flavor, sweetness, texture, and overall acceptability of juice were evaluated by a panel of ten judges. The results revealed that the color, flavor, texture, and overall acceptability were the best in sample S_2. The best sample contained 300 gm juice, sugar-90 gm, citric acid-2.5 gm, KMS-0.6 gm, CMC-1.0 gm and water-605.9 gm for each 1000 gm of juice. The juice did not show any change in quality attributes during the storage period till 2 to 4 months. To get the shelf stable, nutritious and good quality jackfruit juice it should be prepared by taking 300 gm juice, sugar-90 gm, citric acid-2.5 gm, KMS-0.6 gm, CMC-1.0 gm and water-605.9 gm for each 1000 gm of juice and also should be preserved for maximum 4 months at refrigerated temperature.

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LIST OF ABREVIATION

CMC	Carboxyl Methyl Cellulose
KMS	Potassium-meta-bisulphate
CFTRI	Central Food Technology Research Institute
TS	Total Solid
TSS	Total Soluble Solid
$NHSO_4$	Sodium meta- bisulphate
AOAC	Association of Official Analytical Chemistry
BBS	Bangladesh Bureau of Statistics
ANOVA	Analysis of Variance for Overall Acceptability
DMRT	Duncan Multiple Range Test
pH	Hydrogen Ion Concentration

CHAPTER I
INTRODUCTION

CHAPTER I

INTRODUCTION

Jackfruit (*Artocarpus heterophyllus Lam*) is one of the underutilized fruits belonging to the family Moraceae and is the largest edible fruit in the plant kingdom and occupies the top most rank with respect to quantity of food produced per unit area. Jackfruit tree is native to Bangladesh and popular in several tropical and subtropical countries.

To utilize the delicious and nutritious fruit is "Jackfruit" in the form of beverage (juice). Juice may be defined as the liquid foods which are consumed in a liquid state to quench the thirst. Fruit juices are products for direct consumption and are obtained by the extraction of cellular juice from fruit. This operation can be done by pressing or by diffusion.

The jackfruit is one of the most popular and indigenous fruit crop in Bangladesh. It is considered to be the largest fruit in the World (Naik, 1949 and Sturrock, 1959). Originally native to the Indian sub-continent, the jackfruit is now widely cultivated throughout the tropical low lands of both hemispheres (Ochse *et al.*, 1981). It is considered to be the largest fruit in the world and cultivated throughout India, Burma, Ceylon, Malaya, Southern China and East Indies and to a limited extend in Queensland (Australia) and Mauritius (Ahmed, 1959). In Bangladesh, the jackfruit occupies 65905 acres of land having an annual production of 266835 M. tons (BBS, 1998). It ranks next to mango and banana in total average and annual production. The leading districts are Mymensingh, Dhaka, Rangpur, Sylhet, Dinajpur, Khulna, Rajshahi, Kushtia and Tangail although it is grown throughout the country (Ahmed, 1976).

Jackfruit is available generally during the summer months. Main harvesting period in Bangladesh is May to August. Only a small percentage of the fruits are processed and preserved by housewives and small processors by the traditional methods of food processing and preservation. Jam, jelly, squash, nectar, candies, conserves, beverage etc. can be prepared from jackfruit pulp (Tressler and Joslyn, 1971).

The crop is seasonal in nature and is available in large quantity during the pick season. But jackfruit is a perishable food item and cannot be preserved naturally for long time after harvesting. In relation to food, Bangladesh has two major problems: one is the food deficit and other is post harvest losses. The farmers could be encouraged for increasing production if spoilage could be prevented by proper preservation, which could result in increased and balanced consumption. Moreover, substantial amount of foreign exchange could be earned by exporting fresh and processed products.

Form the prevailing condition it seems that the lack of suitable preservation methods is a major factor contributing to the primary limitation to production and consumption of increased amount of fruits.

In developed countries, the processing and preservation of food have taken the form of commercial food industries where sophisticated techniques and equipments are being applied. But at present, there is dearth skilled manpower, machineries and capital to establish modem processing industries in Bangladesh.

In view of the above mentioned limitations and the prevailing socio-economic conditions, one has to start from low cost labour intensive technologies for food preservation in a small scale at the first instance and then gradually shift towards large scale industrialization. Thus developing a processed product in Bangladesh should involve a simple and inexpensive process and the developed product should not involve major changes in food habits. The important role of fruits and fruit products in nutrition and economy of Bangladesh is now generally recognized. Lack of knowledge of nutritional qualities of fruits, its processing technique as well as industrial feasibility of the production of agro-based beverage suggested the area of research.

Objectives:

The research work, therefore, had been undertaken to study the following Objectives:

1. To extract jackfruit juices and to observe proximate composition of the juices.
2. To find out suitable formulations for the jackfruit based juice (soft drinks).
3. Microbiological study of the bottled jackfruit juices and to observe the overall acceptability of the formulations.

CHAPTER II
REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Jackfruit is one of the most important tropical fruits, a very little study has so far been made on jackfruit processing, preservation and storage in Bangladesh to prevent seasonal glut and to ensure the availability of this favorite fruit throughout the year. A review of the available informations relating to the present study is given here.

2.1 Nutritive value

The jackfruit significantly contributes to the nutrition of the people of this country as a source of vitamins, minerals and calories. It is known to contain very high amount of carotene (precursor of vitamin A) which is converted into vitamin A in the body and prevents blindness of the children. It is estimated that around 30,000 children become blind every year due to vitamin A deficiency only in Bangladesh. Its calorific value is quite high, being 88 kilo calories per 100 gm of edible portion (Khanom *et al.*, 1994).

Bhatia *et al.*, (1955) found 7.78 milligrams ascorbic acid per hundred grams of jackfruit pulp on dry weight basis.

Kamaluddin (1967) mentioned that the carotene of jackfruit to be 324 micrograms (540 I. U.) per 100 gms of bulb where as Bhatia *el at.* (1955) found it 16.22 microgram per 100 gms on moisture free basis. Bhatia *et al* (1955) and Purseglove (1968) reported the ash content of the bulb of jackfruit to be 0.5 and 3.57 per cent respectively.

Words and Aurand (1977) reported that ascorbic acid (vitamin-C) was very susceptible to oxidation. Its destruction was accelerated by alkalis, iron and copper salt, heat, oxidation enzymes, air and light. It is readily preserved in acid media, but it disappeared rapidly when heated in neutral and alkaline media, certain respiratory enzymes destroyed ascorbic acid and as a result. Less of vitamin-C during fresh storage of fruit and vegetables might be considerable.

Ahmed *et al.*, (1988) reported that retention, of ascorbic acid was higher and sensory quality characteristics were better in sulphite-treated (0.06% potassium metabisulphite) citrus squash than preserved by benzoic or sorbic acid. Storage of citrus squash in fluorescent light deteriorated its quality coloured glass bottle in retaining

ascorbic acid and other quality indices citrus squash than uncoloured or pvc bottles. Replacement of sucrose with liquid glucose at ≤25% had no significant adverse effect of mango squash.

Salda *et al.*, (1976) studied a beverage prepared from the combination of carrot juice, carrot puree, whole orange puree, grape fruit and pineapple juices, lemon juice concentration, sugar, citric acid, ascorbic acid, artificial pineapple and orange flavour. The beverage was stored at 20°C for 9 monhs. Analytical determination for pH, acidity, °Brix, B-carotene and ascorbic acid, colour and flavour evaluation were made at an intreval 0, l, 2, and 4 months. The major nutrient loss during, processing and storage was ascorbic acid. Storage time had no effect on other quality factors.

Tressler *et al.*, (1961) reported the photochemical decomposition of ascorbic acid in black current syrup was accompanied by a loss of colour and suggested that the pigment of the juice may act as a protective agent for the vitamin.

B.S.F.I.C (1977) revealed that about 17 fruits and vegetables processing industries are producing a number of items of processed fruits. Most of them are producing jam, jelly, chatney, squash, sauce, pickles, syrups etc. None of these industries are producing any carbonated beverage based on fruit juice or fruit pulp. A few beverage industries are producing carbonated beverage based on synthetic colour and flavour. The raw materials are imported an abroad in a concentrated liquid form in exchange of valuable foreign currency. This produces low-calorie beverages with negligible nutritional value. Thus, it is obvious that if any fruit is utilized as raw materials by these local beverage industries, products with a noticeable calorific as well as nutritional value could be prepared. Moreover, it will save a greater portion of the foreign exchange in this regard.

2.2 Chemical composition

In the past only limited workers reported the chemical composition of jackfruit. The reported results on the moisture, total sugar, reducing sugar, non-reducing sugar, ascorbic acid, carotene and ash contents varied greatly over a wide range. Some workers reported that the moisture contents of the jackfruit pulps were 72.0, 72.51 and 81.80 percent (Purseglove *et al.* 1968).

Bhatia *el al.*, recorded the dry matter accumulated in the different types of jackfruit was 26.90, 27.49, 18.92 and 22.8 percent respectively (Bhatia *et al.* 1955). They also studied the total sugar content of the bulb of jackfruit on moisture free basis was 75.04 percent, while Sturrock (Sturrock, D. 1959) reported it to be 15.15 percent on fresh weight basis.

Setty *el al.*, (1978) reported that a ready to beverage could be prepared having pulp content 10%, refractometer solids 20% and acidity 0.3%. Hossain *et al.* (1979) determined biochemical constituents of ten different types of Bangladeshi Jackfruit (Table 2.1). There was variation in the contents of moisture, ash sugar, ascorbic acid carotene among the types.

Table 2.1. Average Contents of Moisture, Ash, Sugar, Ascorbic Acid and carotene of Ten Types of Ripe Fruit (Fresh weight Basis).

Moisture (%)	76.37	**Ascorbic Acid (mg/100gm)**	5.56
Total ash (%)	1.10	**Total carotene (mg/100gm)**	765.79
Total sugar (%)	19.26		

The pH of different types of jackfruit was in the range between 5.20 to 6.20.

Nakatoh *et al.*, (1985) found that summer fruits and juice had higher TSS and lower acidity and ascorbic acid and ash contents than winter fruits. The NO_3-N content of the apex and peduncle portions wits 17 times than that of the flesh, and peduncle portion was richest in TSS. The juice from peeled fruits was superior to that whole fruits in sensory tests.

Flaumenbaum and Shengeliya (1974) reported that the taste of sweetened fruit juice depends upon the sugar / juice / acid ratio. Minimum sugar content should be 18% acidity 0.8-1.5% and the sugar / acid ratio 20-29.

2.3 Jackfruit Products

Jackfruit is a non-seasonal tropical fruit, consumer and preserved in various forms. The drying of the fruit to make leathers is a convenient method of marketing the fruit as confectionery. The marketing trials of the product among 230 teenagers in Malaysia during 1995, Jackfruit leather were well received by the urban Malaysian teenage group, but they had low awareness of fruit leather products. There might be significant market potential for jackfruit leather, depending on price, packaging, marketing and distribution (Man and Sanny, 1997).

The central Food Technological Research Institute (C.F.T.R.I) proposed a recipe for the preparation of a jackfruit necter as follows. Jackfruit pulp l0 lb; water 15 lb; sugar 22.5 lb citric acid 7.5 lb and potassium meta-bisulphite (KMS) at the rate of I ounce per hundred pounds of finished product (C.F.T.R.I, 1959).

Siddappa and Bhatia (1952) reported that the edible bulbs form only 25-30% of the whole fruit, and that the rind, which contains about 8% sugar, and the undeveloped bulbs, but not the gummy core, can be used in the preparation of a jelly of good consistency, taste, and aroma. A little citric acid is added to the water in which the rind is boiled, and more may be added later. A palatable beverage concentrate may be made from l0 lb. Of pulp, 22.5 lb. of sugar, 7.5 lb. of citric acid, and 15 lb. of water (Anon., l954e). After cooking, the mixture is mashed and strained and may be preserved by adding an ounce of potassium metabisulphite per 100 lb.

Hoque and Biswas (1989) reported that the pulp was prepared from the mature, sound and ripe sweetgourd. Calculated amount of sugar and citric acid were mixed with fresh water and boiled for about 3 to 5 minutes to make the syrup. To prepare nectar the syrup was mixed with the pulp and cooled down to about 28 to 30^0C and KMS was added to it and mixed thoroughly. Various amounts of essences were added with some samples of nectars.

Pulp from jackfruit (Artocarpus integrifolia) bulb was analyzed for its composition and the pulp was used to develop nectars of different formulae.

Required amounts of sugar, citric acid and water were mixed and boiled 3 to 5 min. to prepare the syrups. The prepared syrup was filtered through cheese cloth. Then the syrup and pulp were mixed thoroughly and heated to about 95"C for 3 min. to obtain

the desired nectar. The prepared nectars were cooled down to about 28 to 30"C and then required amount of potassium metabisulphite (KMS) was added thoroughly by a waring blender. The prepared nectars were then filled into sterilized bottles of 750 ml capacity and then the bottles were corked airtight. The final products were then stored in the laboratory at room temperature (Hoque *et al.*,1995).

2.4 Microbiology

Anonymous (1984) reported that it was necessary immediately after extraction to pasteurize cloudy juices in order to stabilize them and to prevent microbial and enzymatic breakdown.

Paffen (1976) reported that the poor keeping quality was due to inadequate mixing of the fruit juice concentrate; failure to dilute the concentrate before the addition of the sugar syrup. Growth of yeast (resulting the fermentation of beverages and/or off flavour formation); spoilage by bacteria (specially 'Leuconostoc' and Acetobacter spp.); and growth of mould (with special reference to adverse effect of pectinase forming spp. on the appearance of turbid beverages.

Weiser *et al.*, (1971) reported in their books that the microbiology of fresh fruits is interesting because the normal flora present on the fruit may be involved in spoilage of the product later. Moreover, the possibility of the presence of pathogenic organisms may be significant for public health. The fruits are eaten raw without washing or sterilizing. Lastly, many of the organisms present may be desirable if the juices of the fruit are to be fermented. As a rule molds and yeast rather than bacteria are largely responsible for much of the spoilage in fruits.

2.5 Preservation

For preservation of green jackfruit bulbs 1 to 10% salt solution (brine) were used and pH was maintained below 3.5. In case of ripe jackfruit bulbs preserved in 20% -55% sugar solution and pH was maintained below 3.3. Powder was prepared from jackfruit pulp by heat treatment at 60°C for about 5 hrs. Jam and jelly were prepared from reconstituted jackfruit powder. The components of jam/jelly were; powder-8.1%/2.025%, water-36.9%/52.975%, sugar-55%/45%, pectin-0.4%/0.5% and citric acid-0.5%/0.5%. Jack vita was prepared from jackfruit powder. The ingredients of jack-

vita were; jackfruit powder 2-10%, dextrose 18%, vitamin-C 10mg/100gm, acid 0.2%. Jam (control) and jelly (control) were also prepared from jackfruit pulp and juice respectively (Hoque, 1994).

Pasteurization of juice can be done for temporary preservation (pre- pasteurization) and in this case this operation is carried out with continuous equipment (heat exchangers, etc.); warm juice is stored in drums or large size receptacles (20-30 kg). Pasteurization conditions are at 75°C in continuous stream. Pasteurization of bottles juice is then carried out just before delivery to the market; this is performed in water baths at 75°C until the point where the juice reaches 68°C. In cases when the final pasteurization is done without pre- pasteurization and temporary storage, modern methods use a rapid pasteurization followed by aseptic tilling in receptacles (Mircea, 1995).

Siddappa (1951) reported that the bulbs have been successfully canned in syrup.

According to Siddappa (1954) and Bhatia examined over a period of three years, a large number of cans were prepared using covering syrup with acid content varying from 0.15% to 1% and the pH of cutout syrups were recorded during storage. They concluded the following-

i) Additioning of 0.15% citric acid to syrup is not safe for ordinary processing (pH 4.80-4.95).

ii) 0.5% acidity in syrup is better but still not safe for general use (pH 4.50-4.64)

iii) 0.75% acidity or 1% acid in syrup is safe for processing in boiling water (p^H 4.15-4.45)

iv) In order that the product may not taste acid the strength of syrup used should be 40-50 ^{0}Brix.

As a result a systematic study, it has been shown that addition of 0.75 to 1% citric acid to the canning or bottling syrup is necessary to bring the canned or bottled jackfruit below 4.5, thus making safe for processing in bottling water for 30 minutes.

Two local cultivars of jackfruit (*Artocarpus heterophyllus*), one with a crisp, hard flesh and one with a soft flesh were harvested ripe and then processed in different ways to investigate the best method for long term preservation. The fruit was either cut up,

bottled in sugar syrup (40 ^{0}Brix) with 0.5% citric acid and boiled for 30 min to sterilize, pulped with sugar and acidified water and bottled, or dried to a constant weight in a hot oven at 60°C and sealed in polyethylene bags. Acceptability (appearance, texture, flavour and taste) of the preserved fruit was assessed after 3, 6 and 9 months. Dehydration was the best method of storage for 9 months, for both cultivars, followed by preservation with sugar. Bottling was suitable for the hard cultivar but the soft cultivar could only be bottled for 3 months (Nandini *et al.*,1998).

2.6 Storage

Joslyn *et al.*, (1961) investigated that the effects of length and temperature of storage and the relationship of oxygen, light, sugar, pH and ascorbic acid to deteriorative changes in colour of these factors. Storage temperature and oxygen content were the most specific for colour injury of both juices and isolated pigments. Exposure to light caused little deterioration in colour. Adjustment of acidity within the range of pH 2 to 4.5 or sugar addition had little effect on colour retention in fruit juices during storage.

Mitra (1997) studied on post harvest physiology and storage of tropical and subtropical fruits. He showed in his food that tropical and subtropical fruits are becoming increasingly important food items in countries where they are produced and also in an increasing number of importing countries in non- tropical areas. His book deals with the post harvest storage, physiology and conservation of all of the economically important tropical and subtropical fruits. It should be of particular interest to all horticultural researchers, exporters and importers within the industries concerned with tropical and subtropical fruits.

John and Narasimbam (1998) studied on quality of blast-frozen and cryo-frozen ripe jackfruit bulbs. Instrumental colour and texture and sensory quality changes in blast-frozen and cryo-frozen ripe jackfruit packed in A 2.5 cans stored at -18^{0}C were studied. At the end of 6 months of storage, instron (Warner-Bratzler shear) measurement showed a reduction in toughness from an initial value of 1.62 to 1.42 kg/cm^2 in the case of cryo-frozen fruits and to 1.29 kg/ cm^2 in the case of blast-frozen samples. Similarly, colour retention was better in cryo-frozen product. During sensory evaluation, cryo-frozen fruits were rated as equal to blast-frozen fruits frozen up to 6 months of storage and later as superior to them.

Cruess (1958) stated that fruit juices are most palatable when first expressed from the fresh fruit and any treatment applied to preserve then results in more or less injury to quality. Fruits that are to be used for the preparation of juice should be of marked flavour and aroma, The juice should be prepared from sound fruit only. Even slight fermentation or mold growth spoils the flavour of the juice. The fruit should be picked at the proper stage of maturity for the preparation of juice. Fruits that will be mold attacked will be vigorously washed. The crusher should be of such material that it does not react with the juice.

2.7 Use of additives

FAO & WHO jointly defined "food additive" as non-nutritive substances added intentionally to food, generally in small quantities, to improve its appearance, flavour, texture or storage properties. Some chemicals added to food to impart a desired quality or for some other functional purpose may be of nutritive value.

Wade (1991) studied on the mixed fruit juice using various stabilizers ranging from 0.05-1.5 wt.% preferably 0.3-0.6wt.% xanthan gum (based on total wt. of the mix). Water and other ingredients were incorporated such that the blend had a Brix value of >20-25. No refined sugar or corn sweetener was added. He found that juice mix could form a hard pack material at low temperature storage ($\leq -18^0$C) for days and then be warmed to -5 to -10^0C to be scooped and eaten without the appearance of being too icy, coarse, crumbly or gumy but inhibiting a smooth, fine creamy texture and superior melt characteristics relative to soft pack.

Rangana & Bajaj (1966) reported that SO_2 is widely used throughout the world principally for treating food of plant origin. It is used in the preservation of fruit juices, pulps, beverages 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.Rangana and Bijoy (1966) reported that preservatives are food additives wed to prevent infection or inhibition of spoilage caused by bacteria, yeast, molds or other organisms.

Martin Glicksman (1969) reported that CMC has been shown to be effective as a protective colloid in beverage flavour emulsions.Martin Glicksman (1969) reported that CMC as a bodying agent in sugarless beverages containing sodium cyclohexyl

sulfamade instead of sugar. In this application the CMC bodying agent is necessary to impart the syrupy texture is normally supplied by the high sugar concentration.

Anonymous (1957) reported that the gum arabic has the ability to stabilize soft drinks and it is largely responsible for the "lace curtain" effect on the sides of the glass.

Furia (1972) stated that sulphiting is done to inhibit microbial as well as enzymatics or non enzymatic discolouration of some foods. The level of sulphite is limited by the fact that, at residual level above 500 ppm the taste begins to be noticeable. Ingested quantities are usually less than those initially added to foods because of loss of evaporation in storage and from cooking. Sulpher dioxide and sulphites in the body are oxidised to harmless sulphate and exerted in the urine. It destroys thiamine and usually is not applied in food which is a good source of thiamine.

Stock (1998) reported that stabilization of fruit using bentonite, gelatin and silica soil is discussed with reference to: properties and manufacture of those 3 components: selection criteria; application to fruit juice stabilization; and recommendations for practical use in the fruit juice industry.

Zurowietz (1996) reported that the relationship between subconscious sensory perceptions and product development in the beverage industry is discussed with particular reference to development of soft drinks and fruit juices. Aspects considered include evolutionary aspects of sensory perception; the physiology of olfaction use of common sensory profiling for product development; advertising and psychological aspects of appeal to the senses; recommendations for providing taste / olfactory profiles for fruit juices and nectars, common profiling of other flavoured products; and the concept of global profiling.

2.8 Miscellaneous

The jackfruit was one of the largest fruit born by any tree, ranging from 30.48 cms to 76.20 cms long and from 20.32 cms to 25.40 cms thick but in weight it varied from 9.00 kg to 13.50 kg (Sturrock, D. 1959). It was also reported by Purseglove (Purseglove J.W., 1968) that the fruit was a gigantic syncarp, the barrel or peer shaped.

Bhatia *et al.*, (1955) stated that there were no well defined varieties of jackfruit. However, distinctions among jackfruit were made by many workers from different

angles. Ahmed (Ahmed, K. 1969) found no well established variety in Bangladesh. However, two types of fruits were common; the "Khaja" - green rind, firm flesh and small seeds; the other one was the "Ghila" - reddish rind, soft flesh, juicy and sweet.

Singh *et al.*, (1963) described that some jackfruit had soft flesh, considered too mushy and sweet when ripe; those of another type had firm or crisp flesh and more pronounced flavour and the third group was small limit variety called "Pudraskshi" which had a relatively smooth rind and flesh of inferior quality. The principal types of fruits were found in Seylon as the "Waraka" with a firm rind and the less sweet, "Vela" with a soft rind it was stated that there were two common varieties: "Kapa" and "Barka"; the former had a sweet fleshy and crisp perianth and the latter had a thin mucilaginous and sour pulp (Manjunath, B. L. 1948).

Fruit flavoured beverages could be claasified into two broad categories, from the point of view of composition, those containing fruit juice with or without pulp and fruit cells, and other fruit flavoured ones and those flavoured with natural fruit oils. Most members of the group are citrus flavoured beverages, but other beverages in which fruit juice are commonly used are gape, apple, pineapple etc. (Jacob, 1959).

According to Jacob (1959) "Beverages" are characterized by the principal characters. Firstly, they are liquid or are consumed in a liquid state. Secondly, they are generally used to quench the thirst. The major groups of beverages which conform to this characteristics are the carbonated non-alcoholic beverages and the beverages such as fruit drinks and fruit juices. He also defined carbonated beverages as the drinks that are generally sweetened and flavoured and sometimes are acidified and some times have salts and minerals added, that are artificially charged with carbon dioxide that contain to alcohol.

Hulme (1971) reported that the conversion of fruits into juice was originally developed as a method of making use of supplies surplus to the fresh fruit market hut, while it still fulfils this function, juice production is now firmly established in its own right. The manufacture of juices and especially their concentrates extends the season of fruit consumption and assists in equalizing supplies from one year to another; it has encouraged an increasing international trade in products for direct consumption and for manufacture.

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.

Tressler & Joslyn (1971) studied and reported that squash is a non-carbonated fruit juice drink containing sugar, water and citric acid, sometime gum-arabic artificial colour and flavour. In USA, some canners proposed a minimum juice content of 40 to 50 percent in the drink. The drink could be blended of two or more kinds of fruit juice.

Roy *et al.*, (1997) observed that homogenization affects the viscosity, acceptability and storage properties of mango pulp and mango juice beverages such as squash, nectar etc. He showed that storage at $4\pm1^{0}C$ ensured maximum retention of chemical and sensory properties.

El-Nemr *et al.*, (1989) reported that the freshly prepared and bottled juice were analysed for various volatile aroma compounds including esters, carboxyl compounds, alcohols and lactoses. The bottling process resulted in a sharp decrease in the content of all volatile fractions, especially esters. During subsequent storage, the contents of these fractions, especially alcohols and lactoses, increased to levels higher than those in freshly prepared juice.

Bulbs, rinds and cores of jackfruit were used for preparing jams and jellies. Good quality of jam was prepared from the bulbs and good and excellent quality of jellies were prepared from bulbs, rinds and cores. Biscuits were prepared from different proportions of jackfruit seed powder. One sample of biscuit was found to be excellent and others were as good (Hoque, 1991).

Shunmukhasundaram and Naidu (1941) reported promising experimental work on mango leather, candied jackfruit, jackfruit syrup, custard-apple jam, butter and chutney, and a powder made from dried wild figs (Ficus glomerata) and eaten with milk and sugar, in addition to some of the more usual products.

CHAPTER III
MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted in the Laboratory of the Faculty of Agro-Industrial and Food process Engineering, Laboratory of Chemistry, Hajee Mohammad Danesh Science &Technology University Dinajpur and in other laboratories if required during the month from June 2012 to August 2012. Green and fully matured jackfruit was collected for experimental purposes.

3.1 MATERIALS

The jackfruit *(Artocarpus heterophylus)* of medium soft variety used in this study was procured from the local market. The major ingredients for the preparation of juice were jackfruit pulp, sugar and citric acid. The chemicals such as citric acid, K.M.S (potassium metabisulphite, $K_2S_2O_S$), sodium hydroxide, 2-6 dichlorophenol indophenol, sulphuric acid, hydrochloric acid etc. were reagent grade.

3.1.1 EQUIPMENT

Balances, food mixture machine, muffle furnace, electrical oven, pH meter, blender, disc bowl centrifuge, homogenizer and sealer were used.

3.2 METHODS

3.2.1 Extraction of pulp from bulks

The jackfruit of "Medium soft" variety used in this study was produced from the local market. The ripe healthy and fresh jackfruits was washed thoroughly with clean water and then broken open. The bulb, rinds and cores were collected separately. The seeds with brownish membranes were removed from the bulbs.

The bulb, seed, rind and core were found to be in the following ratios:

Bulb	Seed	Rind	Core
48.50%	12.19%	34.06%	5.23%

The bulbs were separated from seeds and crushed by a waring blender to produce the crude pulp. The crude pulp was put through a screen of 0.020- 0.030 inch mesh. Then the smooth pulp was obtained. The finished pulp was heated to 100°C for 3 min and then cooled down to room temperature and poured in a pot and stored in a deep freeze at about -20°C for the future use.

Fig 3.1: Jackfruit tree with fruits.

3.2.2 Formulation

Different formulations of jackfruit juices were coded sample S_1, S_2, S_3, and S_4 is control. The ingredients required for different formulation are shown in Table 3.1.

Table 3.1 Composition of 1000 gm of jackfruit juices

Ingredients in gram	Formulations (gm)			
	S_1	S_2	S_3	S_4
Jackfruit juice	100	300	200	150
Sugar	110	90	70	100
Citric acid	2.5	2.5	2.5	-
KMS	0.6	0.6	0.6	-
CMC	1.0	1.0	1.0	-
Water (ml)	785.9	605.9	725.9	750

S_1 = 10 % juice; S_2 = 30% juice; S_3=20% juice; S_4 = 15% juice (without KMS).

3.2.3 Preparation of juice

Juice can be prepared either from fresh pulp or frozen pulp. In this study juice were prepared from frozen pulp.

- **Thawing**

Thawing may be done in two ways i.e. at room temperature and artificially by applying heat treatment. The frozen jackfruit puree was thawed by heat treatment.

- **Weighing**

Various ingredients for the preparation of juice were weighed by balance.

- **Preparation of syrup**

Required amount of sugar and citric acid, KMS, CMC and H_2O were calculated for each formulation based on the amount of juice. Then mixture was boiled for about 3 to 5 min to prepare the syrup. The prepared syrup was filtered through cheese cloth.

- **Mixing**

The above mentioned syrup and required pulp were mixed thoroughly to obtain the desired juice. The juice was heated to about 75°C.

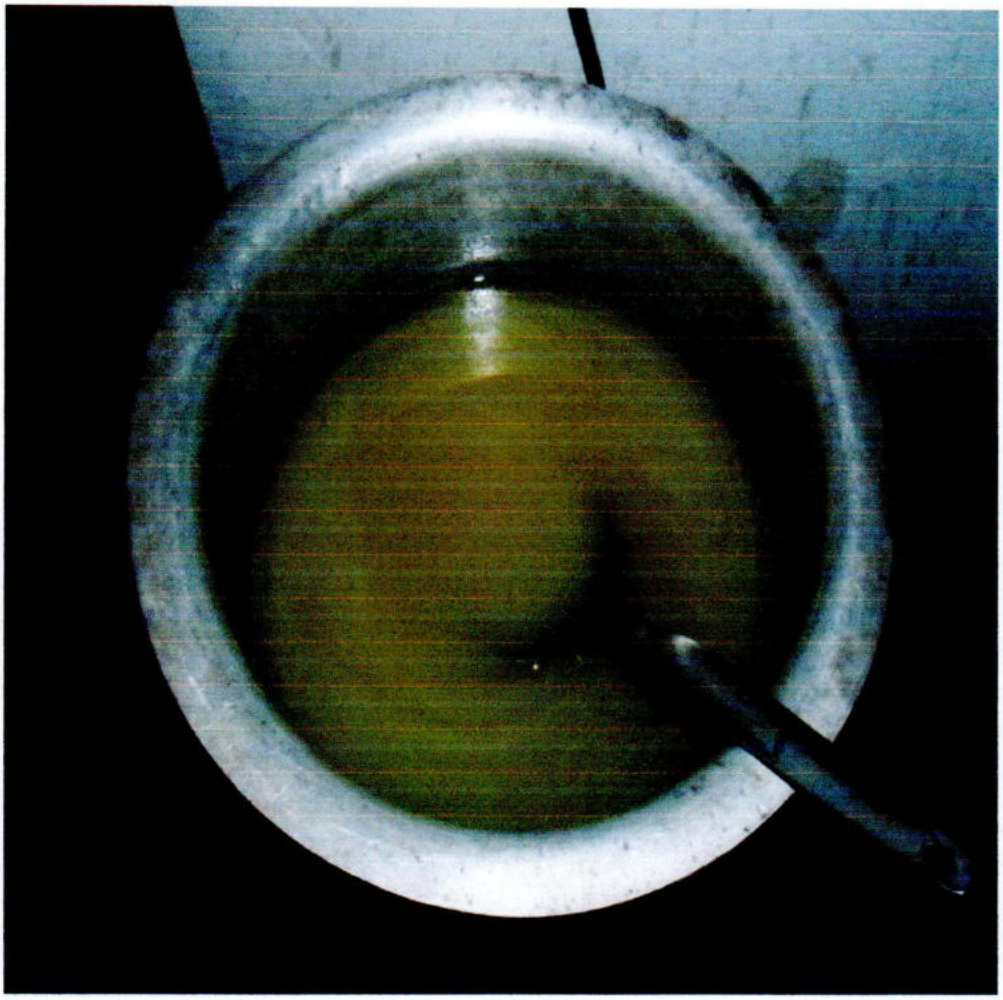


Fig 3.1: Preparation of jackfruit juices

❖ **Cooling and addition of preservative (KMS)**

The prepared juice was cooled down to about 28 to 30°C and then required amount of K.M.S was added and mixed thoroughly with each of the products by a waring blender.

❖ **Bottling**

The prepared juice were poured into sterilized bottles through sterilized funnels keeping head space about 2 cm. The bottles were corked and scaled tightly.

Fig 3.2: Bottling of jackfruit juices

- **Labeling**

The sealed bottles were labelled by indicating the amount of ingredients, the name of the products, the name of the manufacturer, the date of manufacture, the number of sample etc.

- **Storage**

The final products were stored in a dry and cool place for the next experiment.

3.3 Chemical analysis of pulp

Moisture, TSS, reducing sugar, non-reducing sugar and total sugar, ash content, pH, acidity, vitamin-C were analysed as per followed methods Ranganna (1977).

Proximate analysis of jackfruit pulps

3.3.1 Moisture content

Jackfruit pulp (8 gm) was taken in crucible and placed in an oven at 80°C for 72 hours until constant weight attained. The crucibles with the sample was then transferred to a dessicator containing anhydrous calcium chloride and kept there for

about 10 minutes. The final weights were then taken. Percent moisture content was calculated using following formula:

$$\%\text{Moisture} = \frac{(I-F)\times 100}{I}$$

Where,

I = Initial weight of sample

And F= Final weight of sample

3.3.2 Total Soluble Solids (TSS)

Total soluble solids (TSS) content was determined by refractometer by placing a drop of pulp on its prism. Percent TSS obtained from direct reading of the refractometer.

3.3.3 Reducing sugar

Standardization of Fehling's solution

Ten ml of both Fehling's solution A and Fehling's solution B were mixed together in a beaker. Ten 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.

$$\text{Fehling's Factor} = \frac{\text{titer x } 2.5}{1000}$$

Preparation of sample

Mixed 25 ml juice and 100 ml distilled water in a volumetric flask add 2 ml neutral lead acetate solution and stand for 10 minutes. Add 5 ml potassium oxalate solution and made a volume of 250 ml. Then filtrated and made the dilution.

Titration for reducing sugar

Ten 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 heated on a heater. Three drops of methylene blue indicator were 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. Per cent reducing sugar was calculated according to the following formula:

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

Where,

F = Fehling's Factor
D =Dilution
T = Titre
W = Weight of sample

3.3.4 Non-reducing sugar

Fifty ml of purified solution was taken in a conical flask. Fifty ml of distilled water and 5 gm of citric acid were added to it. Then the conical flask was heated for 10 minutes for insertion of sucrose and finally cooled. The sample was then neutralizes by 1 N NaOH solution using phenolphthalein indicator. The volume was made up to 100 ml with distilled water.

The mixed Fehling's solution was titrated using similar procedure followed as in the case of reducing sugar. The percent invert sugar is then calculated by the similar procedure as in the case of reducing sugar from which we got the percent non-reducing sugar by using the following way:

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

3.3.5 Total sugar

Total sugar can be calculated by using the following way:

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

3.3.6 Ash content

Jackfruit pulp (8 gm) were taken in porcelain crucibles and placed into a Muffle furnace at a constant temperature of 650°C for 4 hours. The crucibles with the sample was cooled and transferred to a desiccator containing anhydrous calcium chloride and allowed to stand for a period of 8 hours. The final weight was taken and ash percent was calculated as follows:

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

Where,

A = Weight of ash and

I = Initial weight of bulb

3.3.7 pH

The pH of the pulp was measured by using pH meter at an ambient temperature.

3.3.8 Acidity

Twenty five gm sample was taken in a blender machine and homogenized with distilled water. The blended materials were then filtered and transferred to a 250 ml volumetric flask and the volume was made up to the mark with distilled water. Five ml of solution was taken in a conical flask and titrated with 0.lN NaOH solution just below the end point, using phenolphthalein indicator. The titration was done for several times for accuracy. Percent titratable acidity was calculated using to the following formula:

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

Where,

T = Titre

N = Normality of NaOH

V_1 = Volume made up

E = Equivalent weight of acid

V_2 = Volume of sample taken for estimation

W = Weight of sample

3.3.9 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 Microbiological studies

3.4.1 Determination of total viable bacteria

Standard plate count for total viable bacteria was done according to the method described in "Recommended Method for the Microbiological Examination of Food" (American Public Health Association, 1967).

Preparation of media

In this study dehydrated Tryptone Glucose employed. Yeast extract (TGYE) agar was employed. The composition of the TGYE manufacturer was as follows:

Ingredients	Amount (gm)
Bacto-Tryptone	5.00
Bacto-Yeast Exhale	2.50
Glucose	1.00
Bacto	15.00
Total	23.50

To be dissolved in 1000 ml distilled water.

To rehydrate the media 23.50 gm of TGYE agar was suspended in 1000 ml of cold distilled water and heated to boiling to dissolve the ingredients completely. Later, the media was dispensed into 200 ml screw cap bottles and sterilized at 121°C (6.795 kg cm^{-2}) for 15 minutes in an autoclave. The media was adjusted to pH 7.0 ± 0.1. The agar was then ready for plating or storing. Before plating the medium was kept melted in boiling water bath and pouring was done at 45°C.

Preparation of dilution blanks

One thousand ml of distilled water was taken into a sterilized flask. The phosphate buffer solution was prepared as per recommendation of the "Recommended Method for the Microbiological Examination of Food" (APHA, 1967). Then the buffer solution was added to the distilled water at the rate of 1.25 ml/1000 ml and the pH was adjusted to 7.2. The dilution water was then dispensed into several dilution bottles at the rate of 100 ml each. Later, the dilution blanks were sterilized in an autoclave at 121°C (6.795 kg cm^{-2}) for 15 minutes. The sterilized dilution blanks were kept in a refrigerator until use.

Pipette, petridishes and glasswares were also sterilized at 100°C for 15 minutes in an autoclave.

Dilution making and procedure of plating

This was performed according to the "Recommended Method for the Microbiological Examination of Food" (APHA, 1967). One gram portion of well jackfruit juice was transferred into 99 ml portion of sterilized buffered distilled water dilution blank and the sample was shaken vigorously 25 times up and down movement of about 30 cm in a time interval not exceeding 7 seconds. 1 ml portion was transferred to another 99 ml sterilized dilution blank by using a sterile pipette. One and one-tenth ml portions of diluted sample from each dilution were placed into sterile petridishes aseptically in order to get the dilutions 1:10, $1:10^2$, $1:10^3$, $1:10^4$. Each of the dilutions was shaken as described earlier, just before transferring from the dilution bottle into petridishes or another dilution bottle. The pipette was allowed for 2 to 3 seconds to drain, then gently blown out the last drop and touched the tip of the pipette to a dry spot on the grass. As soon as the dilutions were poured into petridishes, the mouth of the agar bottle was sterilized by flame and poured

0.020-0.030 inch mesh of melted agar of 45°C into wash plate, slightly raising the lid of the petridishes. Quickly the agar was then mixed with the dilution gently by rotating and tilting the dish. The agar was then allowed to solidify.

Incubation and colony count

After solidification of ager, the plates were inverted and placed in an incubator operated at 32°C for 48 hours. After incubation, the plates were taken out from the incubator and the plates which contained 30-300 colonies were selected for counting. Colonies were counted with the aid of a Garbar Colony Counter. The numbers of colonies were multiplied by the dilution and the total viable count per gram of sample was recorded.

3.4.2 Determination of yeast and mould count

Yeast and mould count of jackfruit juice was done according to the method as described in the recommended Method for the Microbiological, Examination of Food (APHA, 1967).

Preparation of media

In this study Potato Dextrose Agar (PDA) was used to enumerate the yeast and mould count of jackfruit juice. The formula of preparation of PDA media is given below:

Formula	
Infusion from 200 gm potato	1000ml
Dextrose, commercial	20 gm
Agar, Shredded	15 gm
Tartaric acid, U.S.P, 10% solution sterilized	2.5 ml/ 100 ml

Two hundred gm of previously peeled and sliced jackfruit was taken in 1000 ml of distilled water and boiled for an hour. After boiling, straining was done through double thickness of a clean cloth. Volume was restored to origin. Then 20 gm of commercial dextrose and 15 gm of agar were added to the potato infusion solution. Later, for complete dissolution the mixture was heated and dispensed into several

200 ml screw cap bottles and sterilized at 121°C (6.795 kg pressure/sp. inch) for 20 minutes. The media was then stored at refrigeration temperature. Before pouring into petridishes the media was melted through boiling and around 2.5 ml of 10% tartaric acid was added per 100 ml of media (at 45°C) to reduce the pH value to (3.5 ± 0.1).

Preparation of dilution blanks

Same as for total viable count of jackfruit juices.

Dilution making and procedure of plating

Same as for total viable count of jackfruit juice except for the media – Potato Dextrose Agar.

Incubation of colony counting

After solidification of agar, the plates were inverted and incubation at 25°C for 5 days. After incubation, the plates were taken out from the incubator and colonies were counted. Yeast colonies were characterized by their smooth, moist and elevated surface, where mould colonies were identified by their profuse growth of hyphae. Finally, the colony number was multiplied by the dilution and the counts per gram of sample were recorded.

3.5 Sensory evaluation

Sensory evaluation of all formulated jackfruit juices were done by taste testing panel. This taste testing panel was carried out by 10 panelists. They were asked to evaluate colour, flavour, sweetness, texture 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 DMRT with the help of a computer program MSTAT.

3.6 Storage studies

The jackfruit juices were processed and bottled for 4 months of storage. The changes of TSS, moisture, reducing sugar, non-reducing sugar, total sugar, ash, pH, acidity and vitamin-C were observed at an interval of 30 days under refrigerant temperature (3-8°C) during the storage period.

CHAPTER IV
RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Chemical analysis of the raw materials

The raw material of jackfruit pulp were analyzed for their moisture content, TSS, reducing sugar, non-reducing sugar, total sugar, ash, acidity, pH and ascorbic acid (vitamin-C). Result obtained after analysis are shown in the Table 4.1.

Table 4.1 Analyzed composition of jackfruit pulp

Parameters	Result (%)
Moisture content	78
TSS	20
Reducing sugar	6.53
Non-reducing sugar	8.80
Total sugar	14.93
Ash	0.88
pH	5.1
Acidity	0.25
Ascorbic acid (vitamin –C)	8 mg/100 gm

The composition of jackfruit was found within the range of previously reported by Hossain and Haque and Anonymous, (1979).

4.2 Chemical composition of jackfruit juice

According to formulation the jackfruit juice was prepared by mixing different ingredients. After preparation of the products the chemical compositions were determined. The compositions of the products have been shown in the Table 4.2.

Table 4.2 Composition of the formulated juices

Sample	Moisture (%)	TSS (%)	Reducing Sugar (%)	Non-Reducing Sugar (%)	Total sugar (%)	Ash (%)	P^H	Acidity (%)	Vita-C mg/ 100gm
S_1	84.40	13	5.13	7.37	12.50	0.23	3.73	0.25	2.95
S_2	85.02	13	5.47	7.01	12.48	0.37	3.63	0.38	2.32
S_3	84.66	13	5.91	6.81	12.72	0.46	4.30	0.44	2.38
S_4	85.56	13	5.71	7.14	12.85	0.32	3.58	0.40	2.36

4.3 Microbiological study of the formulated jackfruit juices

4.3.1 Total number of viable bacteria in formulated jackfruit juice

This study was performed by standard plate count (s.p.c) method. Colonies were developed after 48 hours of incubation. Then the colonies were counted in the formulated juice. The total viable bacterial load was not uniform. The total number of viable bacteria per ml of sample was obtained by multiplying the number of colony forming units (cfu) on the plate with dilution factor then it was converted into logarithmic form. The total numbers of viable bacteria count in different samples have been shown in (Appendix I).The variation of viable bacteria count has been shown. It was observed that the total viable bacteria in sample S_4 (15% juice without KMS) was greater. The sample S_1 showed the minimum total viable count.

4.3.2 Number of Mould and yeast in formulated jackfruit juice

The number of mould and yeast were found in the jackfruit juices have been shown in (Appendix I). In this experiment yeast was found to be maximum in S_4. The total number of mould was found less in samples S_1, S_2, S_3 and S_4. Number of mould was

found to be highest in sample S_3. In case of sample S_2, there was no mould growth. Sample S_1 was similar as far as mould growth is concerned and was closely followed by S_3, and S_4.

The results of microbiological status of these studies correspond to the study of Ranganna and Bajaj (1966). They reported that SO_2 is widely used in the preservation of plant origin food like fruit juices, pulps, partially beverages and concentrates etc. This result is also partially in agreement with the findings of Desrosier (1963). He reported that microorganism could be killed by heating and irradiation.

4.4 Sensory evaluation of jackfruit juice after 4 months of storage

The samples of jackfruit juice were subjected to sensory evaluation. After four months of storage in room temperature the flavour, colour, sweetness, texture and overall acceptability of the products were evaluated by a panel of 15 judges. The mean scores for colour, flavour, sweetness, texture and overall acceptability preference of the samples are presented in Table 4.3. The statistical analysis and ANOVA tables are given in Appendix (II – VI). A two way analysis of variance indicated that all the sensory attributes of different samples were significantly ($p<0.05$) different and thus the sensory attributes of the samples showed various degrees of acceptability.

The results in table 4.3 revealed that fruit juice was significantly ($p<0.05$) different in colour acceptability (details in Appendix II, III and IV). In other words the colour of different formulation was not equally acceptable. In Appendix II table 2.3 there was significant difference among the samples and the sample S_2 scored significantly better colour. Sample S_2 was the most preferred securing 7.3 while the lowest score secured by sample S_1 was 5.3. This result indicates sample S_1 shown least colour acceptability than other samples.

In case of flavour preference among the samples a two way analysis of variance (Appendix III, table 3. 1 & 3.2) showed that the samples were significantly ($p<0.05$) different as far as flavour acceptability is concened in Appendix IV table 4.3. from Appendix III table 3.3 it was obtainted that the sample S_2 was the most preferred

one securing 7.9 and other samples S_1, S_3, and control were equally acceptable securing scores ranging from 5.6 to 6.3 for flavour preference.

In case of sweetness among the different formulations, a two way analysis of variance (Appendix IV table 4.1, 4.2 & 4.3) was carried out and results in table 4.3 revealed that there was significant ($p<0$ 05) difference in sweetness acceptability among the products. Sample S_2 gave the highest score (8.3) for sweetness and was significantly different from the other samples accept S_3 which secured in the second highest score (7.3). In terms of sweetness the other samples equally acceptable securing scores ranging from 5.7 to 6.3.

From the Table 4.3 it was revealed that sample S_2 were highly preferred securing 8.4 out of 9 for overall acceptability. The DMRT test for overall acceptability was presented in Appendix VI table 6.3. From the result, there was a significant ($p <0.05$) difference among the samples S_2 and others but the samples S_1, S_3, and control were statistically equally acceptable.

Table 4.3 Mean sensory score of jackfruit juices

Sample	Sensory attributes				
	Colour	**Flavor**	**Sweetness**	**Texture**	**Overall acceptability**
S_1	5.3^{c}	5.8^{b}	5.7^{c}	6.6^{bc}	6.0^{c}
S_2	7.3^{a}	7.9^{a}	8.3^{a}	8.4^{a}	8.3^{a}
S_3	6.3^{b}	6.3^{b}	7.3^{b}	7.1^{b}	7.1^{b}
S_4	5.9^{bc}	5.6^{b}	6.2^{c}	5.8^{c}	5.4^{c}
LSD	0.6443	0.823	0.8878	0.8930	0.7797

4.5 Storage effect on the analysis of ready to drink jackfruit juice

The chemical compositions of the formulations of jackfruit juices during 4 months of storage were presented in Table 4.4. As the sample S_4 was spoiled at 30 days of storage it was not considered in the later studies.

4.5.1 Moisture content

The moisture content for the pulp of bulb was 76%, which is comparable to the result, obtained by Pursaglovc (1968) and Sturrock (1959). The moisture contents of all the formulations of juices were found to be within the range of 84.4-85%, (Table 4.4). It was observed that there were no remarkable changes in moisture content throughout the storage period.

4.5.2 TSS

Changes of TSS of jackfruit juice have been shown in table. 4.4. It was observed that the TSS of different formulation was not shown any remarkable change upto 90 days of storage. A little change was observed for sample S_2 after 120 days of storage period in room temperature.

4.5.3 Reducing sugar

The reducing sugar contents increased due to inversion of sugar in presence of acid during heating. The initial reducing sugar content of the formulations S_1, S_2, S_3 and S_4 were shown in Table 4.4.

During the storage period (120 days) the reducing the sugar content of the formulated product were gradually increased. This increasing may be due to the hydrolysis of fruit sugar by the acid present in the juice. The increase in reducing sugar with the storage period was also reported by Ewaidah (1992).

4.5.4 Non-reducing sugar

Non-reducing sugar of formulation S_1, S_2, S_3 and S_4 were shown in Table 4.4. Throughout the storage period small variation was observed. The decrease of non-reducing sugar may be due to conversion of some non-reducing sugar to reducing sugar through the process of glucogenesis.

4.5.5 Total sugar

Throughout the storage period insignificant variation in total sugar was observed at room temperature. This variation might be due to the technical measuring error.

4.5.6 Ash content

Ash content of bulb was 0.88% (Table 4.4 contd.) which is comparable to the result obtained by Sturrock (1959). Throughout the storage period there were insignificant changes in ash content of different samples.

4.5.7 pH

The values of pH of different formulations S1, S2, S3 and S4 for different storage period were presented in Table. Slight variations in pH were observed throughout the storage period. The variation in pH was due to variation of acidity occurred during the storage period at room temperature.

4.5.8 Acidity

The acidity was calculated on the basis on titrated acidity. Acidity for all the formulations during storage was determined and the results were shown in Table 4.4. Variation in acidity ranged from 0.28 to 0.1 for formulation S_1, 0.31 to 0.16 for S_2, 0.36 to 0.23 for S_3 and 0.40 to 0.38 for S_4. Ranganna (1977) recommended acidity (as anhydrous citric acid) ranging from 0.12 to 0.23% for various fruit flavoured carbonated beverages.

4.5.9 Ascorbic acid (vitamin-C)

The vitamin-C of different formulations was determined at various storage periods and shown in Table 4.4.

Fruits and vegetables are important source of ascorbic acid but it is sensitive to oxidation. Ascorbic acid prolongs the shelf life of a product by reacting with residual oxygen and retarding the development of off-flavour (Pollard and Timberlake, 1971). During processing the juice had undergone heat treatment and aeration which accelerated the destruction of vitamin-C in the product. It has been shown in Table 4.4. the ascorbic acid reduced remarkably when increasing storage time (0- 120 days) and the reduction was prominent with different treatments. For sample S_1 the vitamin-C content decreases from 2.95 mg/100 gm to 1.296 mg/100 gm, for sample S_2 2.32mg/100 gm to 1.30 mg/100 gm, and for sample S_3 2.38 to 1.44 mg/ 100gm throughout storage period. The loss of vitamin-C is dependent on

temperature and storage time. Sufi (1976) found that vitamin-C content decreased from 35.1 to 2.8 mg per 100 gm in the guava juice based carbonated beverage for the storage period of 35 days at 20-25°C.

Table 4.4 Analysis of jackfruit juice at various storage period.

Storage period	Sample	Moisture (%)	TSS (%)	Reducing Sugar (%)	Non-reducing sugar (%)	Total sugar (%)	Vitamin-C (mg/100gm)
0 days	S_1	84.40	13	5.13	7.37	12.50	2.95
	S_2	82.16	13	5.58	6.82	12.40	2.45
	S_3	84.68	13	5.91	6.83	12.74	2.38
	S_4	85.56	13	5.71	7.14	12.85	2.35
30 days	S_1	84.22	13	5.13	7.37	12.50	2.64
	S_2	82.02	13	5.54	6.82	12.36	2.13
	S_3	84.48	13	5.91	6.81	12.72	2.09
60 days	S_1	83.85	13	5.14	7.35	12.49	2.34
	S_2	81.85	13	5.60	6.72	12.32	1.97
	S_3	84.18	13	5.93	6.78	12.71	1.92
90 days	S_1	83.05	13	5.16	7.32	12.48	1.66
	S_2	81.00	13	5.63	6.52	12.15	1.84
	S_3	83.70	13	5.95	6.76	12.71	1.74
120 days	S_1	82.25	13	5.19	7.29	12.48	1.29
	S_2	80.31	13	5.66	6.54	12.20	1.70
	S_3	82.70	13	5.98	6.73	12.71	1.44

Sample S_4 spoiled within 30 days.

4.6 Studies on Sedimentation of bottled juice during storage period

Sedimentation was observed in the bottles during the storage period. The sediment settles gradually on the bottom of the bottles. However, formation of sediment was settled rapidly just after bottling. Transparent appearance in the upper portion of the bottles was observed. Formulation S_2 and S_3 showed the greater sedimentation than S_1, S_4.

This formation of sediment might be due to the solid contents of the juice. This is the body of fruit juice. If it would be shaken before use then it would be seen to be fresh homogeneous juice. Sedimentation can be removed by proper homogenization, proper water treatment practices, proper filtration practices of water and prevention of microbiological activity etc. Ranganna (1977) suggested some useful method for fruit juice clarification. By using pectic enzyme, tannin and gelatin or by the combination of these two or by centrifuging and filtering the juice might be successfully clarified.

CHAPTER V
SUMMERY AND CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSION

The study was conducted in the Laboratory of the Faculty of Agro-Industrial and Food Process Engineering, Laboratory of Chemistry, microbiology lab, Hajee Mohammad Danesh Science and Technology University, Dinajpur. The microbiological study, storage study and consumer's acceptability of the formulated jackfruit juices were studied. The products were then stored in dry and cool place at room temperature. Sensory evaluation was done at an interval of 30 days up to 120 days by a taste testing Panel.

The ripe healthy and fresh jackfruits were collected from the local market. The bulbs were separated from seeds and crushed by a waring blender. Four formulations coded as S_1 (10% juice), S_2 (30% juice), S_3 (20% juice) and S_4 (15% juice without KMS) were prepared. The required quantity of sugar and acid were dissolved in measured amount of water, which was mixed with weighed amount of jackfruit juice, KMS, CMC and citric acid. The juices were prepared and bottled to store at refrigerated temperature (3-8°C).

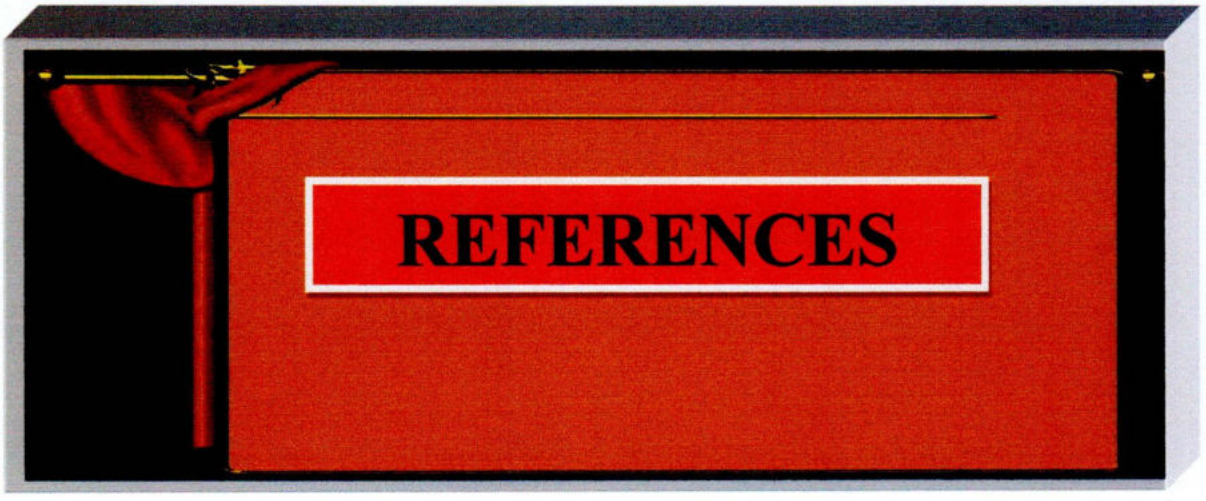
The microbiological examination of the samples was carried out during storage period to examine the total count (cfu/ml) of viable bacteria, mould and yeast. Maximum number of bacteria was found in sample S_4 (15% juice without KMS). The sample S_1 showed the minimum total viable count. Yeast was found maximum in S_4. In case of sample S_2 mould was not found. Negligible change was observed (except the vitamin-C) in the composition of the prepared juice throughout the storage period. Remarkable decrease of vitamin-C was found in the formulations during storage period and TSS, pH and non-reducing sugar increased slightly and acidity and reducing sugar decreased slightly.

The acceptability of the juice was tested by a panel of 10 judges. The scores obtained after tasting the samples were analysed and the acceptability of the finished products were found out. A statistical analysis of the score response by the taste testing panelists on the sensory attributes on juices revealed that colour, flavour, sweetness, texture and overall acceptability of the juices were significantly ($p<0.05$) different. It was found that sample S_2 (300 gm juice, sugar-90 gm, citric acid-2.5 gm, KMS-0.6 gm, CMC-1.0

gm and water-605.9 gm for each 1000 gm of juice) was highly acceptable by the taste panelists.

The storage stability of the accepted products was studied upto four months at an interval of 30 days and the quality attributes were found satisfactory. Use of CMC decreases the cloudiness of the formulated samples. The preservative (KMS) was also effective against microbial growth to prevent spoilage except the sample S_4 (without KMS) of the bottled juices.

The study was carried out to develop suitable formulae for the preparation of jackfruit juice. Another important objective was to explore the new area for the utilization of jackfruit by developing easily implementable process at rural level or in a small scale industry in urban areas. Thus by processing and preserving jackfruit pulps as juice may encourage more production of jackfruit which will provide better nutrition to the people of Bangladesh.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APPENDICES

APPENDICES

Appendix-I

Table 1.1.Total number of viable bacteria count after incubation 48 hr at 32°C.

Sample	Bacteria count (cfu)
S_1	4.2
S_2	4.8
S_3	4.4
S_4	4.9

Table 1.2.Total number of Mould and Yeast count after incubation 72 hr at 32°C.

Sample	Mould (cfu)	Yeast (cfu)
S_1	3	3.3
S_2	0	3.90
S_3	2.8	6.65
S_4	2.6	4.26

Appendix-II

Table 2.1 Rating score for colour of jackfruit juice

No. of taster	Sample			
	S_1	S_2	S_3	S_4
1	6	9	6	6
2	5	7	7	6
3	5	8	6	6
4	5	6	6	5
5	5	7	7	6
6	6	8	6	5
7	5	7	6	7
8	5	6	7	6
9	6	7	7	6
10	5	8	5	6
Total	53	73	63	59
Mean	5.30	7.30	6.30	5.90

Hedonic rating score

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

Table 2.2 Analysis of variance (ANOVA) for colour

Sources of variance	Degrees of freedom	Sum of square	Mean square	Calculated value F	Tabulated value F_t
					5%
Samples	3	21.200	7.067	14.3459	2.960
Panelist	9	3.900	0.433	0.8797	2.250
Error	27	13.300	0.493		
Total	39	38.400			

Since $F > F_t$ at 5 % level of significance, samples are significantly different.

Table 2.3 Duncan's Multiple Range Test (DMRT) for colour

LSD value= 0.6443; P < 0.05

Sample	Original order of means	Sample	Ranked order of means
S_1	5.3^c	S_2	7.3^a
S_2	7.3^a	S_3	6.3^b
S_3	6.3^b	S_4	5.9^{bc}
S_4	5.9^{bc}	S_1	5.3^c

Appendix-III

Table 3.1 Rating score for flavour of jackfruit juice

No. of taster	Sample			
	S_1	S_2	S_3	S_4
1	6	9	6	5
2	5	8	7	6
3	7	9	6	5
4	6	8	6	5
5	6	7	7	6
6	5	8	6	7
7	7	6	6	6
8	5	9	7	5
9	5	7	7	6
10	6	8	5	5
Total	58	72	63	57
Mean	5.80	7.20	6.30	5.70

Hedonic rating score

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

Table 3.2 Analysis of variance (ANOVA) for flavour

Sources of variance	Degrees of freedom	Sum of square	Mean square	Calculated value F	Tabulated value F_t
					5%
Samples	3	32.600	10.867	13.7103	2.960
Panelist	9	1.600	0.178	0.2243	2.250
Error	27	21.400	0.793		
Total	39	55.600			

Since $F > F_t$ at 5 % level of significance, samples are significantly different.

Table 3.3 Duncan's Multiple Range Test (DMRT) for flavour

LSD value=0.823; $P < 0.05$

Sample	Original order of means	Sample	Ranked order of means
S_1	5.8^b	S_2	7.9^a
S_2	7.9^a	S_3	6.3^b
S_3	6.3^b	S_1	5.8^b
S_4	5.6^b	S_4	5.6^b

Appendix IV

Table 4.1 Rating score for sweetness of jackfruit juice

No. of taster	Sample			
	S_1	S_2	S_3	S_4
1	6	9	6	8
2	5	8	9	6
3	7	9	8	7
4	5	8	6	5
5	6	7	9	6
6	5	9	6	7
7	7	8	8	6
8	5	9	7	5
9	5	7	8	6
10	6	9	6	6
Total	57	83	73	62
Mean	5.70	8.30	7.30	6.20

Hedonic rating score

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

Table 4.2 Analysis of variance (ANOVA) for sweetness

Sources of variance	Degrees of freedom	Sum of square	Mean square	Calculated value F	Tabulated value F_t
					5%
Samples	3	40.475	13.492	14.4125	2.960
Panelist	9	8.625	0.958	1.0237	2.250
Error	27	25.275	0.936		
Total	39	74.375			

Since $F > F_t$ at 5 % level of significance, samples are significantly different.

Table 4.3 Duncan's Multiple Range Test (DMRT) for sweetness

LSD value= 0.8878; $P < 0.05$

Sample	Original order of means	Sample	Ranked order of means
S_1	5.7^c	S_2	8.3^a
S_2	8.3^a	S_3	7.3^b
S_3	7.3^b	S_4	6.2^c
S_4	6.2^c	S_1	5.7^c

Appendix V

Table 5.1 Rating score for texture of jackfruit juice

No. of taster	Sample			
	S_1	S_2	S_3	S_4
1	7	9	8	5
2	8	8	7	6
3	7	9	6	7
4	6	8	8	5
5	6	9	7	6
6	5	8	9	7
7	7	9	6	6
8	8	7	7	5
9	6	9	8	6
10	6	8	5	5
Total	66	84	71	58
Mean	6.60	8.40	7.10	5.80

Hedonic rating score

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

Table 5.2 Analysis of variance (ANOVA) for texture

Sources of variance	Degrees of freedom	Sum of square	Mean square	Calculated value F	Tabulated value F_t
					5%
Samples	3	35.675	11.892	12.5543	3.55
Panelist	9	5.725	0.636	0.6716	
Error	27	25.575	0.947		
Total	39	66.975			

Since $F > F_t$ at 5 % level of significance, samples are significantly different.

Table 5.3 Duncan's Multiple Range Test (DMRT) for texture

LSD value=0.8930; P < 0.05

Sample	Original order of means	Sample	Ranked order of means
S_1	6.6^{bc}	S_2	8.4^{a}
S_2	8.4^{a}	S_3	7.1^{b}
S_3	7.1^{b}	S_1	6.6^{bc}
S_4	5.8^{c}	S_4	5.8^{c}

Appendix VI

Table 6.1 Rating score for overall acceptability of jackfruit juice

No. of taster	Sample			
	S_1	S_2	S_3	S_4
1	6	9	8	5
2	5	8	7	6
3	7	7	9	5
4	6	8	6	5
5	6	9	7	6
6	5	8	7	5
7	7	9	6	6
8	7	9	9	5
9	5	8	7	6
10	6	8	5	5
Total	60	83	71	54
Mean	6.00	8.30	7.10	5.40

Hedonic rating score

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

Table 6.2 Analysis of variance (ANOVA) for overall acceptability

Sources of variance	Degrees of freedom	Sum of square	Mean square	Calculated value F	Tabulated value F_t
					5%
Samples	3	49.000	16.333	22.6154	2.960
Panelist	9	7.900	0.878	1.2154	2.250
Error	27	19.500	0.722		
Total	39	76.400			

Since $F > F_t$ at 5 % level of significance, samples are significantly different.

Table 6.3 Duncan's Multiple Range Test (DMRT) for overall acceptability

LSD value=0.7797; P < 0.05

Sample	Original order of means	Sample	Ranked order of means
S_1	6.0^c	S_2	8.3^a
S_2	8.3^a	S_3	7.1^b
S_3	7.1^b	S_1	6.0^c
S_4	5.4^c	S_4	5.4^c

Appendix-VII Taste testing

Hedonic Rating Test

Name of the Tester: ..... Date .....

Please taste these samples and check how much you like or dislike or dislike each one four sensory attributes such as color, texture, taste and overall acceptability. Use the appropriate scale to show your attribute by checking at the point that best describe your feeling about the samples. Please give a reason for this attribute. Remember you are the only one who can tell what you like. An honest expression of your personal feeling will help us.

Sample	Colour	Flavour	Sweetness	Texture	Overall acceptability
S_1					
S_2					
S_3					
S_4					

Extra comments on each sample, if any:

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