CHAPTER I

1.0 INTRODUCTION

Jackfruit (*Artocarpus heterophyllus* Lam.) is the largest tree borne fruit in the world, reaching up to 50 kg in weight and 60-90 cm in length. It belongs to the family Moraceae, along with *Ficus* spp, *Morus* spp. (Mulberry) and *Maclurapomifera Schneid* (Osage orange or hedge apple) (Chandler, 1958; Popenoe, 1974). The fruit is borne on side branches and main branches of the tree. There are two main varieties of jackfruits: one is small, fibrous, soft, and mushy, and the carpels are sweet, with a texture like that of a raw oyster whereas the other variety is crisp and crunchy, but not very sweet. The large seeds from this non leguminous plant are also edible, even though they are difficult to digest (Siddappa, 1957). A single seed is enclosed in a white aril encircling a thin brown spermoderm, which covers the fleshy white cotyledon. Jackfruit cotyledons are fairly rich in starch and protein (Singh *et al*., 1991).

Jackfruit is considered as the national fruit of Bangladesh. It is an important fruit crop in Bangladesh, India, Burma, Sri Lanka, Malaysia, Indonesia, Thailand, the Philippines and many other tropical countries.. The jackfruit ranks third in area under cultivation and second in production among the fruits of Bangladesh. There are 25,110 hectare of land under jackfruit having an annual production of 469,500 tons. It accounts about 22% of total fruit production in the country (BBS, 2000-2007).

Jackfruit contains vitamin A, vitamin C, thiamin, riboflavin, calcium, potassium, iron, sodium, zinc, and niacin among many other nutrients. Jackfruit has a low caloric content where 100 g of jackfruit only contains 94 calories (Mukprasirt and Sajjaanantakul, 2004). The fruit is a rich source of potassium with 303 mg / 100 g of jackfruit. Studies show that food rich in potassium helps to lower blood pressure. Jackfruit is also a good source of vitamin C which is an antioxidant that protects the body against free radicals, strengthens the immune system, and keeps the gums healthy (Umesh *et al*., 2010). Pureed jackfruit can be processed into baby food, juice, jam, jelly, and base for cordials (Roy and Joshi, 1995).

Jackfruit provides about 2 MJ of energy per kg/weight of ripe perianth (Ahmed *et al*., 1986). Jackfruit has been reported to contain high levels of protein, starch, calcium, and thiamine (Burkill 1997).

In addition to its ripe fruit, which has a unique flavor, the jackfruit seed is widely consumed as a dessert or an ingredient in Asian culinary preparations. The jackfruit seeds are used in cooked dishes and its flour is used for baking. Jackfruit seeds are fairly rich in starch (Singh *et al*., 1991). Mature jackfruits are cooked as vegetables, and used in curries or salads (Narasimham 1990). Ripe fruits can be eaten raw, or cooked in creamy coconut milk as dessert, made into candied jackfruit or edible jackfruit leather. In India, the seeds are boiled in sugar and eaten as dessert (Roy and Joshi 1995). Jackfruit is also used for further processing. For instance, jackfruit leather and jackfruit chips can be made from dried jackfruit pulp (Nakasone and Paull 1998). Jackfruits are made into candies, fruit-rolls, marmalades, and ice cream. Other than canning, advances in processing technologies too, have pushed toward more new products (Narasimham 1990). Freeze-dried, vacuum-fried, and cryogenic processing are new preservation methods for modern jackfruit-based products. Various parts of the jackfruit tree have been used in medicine and its wood as an important source in the timber industries (Roy and Joshi 1995).

It is now widely accepted that the beneficial effects of fruits and vegetables for the prevention of certain diseases are due to the bioactive compounds they contain (Galaverna *et al*., 2008). Recent years have seen increased interest on the part of consumers, researchers, and the food industries into how food products can help maintain health; and the role that diet plays in the prevention and treatment of many illnesses has become widely accepted (Vinuda-Martos *et al*., 2010).

The bulbs (excluding the seeds) are rich in sugar, fairly well in carotene and also contain vitamin C (Bhatia *et al.*, 1955). Presence of carotenoids can be important for the prevention of several chronic degenerative diseases, such as cancer, inflammation, cardiovascular disease, cataract and age-related macular degeneration (Krinsky *et al*., 2003; Stahl and Sies, 2005). Despite all those merits, jackfruit has remained the most underutilized fruits in Bangladesh and many other parts of the World.

However, the fruit is perishable and cannot be stored for long time because of its inherent compositional and textural characteristics. In every year, a considerable amount of jackfruit, specially obtained in the glut season (June-July) in every year goes waste due to lack of proper postharvest knowledge during harvesting, transporting and storing both in quality and quantity. Proper postharvest technology for prolonging shelf life is, therefore, necessary. Besides, alternate ways of using jackfruits in on-season plays significant roles in reducing postharvest losses. Among them, processing is important one. It adds diversified and attractive food items in dietary menu as well as contributes to generation of income and employment. A number of products have been developed from raw, tender and ripe fruits and seeds. The ripe fruit bulbs (excluding seed) and the rind of the ripe fruit (including perianth and unfertilised flowers) have been used for processing in a number of products. Ripe jackfruit bulbs are canned in syrup, made into jams either pure or mixed with dehydrated bulbs, chutney, preserves, candy, and concentrate and powder. Rinds of ripe fruit are made into jelly. Preservation of fruits by processing has been the research pursuits of many developed and developing countries and has yielded quite a number of technologies. Home and cottage level processing of some fruits, specially 'Berry, Tamarind, Indian olive,' etc. exists in Bangladesh. However, processing techniques of jackfruit is very scanty in Bangladesh. There has been a little research work mentioning to find possibility of processing of jackfruit into durable and nutritious food products. So, it is now a burning issue to reduce the losses by developing the processing technique of jackfruit. Cottage industries and small scale industries establishment can be encouraged in our country, efforts of which are as yet quite inadequate. It can be hoped that a continuous increase of the agro based industries, unemployed people can be provided with work through auxiliary and useful services which would lead the rural life more prosperous in near future. In consideration of the above circumstances, the present study was under taken to develop products by processing different parts of jackfruits and to know the nutritional quality of the processed products.

Jam is an example of fruit preserve usually made from pulp and juice of one fruit (whole fruit). It can be defined as cooked and gelled fruit purses packaged for long term storage which is normally used as bread spread, fillings and food jellies. The preparation of fruit jam traditionally involves the use of pectin as a gelling agent, although sugar or honey and

citric acid may be added as well (Pattern, 2001). Good jam has a soft even consistency without distinct pieces of fruit, a bright color, good flavor and a semi-jelled texture that is easy to spread but has no free liquid (Isabel and William, 1990).

With malnutrition experience in Bangladesh, processing jackfruit into jam will help to make the nutrients that it provides available throughout the year. Jackfruit also reach in pectin, thus making it favorable for processing into jam. After making jam, I want to develop a new food product by using jackfruit jam which is suitable for industrial production.

1.1 Aim and Objectives of the Study :

1.1.1 Aim:

This study aims at developing jackfruit jam and evaluate its acceptability by consumers. This will add knowledge on how to process and preserve jackfruit thus reducing post-harvest losses. By adding value to the product it will promote widespread utilization of jackfruit nutrients. Also, post-harvest processing will increase demand for jackfruit and consequently stimulate increased jackfruit production in the areas where it is grown and possibly introduced in the areas where there is potential. Thus, the increased intake of processed jackfruit products will contribute to the nutrition and health benefits of the Bangladeshi people throughout the year. Those engaged in jackfruit business will also earn more income through employment and product selling. This will in turn contribute to improve household food security and livelihood.

1.1.2 Objectives :

- The overall objective of this research is to develop and nutritional evaluation of jackfruit based jam product.
- To develop jackfruit jam.
- To determine physiochemical (proximate composition, TSS, pH, Titratable acidity, vitamin C and minerals) qualities of fresh jackfruit and developed jam.

- To evaluate sensory properties and consumer acceptability of the developed and commercial jam.
- To develop a new variety food product by using jackfruit jam which is suitable for industrial production.
- One of the most important objective of this study is develop jackfruit jam cake and increase shelf life of this product for commercial production.
- To develop a new product at low cost that can help to prevent carbohydrate, protein, fat, vitamin and mineral deficiency of Bangladeshi people.
- To identify the nutritional benefits of jackfruit jam.

CHAPTER II

2.0 REVIEW OF LITERATURE

2.1 Originality and Distribution of Jackfruit :

There is a controversy in the literature about the exact region of origin of jackfruit. Some authors believed that Malaysia could be the possible center of origin (Ruehle, 1967), while Martin *et al*. (1987) reported that jackfruit is indigenous to tropical Asia. However, most authors believe that it originated in the rain forest of the Western Ghats of India (Purseglove, 1968; Popenoe, 1974; Rowe-Dutton, 1985; Singh, 1986; Morton, 1987; Soepadmo, 1992). Jackfruit is now widely grown in many Asian countries especially Bangladesh, Myanmar, Nepal, Sri Lanka, Thailand, Malaysia, Indonesia, India and the Philippines. It is also grown in Southern China and in the Indo- Chinese region in Laos, Cambodia and Vietnam (Morton, 1987; Narasimham, 1990; Gunasena *et al.*, 1996). Jackfruit is also found in East Africa (e.g. Uganda, Tanzania), Mauritius as well as throughout Brazil and Caribbean nations such as Jamaica.

2.2 Species of Jackfruit :

Artocarpus heterophyllus Lam, belongs to the family Moraceae, along with *Ficus* spp. (Fig), *Morus*spp. (Mulberry) and *Maclurapomifera Schneid* (osage orange or hedge apple) (Chandler, 1958; Popenoe, 1974). This family encompasses about 1,000 species in 67 genera, mostly tropical shrubs and trees, but also a few vines and herbs (Bailey, 1949). Jackfruit (*A. heterophyllus*) is a congener of (i.e. member of the same genus as) breadfruit (*Artocarpus saltilis*) as well as a number of other culturally and economically important trees (e.g. *A. mariannensis*, *A. camansi*, *A. integer*, *A. lakoocha*, *A. odoratissima* and *A. lingnanensis*) (Elevitch and Manner, 2006).

2.3 Description of the Fruit :

The jackfruit, the largest of all cultivated fruits, is oblong to cylindrical and typically 30 to 40 cm in length, although it can sometimes reach 90 cm. Jackfruits usually weigh 4.5 to 30 kg (commonly 9 to 18 kg), with a maximum reported weight of 50 kg. The heavy fruits are

borne primarily on the trunk and on the interior parts of main branches. Jackfruit is a multiple aggregate fruit (i.e. it is formed by the fusion of multiple flowers in an inflorescence). It has a green to yellow-green exterior rind. The hard outer covering is derived from the enlarged female flowers. The whitish fibrous pulp within contains many seeds (as many as 500 per fruit). The acid to sweetish (when ripe) banana-flavored flesh (aril) surrounds each seed. The heavy fruit is held together by a central fibrous core. In the Northern Hemisphere, the fruiting season is mainly late spring to early fall (March to September), especially in summer. A few fruits mature in winter or early spring. (Little and Wadsworth, 1964; Seddon and Lennox, 1980; Vaughan and Geissler, 1997; Elevitch and Manner, 2006). In Bangladesh the jackfruit normally matures from early May to end of July but the peak season is usually June.

2.4 Growth Requirement :

The jackfruit is adapted to humid tropical and sub-tropical climates. It thrives from sea level to an altitude of 1,600 m. The species extends also into much drier and cooler climates than that of other *Artocarpus* species (Popenoe, 1974) such as breadfruit. Jackfruit can be grown in a wide range of climates from intermediate to wet and moist types in Bangladesh, India and Sri Lanka. The tree bears good crops particularly between latitudes of up to 25º N and S of the equator, and up to 30º N and S (Soepadmo, 1992). Trees grown above 1,330 m grow poorly and the fruits if any are of poor quality. The quality is better at the lower elevation from 152-213 m (Crane *et al.*, 2003). For optimum production, jackfruit requires warm, humid, climates and evenly distributed rainfall of at least 1,500 mm (Baltazar, 1984; Concepcion, 1990). Growth will be retarded if rainfall is less than 1,000 mm. Jackfruit trees are not tolerant to continuously wet and/or flooded soil conditions and the trees may decline or die after 2-3 days of wet soil conditions. For the production of jackfruit the annual rainfall should be 1,000-2,400 mm or more.

2.5 Nutrition Composition of Jackfruit :

Jackfruit contains vitamin A, vitamin C, thiamin, riboflavin, calcium, potassium, iron, sodium, zinc, and niacin among many other nutrients. Jackfruit has a low caloric content: 100 g of jackfruit only contains 94 calories (Mukprasirt and Sajjaanantakul, 2004).

Jackfruit is a rich source of potassium with 303 mg found in 100g of jackfruit. Studies show that food rich in potassium helps to lower blood pressure. It is also rich in energy, dietary fiber which makes it a good bulk laxative. Jackfruit seeds are a good source of starch (22%) and dietary fiber (3.19%) (Hettiarachchi *et al*., 2011). Jackfruit seed contains lignans, isoflavones, saponins, all phytonutrients and their healthy benefits are wide-ranging from anticancer to anti hypertensive, anti aging, antioxidant, antiulcer, and so on (Omale and Friday, 2010).

2.6 Nutrition Benefit of Jackfruit :

Jackfruit contains phytonutrients: lignans, isoflavones, and saponins that have health benefits that are wide ranging. These phytonutrients have anticancer, antihypertensive, antiulcer and anti-aging properties. The phytonutrients found in jackfruit, therefore, can prevent formation of cancer cells in the body, can lower blood pressure, can fight against stomach ulcers, and can slow down the degeneration of cells that make the skin look young and vitae. Jackfruit also contains niacin that is known as vitamin B3 and necessary for energy metabolism, nerve function, and the synthesis of certain hormones. A portion of 100 g of jackfruit pulp provides 4 mg niacin (Soobrattee *et al*., 2005). The recommended daily amount for niacin is 16 mg for males and 14 mg for females (Institute of Medicine, 2000). The jackfruit contains many carotenoids (De Faria *et al*., 2009) including all-trans-β-carotene which is important antioxidant for human health (Cadenas and Packer, 1996). Jackfruit containing carotenoids can be important for the prevention of several chronic degenerative diseases, such as cancer, inflammation, cardiovascular disease, cataract, age-related macular degeneration (Krinsky *et al*., 2003; Stahl and Sies, 2005). It is also rich in energy, dietary fiber which makes it a good bulk laxative. The fiber content helps to protect the colon mucous membrane by decreasing exposure time and as well as binding to cancer causing chemicals in the colon (Morton, 1987) as well as mineral and vitamins. In addition, it is one of the rare fruit that is rich in B-complex group of vitamins. It contains very good amounts of vitamin B-6 (pyridoxine), niacin, riboflavin, and folic acid. The pulp and seeds of jackfruit are considered as a cooling and nutritious tonic.

2.7 Medicinal and Functional Properties of Jackfruit :

The presence of high fiber content (3.6 g/100 g) in the jackfruit prevents constipation and produces smooth bowel movements. It also offers protection to the colon mucous membrane by removing carcinogenic chemicals from the large intestine (colon) (Siddappa, 1957). Jackfruit is rich in magnesium (27 mg/100 g in young fruit and 54 mg/100 g in seed) (Gunasena *et al.,* 1996). It is a nutrient important in the absorption of calcium and works with calcium to help strengthen the bones and prevents bone-related disorders such as osteoporosis (Singh *et al*., 1991). Jackfruit also contains iron (0.5 mg/100 g), which helps to prevent anemia and also helps in proper blood circulation (Singh *et al.,* 1991). Copper (10.45 mg/kg) plays an important role in thyroid gland metabolism, especially in hormone production and absorption and jackfruit is loaded with these important micro minerals (Gunasena *et al*., 1996). The benefit of eating jackfruit is that it is a good source of vitamin C. The human body does not make vitamin C naturally it must be eaten in food that contains vitamin C to reap its healthy benefits. Jackfruit is gluten-free and casein-free, thus offer systemic anti-inflammatory benefits to skin. Jackfruit also contains antioxidants and has vitamin C, flavonoids, potassium, magnesium and fiber. Vitamin C is vital to the production of collagen, a protein that provides skin with structure and gives it its firmness and strength (Babitha *et al*., 2004). Potassium in the jackfruit is found to help in lowering blood pressure and reversing the effects of sodium that causes a rise in blood pressure, which affects the heart and blood vessels. This helps in preventing heart disease and stroke. Potassium also helps in preventing bone loss and improves muscle and nerve function. Another heart-friendly property found in the jackfruit is due to vitamin B6 that helps reduce homocysteine levels in the blood thus lowering the risk of heart disease (Fernando *et al*., 1991). Jackfruit seed powder contains manganese and magnesium elements (Barua and Boruah, 2004). Seeds also contain two lectins namely jacalin and artocarpin. Jacalin has been proved to be useful for the evaluation of the immune status of patients infected with human immunodeficiency virus 1 (Haq, 2006).

Table 1: The use of jackfruit in local medicine

No.	Plant part	Use
1	Roots	An extract of roots is used in treating skin diseases, asthma and diarrhea.
2	Leaves	An extract from leaves and latex cures asthma, prevents ringworm infestation and heals cracking of feet. Leaf extract is given to diabetics as a control measure. Heated leaves are reported to cure wounds, abscesses and ear problems and to relieve pain. An infusion of mature leaves and bark is used to treat gallstones. A tea made with dried and powdered leaves is taken to relieve asthma. The ash of jackfruit leaves burned with maize and coconut shells is used alone or mixed with coconut oil to heal ulcers.
3	Flowers	Crushed inflorescences are used to stop bleeding in open wounds.
4	Fruits	Ripe fruits are laxative.
5	Pulp	The jackfruit pulp and seeds are nutritious tonic and useful in overcoming the influence of alcohol on the system.
6	Seed	The seed starch is given to relieve biliousness. Roasted seeds are regarded as an aphrodisiac. Increased consumption of ripe jackfruit kernels alleviates vitamin A deficiency. Extract from fresh seeds cures diarrhea and dysentery. Extract from seeds (or bark) helps digestion.
7	Bark	An extract from bark and rags (non edible portion of ripe fruits) or roots helps cure dysentery. The bark is made into poultices. Ash

		produced by burning bark can cure abscesses and ear problems.
8	Latex	Mixed with vinegar, the latex promotes healing of abscesses, snakebites and glandular swellings.
9	Wood	The wood has a sedative property; its pith is said to aid abortion

Source: Haq (2006).

2.8 Other Uses of Jackfruit :

The fruit provides about 2 MJ of energy per kg /wet weight of ripe perianth (Ahmed *et al.*, 1986). The unripe fruits are used in vegetable curries and pickles (Prakash *et al.,* 2009). The ripe fruits are used to make ice cream, squash, drinks, halwa, jam, and jelly. The pulp is desiccated and used as dried fruit during off season. Fruit can also be used to prepare alcoholic liquor (Elevitch and Manner, 2006).

Figure 1: Preserved jackfruit in sugar syrup

Figure 2: Jackfruit beverages

Jackfruit has been reported to contain high levels of protein, starch, calcium, and thiamine (Burkill, 1997). The seeds may be boiled or roasted and eaten or boiled and preserved in syrup like chestnuts. Roasted, dried seeds are ground to make flour that is blended with

wheat flour for baking (Morton, 1987). In addition to unique flavor of the ripe fruit, the jackfruit seed is widely consumed as a dessert or an ingredient in Asian culinary preparations. The jackfruit seeds are used in cooked dishes and its flour is used for baking. Jackfruit seeds are fairly rich in starch (Singh *et al*., 1991). Mature jackfruits are cooked as vegetables and used in curries or salads (Narasimham, 1990). Ripe fruits can be eaten raw, or cooked in creamy coconut milk as dessert, made into candied jackfruit or edible jackfruit leather. Pureed jackfruit is also manufactured into baby food, juice, jam, jelly, and base for cordials. In India, the seeds are boiled in sugar and eaten as dessert (Roy and Joshi, 1995).

Figure 3: Preserved jackfruit bulbs under vacuum.

Figure 4: Jackfruit toffee.

Jackfruit is also processed into other products. For instance, jackfruit leather and jackfruit chips can be made from dried jackfruit pulp (Nakasone and Paull, 1998). Jackfruits are made into candies, fruit-rolls, marmalades, and ice cream. Other than canning, advances in processing technologies too, have pushed toward more new products (Narasimham, 1990). Freeze-dried, vacuum-fried, and cryogenic processing are new preservation methods for modern jackfruit-based products. Various parts of the jackfruit tree have been used in medicine and its wood as an important source in the timber industries (Roy and Joshi, 1995). Jackfruit is an important tree in home gardens in India, the Philippines, Thailand, Sri Lanka, and other regions where Jackfruit is grown commercially and is perhaps the most widespread and economically important *Artocarpus* species, both providing fruit and functioning as a visual screen and ornamental. The wood of jackfruit, which ages to an

orange or red-brown color, is highly durable, resisting termites and decay (Elevitch and Manner, 2006). A yellow dye is sometimes extracted from the wood and used for dyeing clothes, especially in India and the Far East (Seddon and Lennox, 1980).Rinds and other waste parts of the fruits have high value as a nourishing feed for livestock, especially for sheep (Sudiyani *et al.,* 2002). The leaves are not eaten by humans but are used as food wrappers in cooking and fastened together to make plates in many parts of the Indian subcontinent. However, young leaves are. readily eaten by cattle and other livestock. Sole feeding of jackfruit tree leaves can meet the maintenance requirements of a goat, similar results have been reported from the evaluation of digestibility of leaves for pigs (Ly *et al.*, 2001). Jackfruit leaves are good sources of calcium (Ca) and sodium (Na) and if combined with rice bran give better growth for ruminants.

2.9 Jackfruit Jam :

Jam is an intermediate moisture food prepared by boiling fruit pulp with sugar (sucrose), pectin, acid, and other ingredients (preservative, coloring, and flavoring materials) to a reasonably thick consistency, firm enough to hold the fruit tissues in position (Baker *et al*., 2005; Lal *et al*., 1998). Jam is a mixture brought to a suitable gelled consistency of sugars, the pulp and/ or purée of one or more kinds of fruit and water (www.agriculture.gov.ie). Generally, jam is produced by taking mashed or chopped fruit or vegetable pulp and boiling it with sugar and water. The proportion of sugar and fruit varies according to the type of fruit and its ripeness, but a rough starting point is equal weights of each. When the mixture reaches a temperature of 104 °C, the acid and the pectin in the fruit react with the sugar, and the jam will set on cooling (Berolzheimer *et al*., 1959).

The jackfruit pulp can be used to make jam. The addition of a synthetic flavoring agent such as ethyl or n-butyl ester of 4-hydroxybutyric acid at 100 and 120 ppm, respectively, will greatly improve the taste of the jackfruit products (ICUC, 2004). Other fruit jams in supermarkets are mixed with a generous amount of sugar, which increases the risk for diabetes. On the contrary, jackfruit jam is full of natural sugars and low in calories making it an ideal food source to reduce body weight.

2.10 Existing Jackfruit Jam :

Outside of its countries of origin, fresh jackfruit can be found at Asian food markets, especially in the Philippines, Thailand, Vietnam, Malaysia, Cambodia, and Bangladesh. Many of these countries process jackfruit into jam in a traditional way, but Kerara, Vietnam and Sri lanka have started small industries for processing jackfruit. In Kerala, India two varieties of jackfruit predominate and koozha .Varikka has a slightly hard inner flesh when ripe, while the inner flesh of the ripe koozha fruit is very soft and almost dissolving. A sweet preparation called chakka varattiyathu (jackfruit jam) is made by seasoning pieces of varikka fruit flesh in jaggery, which can be preserved and used for many months (www.enwikipedia.org). Also the Grandmas food company in Kerara, India produces jackfruit jam as one of its products (www.tradeindia.com). In Vietnam they produce different jackfruit products including jackfruit and pineapple fruit of 225g (naturallyvietnam.com). Advances in jackfruit jam development have been seen in quiet a few numbers of scientific publications. Eke- Ejiofor and Owuno (2013) did a study on the Physiochemical and sensory properties of jackfruit (*Artocarpus heterophyllus*) jam and concluded that the developed jam had high total acidity this shows it can be stored for a long period. With its high nutrients composition and sensory attributes it can successfully be used for jam preparation. Also, (Ihediohanma *et al.*, 2014) evaluated the sensory quality of jam produced from jackfruit. He concluded that jackfruit is promising industrial source of pectin which can be successfully applied in food gel systems and the lower pH create preserved and stable jam which is less prone to microbial spoilage. Furthermore, production of pectin using jack fruit should be encouraged and use of jam produced from jack fruit could be an innovation.

2.11 Requirements for Jam Making :

Factors that have an influence on quality of jam consist of color content, taste, flavor, and texture and nutritional value. All the parameters mentioned are affected from the nature of the raw material and the processing conditions. For manufacture of traditional jam fruit, sugar, pectin and organic acids such as citric acid are used. In traditional products a high content of soluble solids is desired in order that the products shelf life increases and it can be stored and transported in ambient temperatures. The high content of soluble solids is

achieved by adding sugar to around 55%. The quality of the raw material and the manufacturing process are the indicators of the final products quality (Nindo *et al*., 2005). Citric acid is considered necessary to correct the balance which is needed in jam production. Lime and lemon juice are high in citric acid therefore they can be used as a replacement of citric acid in jam manufacture (Cancela *et al*., 2005). The added sugar acts as a dehydrating agent for the pectin molecules, permitting closer contact between the chain molecules (Suutarinen, 2002). Pectin is also the most important in the food industry as a thickening agent because it brings changes in the texture or flow behavior of the final product (Endress *et al*., 2005).

Product quality is the major determinant of consumer choice. The ingredients affect the jam quality in terms of both subjective (sensory) and objective (textural and rheological) attributes. Product quality is one of the prime factors in ensuring good final processed jackfruit products. It is known that quality is a combination of various parameters such as color, appearance, shape, size, texture and taste. Therefore jackfruit should be well ripened, free from defects example sunburn, cracks bruises and decay in order to get suitable jam product (Sallel *et al*., 2000).

2.12 Product Development Technologies/Concept :

The new product development literature emphasizes the importance of introducing new products in the market for continuing business success. Its contribution to the growth of the companies, its influence on profit performance and its role as a key factor in business planning have been well documented (Urban and Hauser, 1993; Cooper, 2001; Ulrich and Eppinger, 2011). New products are responsible for employment, economic growth, technological progress, and high standards of living. In the last few decades, the number of new product introductions increased dramatically as the industry became more aware of the importance of new products to business. For every seven new product ideas, about four enter development stage, one and a half are launched, and only one succeeds (Booz *et al*., 1982). As the number of dollars invested in NPD goes up, the pressure to maximize the return on those investments also goes up.

The product development process consists of the activities carried out by firms when developing and launching new products. A new product that is introduced in the market

evolves over a sequence of stages, beginning with an initial product concept or idea that is evaluated, developed, tested and launched on the market (Booz *et al*., 1982). This sequence of activities can be viewed as a series of information gathering and evaluation stages. In effect, as the new product evolves, management becomes increasingly more knowledgeable (or less uncertain) about the product and can assess and reassess its initial decision to undertake development or launch. The product development process differs from industry to industry and from firm to firm. Indeed it should be adapted to each firm in order to meet specific company resources and needs.

Many have tried to develop a model that captures the relevant stages of the NPD process (Ulrich and Eppinger, 2011; Cooper, 2001). A number of detailed models have been developed over the years, the best known of which is the Booz *et al*. (1982) model, shown in Figure 5. It is based on extensive surveys, in depth interviews, and case studies and appears to be a fairly good representation of prevailing practices in industry.

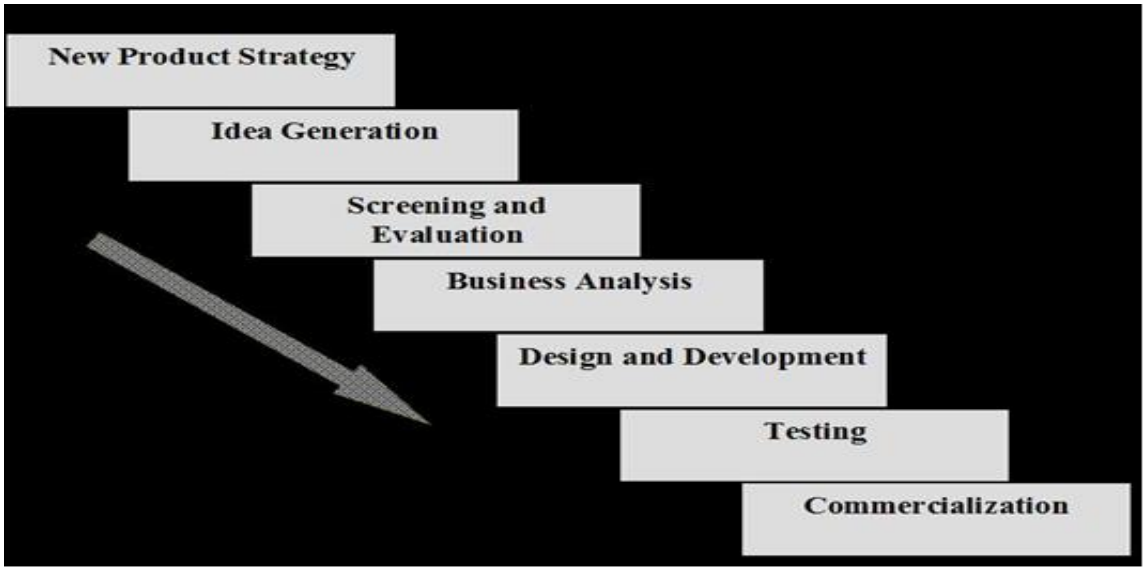

Figure 5: Stages of new product development (Booz *et al*., 1982)

- The stages of product development model are as follows:
- New Product Strategy- links the NPD process to company objectives and provides focus for idea/concept generation and guidelines for establishing screening criteria,
- Idea generation- searches for product ideas that meet company objectives,

- Screening- Comprises of an initial analysis to determine which ideas are pertinent and merit more detailed study,

- Business analysis- Further evaluates the ideas on the basis of quantitative factors, such as profits, Return-on-investment and sales volume,

- Development- Turns an idea on paper into a product that is demonstrable and producible,

- Testing- Conducts commercial experiments necessary to verify earlier business judgments and
- Commercialization- Launching of products (Bhuiyan, 2011).

2.13 Method of Statistical Analysis

It is noteworthy that the use of mathematical and statistical methods, including chemo metrics and many other statistical methods/algorithms, in food science and technology has increased steeply in the last 20 years and this trend is clearly followed by the development of different algorithms and computational software that facilitates the widespread use of those methods. This trend can be attributable to the low cost of computers and the increasing capacity of processing techniques to analyze complex and high volumes of experimental results. In addition, there is a concern by software developers in providing computational packages with user-friendly interfaces. In this sense, mathematicians and statisticians have optimized and developed new methods to solve problems in different areas, such as medicine, chemistry, agronomy, biology, food science and technology, among others. These methods or models have been implemented in computational packages (software) and scientists have been benefited from their use as the manual calculation is time-consuming and usually imprecise (Granato *et al.*, 2014). Is a multivariate technique that simplifies and describes interrelationships among multiple dependent variables (in sensory data these are usually the descriptors) and among objects (in sensory data these are usually the products) (Anderson, 2003; Tabachnik et al.,2006).

Many statistical software are available for the data analysis. Although there are a large variety of free software (freely downloaded and used in their fully-functional mode), such as OpenStat, SOFA, EpiInfo, ViSta, and PSPP, many statistical software need to be purchased in order to be used, and licenses, overall, need to be upgraded from time to time, which is somehow a limiting factor for young scientists and students. Some of these commercial software are Statistica, Stata, Unscrambler, Minitab, SAS, Pirouette, Design-Expert, Matlab, MathCad, Statistical Package for the Social Sciences = SPSS, Origin, Microsoft Excel, among others.

Proximate, sensory and carotenoids data was collected in Microsoft excel 2007 spread sheet. Afterwards data were exported to SPSS 17 (SPSS Inc., 233 South Wacker Drive, 11th Floor, Chicago, IL 60606-6412). Data were sorted, coded and recorded before statistical analysis in SPSS 17 software. Proximate and sensory data was analyzed by one way ANOVA test to assess the significant level of variation at 95% confidence interval (CI). Post hoc (Turkey) test was done to identify the variation between sample groups. Descriptive statistics (frequency, means, standard deviation and error mean) were performed for different samples. From the ANOVA, one may find that many descriptors significantly discriminate among the samples; however, several descriptors may be describing the same characteristic of the product.

CHAPTER III

3.0 MATERIALS AND METHODS

3.1 Study Area

The study was conducted at Department of Applied Chemistry and Chemical Technology, Chittagong Veterinary and Animal Sciences University, Khulshi-4225, Chattogram, Bangladesh.. Product development and laboratory analysis was done at the Department of Applied Chemistry and Chemical Technology and Food Processing And Engineering.

Figure 6: Geographical locations of the study area (CVASU)

3.2 Materials

Three fresh ripe jackfruits (*Artocarpus heterophyllus Lam*) were purchased from Reazuddin Bazar, New Market, Chattogram. Sugar, Flour, Whole Egg, Oil, Lemons, Plastic Basin, Muslim Cloth commercial mango jam and Sieves were all purchased from Khulshi Mart, West Khulshi, Chattogram . Jam bottles were purchased from RFL plastic, Pahartoli, Chattogram. Cake Gel, Cake Mix, Glycerin, Sorbitol, Vanilla Flavor, SAPP, SBC, Liquid Glucose, Potassium Sorbet, Citric Acid, Ascorbic Acid, Pectin & Color were purchased from 3 Bundle Road, Pathorghata, Chattogram. Analytical food grade reagents and chemicals were obtained from Department of Applied Chemistry & Chemical Technology at CVASU.

3.3 Methods

3.3.1 Research Design

The entire study was divided into three major categories: production jackfruit of jam, nutritional evaluation of jackfruit jam and jackfruit, develop a new variety food product by using jackfruit jam and shelf life observation. A purposive sampling procedure was used to collect a fresh ripen jackfruit from Reazuddin Bazar in order to obtain fruits with better quality. A total of 3 jackfruits were collected and processed into jam and the remaining fresh sample was kept for further analysis. Crude protein, moisture content, dietary fiber, crude fat, ash content, carbohydrate, minerals content, vitamin C, pH, total titratable acidity were determined of jackfruit and jackfruit jam. A new variety food product was developed by using jackfruit jam. In this study jackfruit jam cake was developed and observed shelf life of this product about three months. Complete Randomized design (CRD) was used in this study. In this study Statistical Package for the Social Sciences (SPSS) software was used for statistical analysis. The experimental design is schematically presented in chart below.

1. Production of jackfruit jam.	**2. Nutritional Evaluation.**	**3. Develop a new variety food**
A. Recipe development for production of jackfruit jam.	A. Crude protein. B. Moisture content. C. Dietary fiber. D. Crude fat. E. Ash content. F. Carbohydrate. G. Minerals content. H. Vitamin C. I. pH. J. Total titratable acidity.	A. Develop a new variety food product by using jackfruit jam e.g. jackfruit jam cake.

3.3.2 Jam Production

Fresh ripe jackfruits were washed thoroughly with tap water to remove all the dirt. Then they were cut diagonally and fresh bulbs were separated from seeds and other unwanted materials. The jackfruit bulb weighed about 4 kg 128 gram were mixed with 3 liters of water and boiled for about 10 minutes to soften the mixture for easy homogenization. After boiling the mixture was blended with fruit grinder and later sieved with a 2mm mesh sieve and the resulting jackfruit pulp was weighed to 7 kg. Then 3 kg 769 gram of sugar and 10 ml of lemon juice together were added to the pulp whereby the lemon juice was used to add acid in order to lower pH and increase pectin in jam. The following formula was used to determine the amount of sugar to be added to the fruit pulp to meet the jam requirement:

$$Sugar\ to\ be\ added = \frac{TSS(Final) - TSS(Pulp)}{100} \times W$$

Where TSS (final) - is required sugar level of the jam which is 69%; TSS (pulp) - sugar level of the pulp and W- weight of the pulp used (in grams). The juice mixture was cooked on a gas cooker until the brix reached 69^0. The hot jam was then poured into sterilized bottles and covered with a lid and left to cool at room temperature (Molla et al., 2011). In the cooking time 15 gram citric acid, 15 gram pectin, 5 gram ascorbic acid, 0.5 gram egg yellow color and 5 gram potassium metabisulfite was added for the production of jackfruit jam.

Table 2 : Recipe of Jackfruit Jam

Serial No.	Name of Ingredient	Quantity
1.	Jackfruit Bulb	4 kg 128 gram
2.	Sugar	3 kg 769 gram
3.	Citric Acid	15 gram
4.	Pectin	15 gram
5.	Ascorbic Acid	5 gram
6.	Potassium Metabisulfite	5 gram
7.	Egg Yellow Color	0.5 gram
8.	Lemon Juice	10 ml
9.	Water	3 kg

Flow diagram for jackfruit jam manufacture :

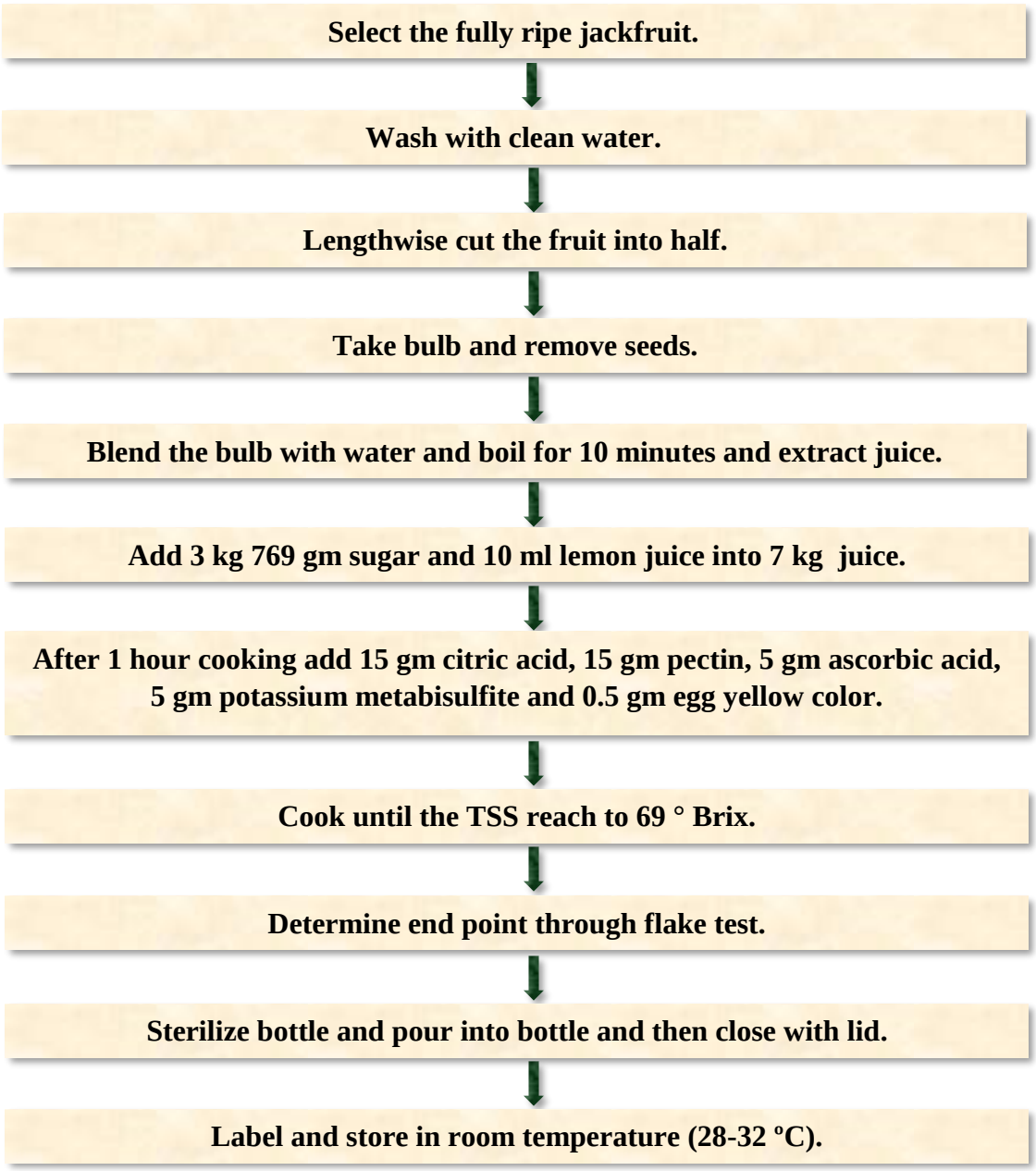

Figure 7 : Flow diagram for jackfruit jam manufacture.

3.3.3 Cake Production

3.3.3.1 Raw Materials of Cake

Wheat Flour (Gluten 8-9%), Xanten Gum, Custer Sugar, SAPP, SBC, Liquid Glucose, Potassium Sorbet, Cake Mix, Cake Gel, Whole Egg, Palm Oil, Glycerin, Sorbitol, Vanilla Flavor, Common Salt and Cold Water.

Table 3 : Recipe of Cake

Serial No.	Name of Ingredient	Quantity (gm)	Percentage (%)
1.	Wheat Flour (Gluten 8-9%)	212.0	31.51
2.	Xanthen Gum	0.8	0.119
3.	Custer Sugar	175.0	26.01
4.	Common Salt	1.3	0.193
5.	SAPP	2.1	0.312
6.	SBC	0.7	0.104
7.	Liquid Glucose	7.6	1.13
8.	Potassium Sorbet	4.0	0.595
9.	Cake Mix	10.0	1.486
10.	Cake Gel	3.0	0.446
11.	Whole Egg	100.0	14.86
12.	Palm Oil	90.0	13.38
13.	Glycerin	10.0	1.486
14.	Sorbitol	5.0	0.743
15.	Vanilla Flavor	1.3	0.193
16.	Cold Water	50.0	7.432
	Total	672.8	100

3.3.3.2 Production Process of Cake

All the raw materials were collected and weighted. Sugar, salt and egg were mixed in the mixer for 10 minutes at high speed. Then xanthen gum, cake mix, cake gel, glycerin,

potassium sorbet, sorbitol, vanilla flavor, liquid glucose and cold water were added to the mixer and mixing for 10 minutes at high speed. Then flour, SAPP, SBC and palm oil were added to the mixer and mixing for 1 minute at medium speed. Specific gravity was checked because for cake production specific gravity is very important and the range of specific gravity is 0.55 to 0.65 for cake production. Then dough was baked at 180 degree celsius temperature for 30 minutes in the tunnel oven. After baking prepared cake was cooled for 20 minutes. Then cake was separated from cup and it was stored at room temperature

Flow diagram for cake manufacture :

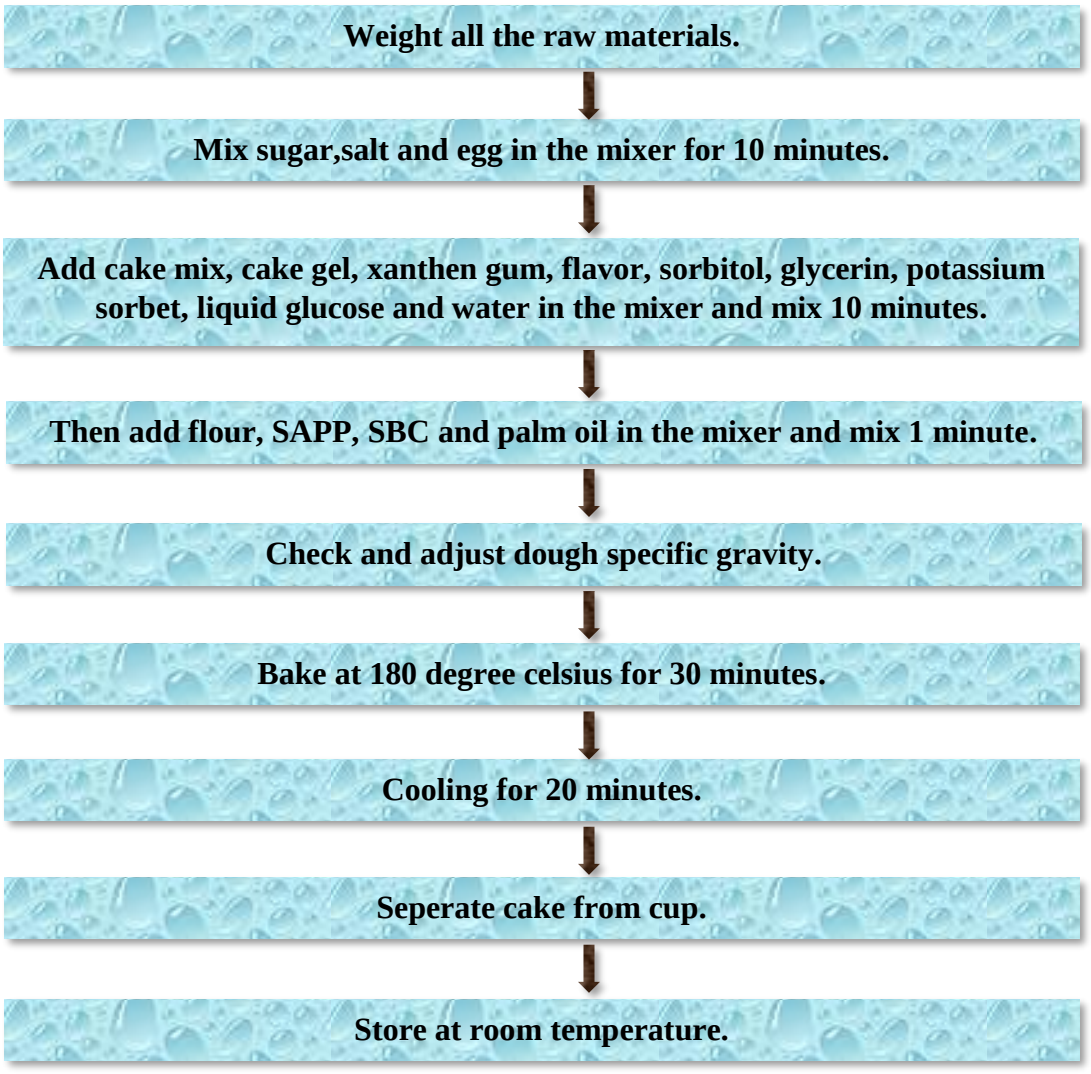

Figure 8 : Flow diagram for cake manufacture.

3.3.4 Jackfruit Jam Cake Preparation

After preparation of jackfruit jam and cake, jackfruit jam was injected to cake by injector. Then jackfruit jam cake was packaged and it was stored at room temperature for.

Figure 9 : Jackfruit jam cake preparation.

3.3.5 Chemical Analysis

The proximate analysis (moisture, ash, fat, crude fiber, crude protein)and minerals of the fresh jackfruit and jam were analyzed according to standard AOAC (1995) and for vitamin C according to AOAC (2000). Moisture content was determined by method number 925.09, ash content by method number 923.03, crude fiber by method number 920.86, crude protein by macro kjeldah method number 920.87 and Carbohydrate content was calculated as percentage difference. Total soluble solids (Brix %) was determined using a

hand refractometer- Mettler Toledo model LXC59107 Japan, pH was determined using a digital pH meter model – pH 010 (ATC), Total titratable acidity (TTA) was determined by the AOAC (1995) method. The samples were analyzed in duplicate for crude protein, crude fiber, crude fat, moisture, and ash contents. The average values of the three measurements were obtained.

3.3.5.1 Determination of Crude Protein

Crude protein content of fresh and jackfruit jam were determined by macro kjeldah method number 920.87. About 1gm portion of the samples was weighed onto a tarred filter paper. The samples were wrapped securely and dropped into a 100 ml Kjeldahl digestion tube. A blank was prepared by dropping a piece of filter paper without sample into a separate 100 ml digestion tube. To each tube, 2 g of Kjeldahl catalyst and 5.0 ml of concentrated sulphuric acid was added. Samples were digested until a clear, blue solution was obtained and digestion continued further to allow the nitrogen held in the heterocyclic ring to be released. The digest was cooled and then 20 ml of distilled water was added to dissolve the content. The dilute digest was distilled using macro-distillation apparatus (Kjeltec^{TM}8200 Auto Distillation Unit, 2012). 50 ml of 40% sodium hydroxide was added to the digest to facilitate the release of ammonia. Ammonia was extracted by steam distillation and collected in a 50 ml flask containing 4% boric acid. The distillate was titrated with 0.1520 N HCl standard solution using bromocresol green methyl red mixture as an indicator. Nitrogen content was calculated using the formula shown in equation:

$$\%\ Nitrogen\ = \frac{(Titre\ blank)\ in\ ml \times Conc.\ of\ acid\ N/mol}{Weight\ of\ sample\ (gm)} \times 100$$

Percentage protein was calculated from the percentage nitrogen using the factor 6.25 for plant materials as shown in equation:

$$\%CP = \%N\ \times Factor\ (6.25)$$

3.3.5.2 Determination of Moisture Content

Moisture content of fresh and jackfruit jam was determined by method number 925.09 as described by AOAC (1995). The crucibles were washed and dried in an oven at 105^0C for three hours and cooled in desiccators. Then crucibles were weighed. About 2 g of the sample was weighed in the crucible. The sample was spread in the crucible and subjected into drying in an oven at 105^0C for approximately 48 hrs. After drying, the crucibles were transferred to the desiccators for cooling. The crucibles were reweighed after cooling. The percentage moisture content was then calculated with the formula shown in equation.

Calculation:

$$\%Moisture\ Content\ = \frac{W1\ - W2}{W1} \times 100$$

Whereby;

W1 is weight of sample (gm) before drying and W2 is weight of sample (gm) after drying.

3.3.5.3 Determination of Dietary Fiber

Dietary fiber of fresh and jackfruit jam were determined by method number 920.86. About one gram of each samples were taken for crude fiber determination with Fibertec^{TM}1020 FOSS model 2012. The samples were first digested by dilute sulphuric acid (0.125M) for 30 minutes and washed three times with hot water. The residue was then digested by dilute alkali (0.125M KOH) for another 30 minutes and then washed by hot water three times. Digested residue was dried in an oven for 5 hours then cooled and weighed. The residue was then placed in muffle furnace and incinerated for 2 hours temp 525^0C, then cooled and weighed again. Total fiber content was calculated by using the formula shown in equation:

$$\%\ Crude\ Fibre = \frac{W1\ (gm) - W2\ (gm)}{W\ (gm)} \times 100$$

Where;

W1 is weight of sample residue before incineration (gm), W2 is weight of sample residue after incineration (gm) and W is weight of dry sample taken for determination (gm).

3.3.5.4 Determination of Crude Fat

Crude fat of fresh and jackfruit jam were determined by ether extraction using the Soxtec System AOAC (1995) method number 920.65 was used. The method involved extracting crude fat from the samples into petroleum spirit (40-60^{o}C), which was then evaporated, and the weight of the crude fat was determined. About 6 grams of pre-dried samples were weighed and placed into extraction thimble. The thimbles were covered with fat free cotton and placed in the central part of the Soxtec apparatus. 60 ml of petroleum ether were poured into the pre-dried and pre-weighed cups and adjusted to the Soxtec extractor where extraction process took place for approximately one hour. After extraction, the cups with fat extract were further dried in the oven at 105^{o}C for 30minutes, and then cooled in desiccators for 30 minutes and the weighed. Percentage crude fat content was calculated using equation:

$$\%\ Crude\ Fat = \frac{Weight\ of\ Crude\ Fat\ (gm)}{Weight\ of\ Dry\ Sample\ (gm)} \times 100$$

3.3.5.5 Determination of Ash Content

The ash content of fresh and jackfruit jam samples was determined by using a muffle furnace as described in standard method (AOAC, 1995), official method 923.03. About 5 grams of each sample in duplicate were placed in a pre-weighed crucible and dried in an oven at 105^{0}C for about approximately 48 hours. The dried samples were weighed and then placed in muffle furnace at 550^{o} C for 3 hours until white or grey ash was obtained. The samples were then cooled in desiccators to room temperature and weighed. Percentage ash was calculated using equation:

$$\%\ Ash\ Content = \frac{Weight\ of\ Ash\ (gm)}{Weight\ of\ \ Sample\ (gm)} \times 100$$

3.3.5.6 Determination of Carbohydrate

Carbohydrate content of fresh and jackfruit jam was calculated as percentage by difference (AOAC, 1995). The following formula is depicted in equation:

% Carbohydrate = 100 – (% Moisture+ % Protein + % Crude fiber +% Crude fat +% Ash content)

3.3.5.7 Determination of Minerals Content

Mineral content of fresh jackfruit and jam were determined by the use of Unicam 919 Atomic Absorption Spectrophotometer U.K method described in AOAC (1995), Official Method number. 968.08. Test portions were dried and then ashed at 450^0C under a gradual increase (about 50^0C/hr) in temperature. The obtained ash from ash determinations were used for analysis of minerals according to the AOAC (1995) procedures. The ash was dissolved in 20 ml of 1N HCl and heated for 5minutes at 70^oC.The solute was then transferred quantitatively to a 100 ml volumetric flask and made up to volume with distilled water. Mineral content (Calcium, sodium, iron, zinc, and potassium) were determined by Atomic Absorption Spectrophotometer method as described in Method number 968.08. It was done at the Food Testing Lab, Dhaka. The absorbance of sample and standard solutions was determined. The standard curve plot of absorbance against the known concentration of standard solutions was used to determine the concentration of minerals in samples and expressed as shown in equation:

$$\%\ Mineral\ Content\ mg/100gm = \frac{R\ \times Extract\ volume\ (l)}{S\ (kg)} \times D.F.$$

Where,

R = mineral concentration in ppm (mg/Kg) as calculated using linear regression equation,

D.F = Dilution Factor and

S = sample weight (Kg).

3.3.5.8 Determination of Vitamin C

Vitamin C for fresh jackfruit bulb and jackfruit jam was determined by 2, 6-Dichlorophenol indophenols (DCIP) sodium salt method (AOAC, 2000 method 967.21). Under this method, titration was performed in the presence of phosphoric acid/acetic acid solution to maintain proper acidity (pH 1 - 3) for titration and to inhibit oxidation of the acid whereby 5g of grinded jackfruit sample as well as jam sample were taken into 250ml Erlenmeyer flask. 50ml of Orthophosphoric acid were added to extract, to lower pH as well as to deproteinize the sample. The extracted samples were then filtered and titrated against standardized Dichlorophenol indophenols until pink color which is the end point of the reduction process was observed. The volume of Dichlorophenol indophenols used was recorded and vitamin C content in samples was calculated according to equation:

$$Mg\ of\ Ascorbic\ Acid = (X - B) \times (F/E) \times (V/Y)$$

Where,

X = titrate value,

B = blank,

F = mg of ascorbic acid equivalent to 1.0ml indophenols,

E = number of ml assayed,

V = initial assay solution volume and

Y = volume of sample aliquot titrated.

3.3.5.9 Determination of Total Titratable Acidity

Acidity, expressed as total titratable acidity (TTA) was determined according to AOAC (1995) method 942.15 and 920. 49 standard methods by titrating 5 ml of the jackfruit pulp and jam diluted to 250 ml of boiled water against 0.1 M NaOH standard solution using 0.3 ml phenolphthalein indicator for each 100ml of solution to pink end point persisting for 30 seconds (AOAC, 2000). Reported acidity as ml 0.1N NaOH per 100 ml was calculated as shown in equation:

$$Total\ Titratable\ Acidity\ gm/100gm = \frac{Titre\ Volume\ \times N}{Sample\ Weight} \times 100$$

Where,

N is Normality of the Alkali used.

3.3.6 Determination of pH

In chemistry, pH is a measure of the acidity or basicity of an aqueous solution. Solutions with a pH less than 7 are said to be acidic and solution with a pH greater than 7 are basic or alkaline. Pure water has a pH very close to7.In technical terms, pH is the negative logarithm of the activity of the (solvated) hydronium ion, more often expressed as the measure of the hydronium ion concentrations. The pH scale is traceable to a set of standard solutions whose pH is established by international agreement. Primary pH standard values are determined using a concentration cell with transference, by measuring the potential difference between a hydrogen electrode and a standard electrode such as the silver chloride electrode. Measurement of pH for aqueous solutions can be done with a glass electrode and a pH meter, or using indicators, pH is defined as the decimal logarithm of the reciprocal of the hydrogen ion activity in a solution (McClements & Decker, 2009). pH is the most important parameter for food product quality and safety control.

3.3.7 Sensory Evaluation

3.3.7.1 Sensory Evaluation for Jackfruit Jam

Developed and control jam sample were subjected to sensory evaluation using a 7 point hedonic scale ranging from dislike very much to like very much (1 = dislike very much, 2 = Dislike moderately, 3 = Dislike slightly, 4 = Neither like nor dislike, 5 = Like slightly, 6 = Like moderately, 7 = Like very much). Ten consumer panelist members were selected randomly within Chattogram Veterinary & Animal Sciences University to perform consumer test where commercial mango jam was used as a control. All evaluation sessions were held in the laboratory of Food Science & Technology at Chattogram Veterinary & Animal Sciences University. All samples were presented before the panelists at room temperature under normal lighting conditions in white disposable plastic cups and coded with three-digit numbers. Spoons were provided to the panelists and drinking water was

provided for oral rinsing. The samples attributes assed were color, texture, taste, aroma, spreadability, sweetness and overall acceptability.

3.3.7.2 Sensory Evaluation for Jackfruit Jam Cake

Developed and control cake sample were subjected to sensory evaluation using a 7 point hedonic scale ranging from dislike very much to like very much (1 = dislike very much, 2 = Dislike moderately, 3 = Dislike slightly, 4 = Neither like nor dislike, 5 = Like slightly, 6 = Like moderately, 7 = Like very much). Ten consumer panelist members were selected randomly within Chattogram Veterinary & Animal Sciences University to perform consumer test where commercial cake was used as a control. All evaluation sessions were held in the laboratory of Food Science & Technology at Chattogram Veterinary & Animal Sciences University. All samples were presented before the panelists at room temperature under normal lighting conditions in white disposable plastic plate and coded with three-digit numbers. Drinking water was provided for oral rinsing. The samples attributes assed were appearance, texture, taste, aroma, mouthfeel. sweetness and overall acceptability.

3.3.8 Statistical Analysis

Proximate, sensory and carotenoids data was collected in Microsoft excel 2007 spread sheet. Afterwards data were exported to SPSS 17 (SPSS Inc., 233 South Wacker Drive, 11th Floor, Chicago, IL 60606-6412). Data were sorted, coded and recorded before statistical analysis in SPSS 17 software. Proximate and sensory data was analyzed by one way ANOVA test to assess the significant level of variation at 95% confidence interval (CI). Post hoc (Turkey) test was done to identify the variation between sample groups. Descriptive statistics (frequency, means, standard deviation and error mean) were performed for jackfruit, jam, and jackfruit jam cake samples. Results were expressed as mean ± SD and presented in tabular and graphical forms.

CHAPTER IV

4.0 RESULTS AND DISCUSSION

4.1 Developed Jackfruit Jam

Figure 10 shows jackfruit jam was produced from the mixture of jackfruit pulp sugar and other raw materials. Jackfruit jam was stored in glass bottles and plastic jar and labeled.

Figure 10 : Jackfruit jam (*Artocarpus heterophyllus*).

4.2 Developed Jackfruit Jam Cake

Figure 11 shows cake produced and jackfruit jam cake was produced by using jackfruit jam. Jackfruit jam cake was packaged and stored at room temperature.

Figure 11 : Jackfruit jam cake.

4.3 Gross Chemical Composition

Chemical composition of jackfruit and jackfruit jam is presented in below. The results indicate that jackfruit and jackfruit jam were significantly different in terms of crude protein, total carbohydrates, fat, ash, crude fiber, moisture, TSS, titratable acidity, pH and vitamin C. One way ANOVA (Analysis of variance) test was performed to see the overall mean difference of samples for proximate compositions. Tukey's multiple comparison test was performed to make sure for which samples were the most significant for proximate compositions. The descriptives table (table 4) provides some very useful descriptive statistics, including the mean, standard deviation and 95% confidence intervals for the dependent variable (value) for each chemical composition (crude protein, total carbohydrates, fat, ash, crude fiber, moisture, TSS, titratable acidity, pH and vitamin C), as well as when all chemical composition are combined (Total). These figures are useful to describe data.

Table 4 : Descriptives table of chemical composition

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence ... Lower Bound
Jackfruit	Moisture Content %	3	74.8967	.04509	.02603	74.7847
	Crude Protein%	3	3.8067	.02082	.01202	3.7550
	Crude Fiber%	3	.9567	.02082	.01202	.9050
	Ash Content%	3	.6000	.02000	.01155	.5503
	Crude fat%	3	1.9033	.02082	.01202	1.8516
	Carbohydrate %	3	17.8367	.11240	.06489	17.5575
	TSS%	3	23.7000	.10000	.05774	23.4516
	Titrable Acidity g/100g	3	.0700	.01000	.00577	.0452
	pH	3	5.2000	.10000	.05774	4.9516
	Vitamin C mg/100gm	3	6.2333	.01528	.00882	6.1954
	Total	30	13.5203	22.15930	4.04572	5.2459
Jackfruit_jam	Moisture Content %	3	33.4000	.20000	.11547	32.9032
	Crude Protein%	3	3.4000	.10000	.05774	3.1516
	Crude Fiber%	3	.8000	.05000	.02887	.6758
	Ash Content%	3	.4500	.01000	.00577	.4252
	Crude fat%	3	1.9733	.02517	.01453	1.9108
	Carbohydrate %	3	59.9767	.35076	.20251	59.1053
	TSS%	3	69.0000	1.00000	.57735	66.5159
	Titrable Acidity g/100g	3	.4333	.01528	.00882	.3954
	pH	3	3.8000	.10000	.05774	3.5516
	Vitamin C mg/100gm	3	13.0000	.50000	.28868	11.7579
	Total	30	18.6233	25.33845	4.62615	9.1618

Descriptives

		95% Confidence ...		
		Upper Bound	Minimum	Maximum
Jackfruit	Moisture Content %	75.0087	74.85	74.94
	Crude Protein%	3.8584	3.79	3.83
	Crude Fiber%	1.0084	.94	.98
	Ash Content%	.6497	.58	.62
	Crude fat%	1.9550	1.88	1.92
	Carbohydrate %	18.1159	17.74	17.96
	TSS%	23.9484	23.60	23.80
	Titrable Acidity g/100g	.0948	.06	.08
	pH	5.4484	5.10	5.30
	Vitamin C mg/100gm	6.2713	6.22	6.25
	Total	21.7948	.06	74.94
Jackfruit_jam	Moisture Content %	33.8968	33.20	33.60
	Crude Protein%	3.6484	3.30	3.50
	Crude Fiber%	.9242	.75	.85
	Ash Content%	.4748	.44	.46
	Crude fat%	2.0358	1.95	2.00
	Carbohydrate %	60.8480	59.64	60.34
	TSS%	71.4841	68.00	70.00
	Titrable Acidity g/100g	.4713	.42	.45
	pH	4.0484	3.70	3.90
	Vitamin C mg/100gm	14.2421	12.50	13.50
	Total	28.0849	.42	70.00

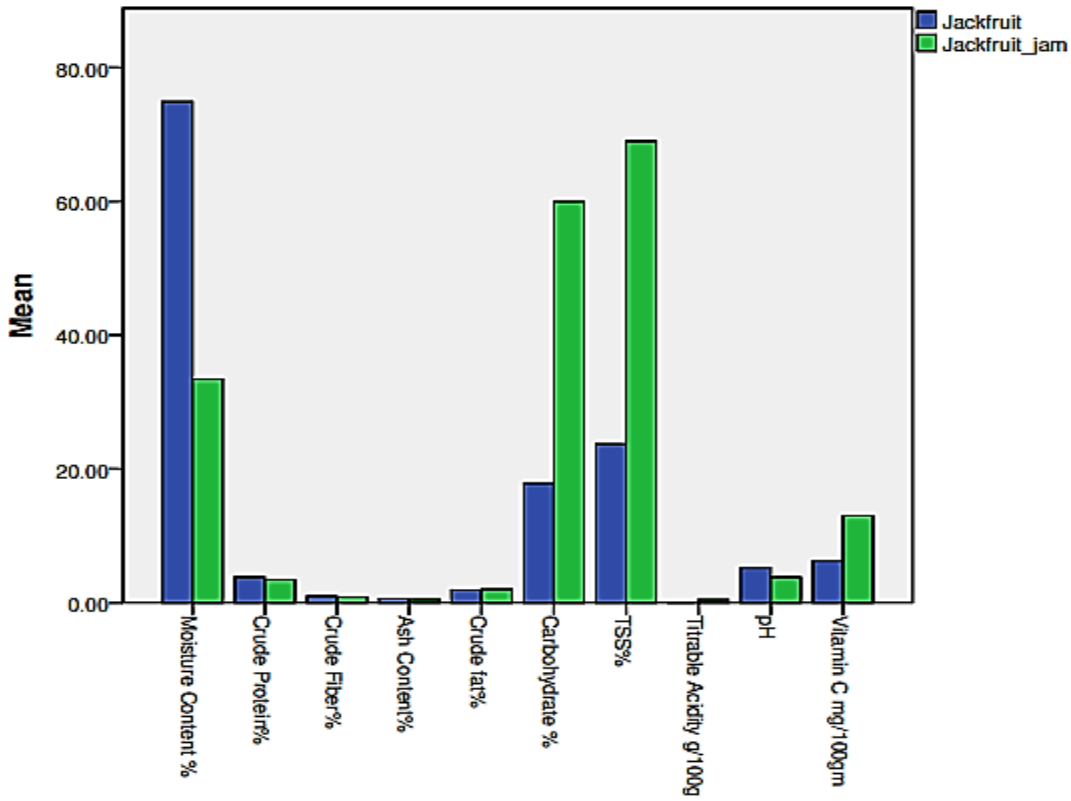

Figure 12 : Gross Chemical Composition of Jackfruit and Jackfruit Jam.

4.3.1 Carbohydrate

Carbohydrate content was 17.83 % in unprocessed jackfruit while in jackfruit jam it was 59.97 % with jackfruit jam having the highest value than fresh jackfruit. This is expected because processing increased carbohydrate as moisture is reduced in the unprocessed state. These results were slightly close to the findings of fresh jackfruit, jackfruit jam and pineapple jam 13.92%, 30.90% and 48.48% by (Eke-Ejiofor and Owuno, 2013). Also Mohd Naeem *et al*. (2015) reported carbohydrate content range of (65.99 - 67.65 g/100g) in grape, strawberry, apricot and blueberry jams. High carbohydrate content in jams can be associated with the large presence of sugar.

4.3.2 Moisture

Moisture content of jackfruit jam was found to be 33.40 % while that of fresh jackfruit was 74.89 % with the jam having the least value (Table 4). This difference in moisture between processed and unprocessed jackfruit is expected because of the sugar added and heating process involved during jam making that caused moisture evaporation. These results were found to be higher compared to the findings of Eke-Ejiofor and Owuno (2013) who reported the moisture content of jackfruit jam to be 24.60%, pineapple jam (23.29%) and that of fresh jackfruit (73.60%). The difference may be due to geographical location and different existing varieties. The moisture content of the food is normally used as indicator of its shelf life (Fellows, 2000). Higher moisture content suggests that the jams have a short shelf life. According to FAD/WFP, 1970 the moisture level of jam made from stone fruit, an apricot, peach and other fruit is 29.6%.

4.3.3 Protein

Protein content of jackfruit jam was found to be 3.40 % while fresh jackfruit contained 3.80 %. These results were close to the findings of Watt *et al.* (1963) who observed protein content in the edible portion to be 2.3 % , 1.19% and 2.32% for jackfruit jam, pineapple jam and fresh jackfruit respectively. According to jam nutritional labeling, the most common ingredients are fruits, sugar, pectin and citric acid. None of these ingredients used are rich source of protein, hence low protein content of jam (Mohd Naeem *et al*., 2015). Most processed products such as jams tend to have lower nutritional values when compared

to fresh fruits due to exposure to the heat generated during processing (Jawaheer *et al*., 2003).

4.3.4 Crude fat

Fresh jackfruit had 1.90 % fat whereas jackfruit jam had 1.97 %. The results of fresh jackfruit was slightly higher than that of strawberry, blueberry and grape jams which ranged from 0.01% - 0.03% as reported by Mohd Naeem *et al*. (2015) which explain very low fat contents in jackfruit jam. Fat is also a major source of energy and provide essential lipid nutrients. In many foods the fat component plays a major role in determining the overall physical characteristics, such as flavor, texture, mouth feel and appearance (Muhammad *et al*., 2009). Norman (1976) reported that, fat content of different fruits is usually not greater than 1%. Also Haque *et al*. (2009) observed that the fat content of different fruits ranged between 0.0084% and 1.27%. Jackfruit contains no saturated fatty oil and cholesterol making it a healthy fruit to savor (Priya *et al*., 2014). The research results showed that both the jam and fresh jackfruit contained small amount of fat which is for human health especially those under weight control programs.

4.3.5 Ash Content

The ash content of the jackfruit jam was found to be 0.45 % and that of fresh jackfruit 0.60 %. These findings are comparable to those reported by Eke-Ejiofor and Owuno (2013) for jackfruit jam 0.27 % and fresh jackfruit 0.43%. Goswami *et al*. (2011) also reported different fresh jackfruit (*A. heterophyllus*) types for ash values of (0.98, 1.04, 1.11, 0.88 and 0.70). Haque *et al*. (2009) reported that ash contents of fresh fruits ranged from 0.053% to 0.902%. Ash content is a measure of the total amount of minerals present within a food, although most minerals have fairly low volatility at high temperatures of 500^0C; some are volatile and may be partially lost, *e.g.,* iron and zinc (www.people.umass.edu). Ash is important in terms of nutrition because it tells how dense the minerals are in a particular food sample. Generally, low ash content indicates that the food product analyzed is not a rich source of minerals.

4.3.6 Crude Fiber

The percent crude fiber of the fresh jackfruit was 0.95 % (Table 4). This value is lower compared to the value 2.06 % reported by Singh *et al.* (1991). The difference may be due to varietal distinctions and the geographical location while crude fiber in jackfruit jam was 0.80 %. The fiber content of jackfruit helps protect the colon mucous membrane by binding to and eliminating cancer-causing chemicals from the colon.

4.3.7 pH

The results (Table 4) show that pH of the fresh jackfruit and jam was 5.20 and 3.80, respectively. Eke-Ejiofor and Owuno (2013) reported the pH value of fresh jackfruit, jackfruit jam and pineapple jam to be 5.57, 3.36 and 3.35, respectively. The pH of jam is an important factor for optimum gel condition. Also low pH in food will prevent the microbial growth.

4.3.8 Titratable Acidity

Total titratable acidity of fresh jackfruit was found to be 0.07 g/100g and that of jackfruit jam was recorded as 0.43 g/100g (Table 4). The values obtained were close to those reported by Eke-Ejiofor and Owuno (2013) who found jackfruit jam value to be 0.313 g/100g and fresh jackfruit 0.058 g/100g. Jam had higher acidity content the reason mybe due to addition of lemon juice and citric acid during jam making. However Goswam *et al.* (2011) found the value of total acidy of five different varieties for fresh jackfruit to be high ranging from (0.46 – 0.91%). The total acidity in fresh jackfruit is low at the ripe stage (0.130%) and it shows little change consequently (Bhatia *et al.*, 1955). Also, Nandini (1989) reported that firm types of jackfruit have lower acidity (0.300%) than soft (0.550%) types. The importance of high acidity in developed food product shows that it can be stored for some time. Also acidity is useful to correct the balance which is needed in jam production.

4.3.9 Total Soluble Solids

Fresh jackfruit was found to contain TSS of 23.70% and the developed jackfruit jam contained 69.0 %. Eke-Ejiofor and Owuno (2013) reported the value of 23% for fresh

jackfruit and 40 % brix for jackfruit jam. According to India standards the total soluble solids of jam should not be less than 68.0% BIS 5861 (1993). The sugar present in the jam includes that of natural and added sugar reduces the available moisture for microbial growth thus extending shelf life of the product. Sugar contributes to soluble solids, an effect that is essential for the physical, chemical properties, thus providing body and mouth feel, improves appearance (color and shine) and makes gelation of pectin possible (Hyvönen and Törmä, 1983).

4.3.10 Vitamin C

Vitamin C was recorded as 6.23 mg/100g for the fresh jackfruit and 13.00 mg/100g for developed jackfruit jam. The vitamin C present in the jam was expected to be high due to addition of lemon juice and ascorbic acid during jam making. Sharma *et al.* (2011) reported the value (11.20 mg/100g) ascorbic acid for quince jam. The results of vitamin C for fresh jackfruit is comparable to the findings by Goswami *et al.* (2011) who reported high vitamin C value of 8.18 mg/100g, 7.26 mg/100g, 7.13 mg/100g, 5.20 mg/100g and 4.57 mg/100g for different fresh jackfruit varieties. Vitamin C is an antioxidant that protects the body against free radicals, strengthens the immune system, and keeps the gums healthy (Umesh *et al*., 2010). Frequent consumption of jackfruit and jackfruit jam will helps the body develop resistance against infectious agents and scavenge harmful free radicals (Southampton Center for Underutilized Crops, 2006).

4.4 Mineral Composition

Table 5 shows the mineral composition of the developed jackfruit jam and fresh jackfruit. The jackfruit jam prepared had calcium (29.57 mg/100g), sodium (6.98 mg/100g), potassium (256.72 mg/100g), zinc (0.21 mg/100g) and iron is (0.31 mg/100g). Mohd Naeem *et al*. (2015) reported the low value of sodium content in strawberry jam 1.37 mg/100g followed by grape jam 4.1 mg/100g, while apricot and blueberry jams have almost high sodium content of 8.92 mg/100g and 9.23 mg/100g and these values are close to that found in this study. Apricot jam, grape jam and strawberry jam were all found to contain very low amount of zinc ranging (0.01mg/100g - 0.07mg/100g) except for blueberry which had no zinc at all. Beenu *et al*. (2014) reported the value of iron to be 6.2

mg/100g and 1.6 mg/100g in guava pulp and guava jam respectively. Also reported calcium content of guava pulp to be 28.2 mg/100g and guava jam 26.7 mg/100g. The descriptives table (table 5) provides some very useful descriptive statistics, including the mean, standard deviation and 95% confidence intervals for the dependent variable (value) for each mineral composition (calcium, sodium, iron, zinc and potassium), as well as when all mineral composition are combined (Total).

Table 5 : Descriptives table of mineral composition.

Descriptives

		N	Mean	Std. Deviation	Std. Error
Jackfruit	Calcium mg/100gm	3	30.8767	.02517	.01453
	Sodium mg/100gm	3	8.3433	.02517	.01453
	Iron..... mg/100gm	3	.5433	.02082	.01202
	Zinc.....mg/100gm	3	.3200	.02000	.01155
	Potasium mg/100gm	3	259.1433	.04041	.02333
	Total	15	59.8453	103.79030	26.79854
Jackfruit_jam	Calcium mg/100gm	3	29.5767	.02517	.01453
	Sodium mg/100gm	3	6.9833	.02517	.01453
	Iron..... mg/100gm	3	.3100	.02000	.01155
	Zinc.....mg/100gm	3	.2100	.02000	.01155
	Potasium mg/100gm	3	256.7267	.05508	.03180
	Total	15	58.7613	103.06149	26.61036

Descriptives

		95% Confidence Interval for Mean		Minimum	Maximum
		Lower Bound	Upper Bound		
Jackfruit	Calcium mg/100gm	30.8142	30.9392	30.85	30.90
	Sodium mg/100gm	8.2808	8.4058	8.32	8.37
	Iron..... mg/100gm	.4916	.5950	.52	.56
	Zinc.....mg/100gm	.2703	.3697	.30	.34
	Potasium mg/100gm	259.0429	259.2437	259.10	259.18
	Total	2.3682	117.3225	.30	259.18
Jackfruit_jam	Calcium mg/100gm	29.5142	29.6392	29.55	29.60
	Sodium mg/100gm	6.9208	7.0458	6.96	7.01
	Iron..... mg/100gm	.2603	.3597	.29	.33
	Zinc.....mg/100gm	.1603	.2597	.19	.23
	Potasium mg/100gm	256.5899	256.8635	256.67	256.78
	Total	1.6878	115.8349	.19	256.78

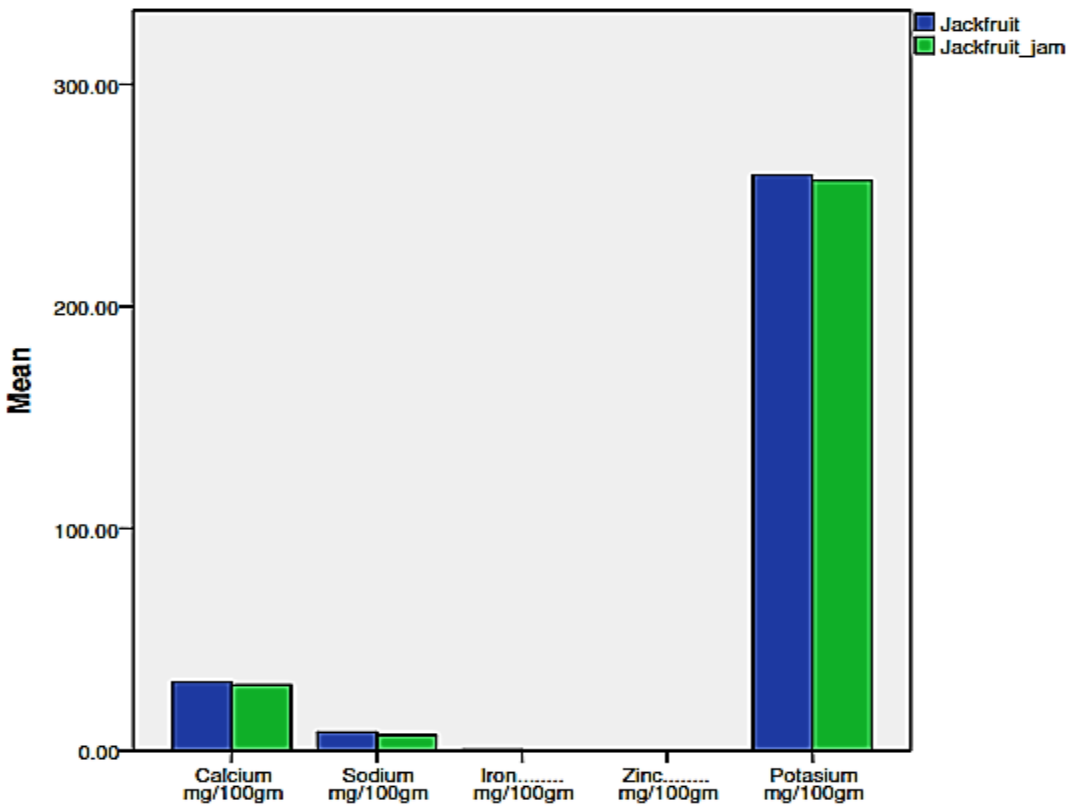

Figure 13 : Mineral Composition of Jackfruit and Jackfruit Jam.

4.5 Sensory Evaluation

4.5.1 Consumer Characteristics

Panelist (70 %) were male and the remaining percent were female. 100 % of the panelists fall on the age group of 19-27 years. Education level was also one of the consumer characteristics where 80% of panelists are studying bachelor degree, 20 % are studying Master Degree. With preference, on commercial mango jam 81.69% of panelists preferred the product if brought to the market while 18.31% did not prefer it. On the other side 79.87% preferred jackfruit jam if found it in the market while the remaining 20.13% did not prefer to buy it. The reasons why they would not buy it are because of the aroma which appeared not to be satisfactory to the panelists . 50% of the panelists are regular consumer of jam, this show that a good number of people are familiar with such products, so if this new developed jam gets introduced to the market consumers will accept it.

4.5.2 Sensory Evaluation of Jackfruit Jam

Table 6 shows the sensory evaluation of the developed jackfruit jam. The mean score for color, taste, aroma, texture, spreadability, sweetness and overall acceptability of the jackfruit jam and commercial mango jam were evaluated and the mean score of their responses are represented in Table. It was observed that the mean scores of hedonic scales were significantly different for color, taste, aroma, texture, spreadability, sweetness and overall acceptability for each samples. It was observed that aroma and spreadability of jackfruit jam lower than commercial mango jam at hedonic scale score. Sensory characteristics of the developed jackfruit jam and the commercial mango jam showed that the overall acceptability of the samples got the hedonic scale like moderately. The results indicate that the formulated jackfruit jam are equally acceptable since it got the same hedonic scale of that commercial mango jam . However, no significant difference in terms of color, taste and texture of the formulated products with the commercial products, which indicates positive sign for the developed product.

Table 6 : Descriptives table of jackfruit jam.

Descriptives

		N	Mean	Std. Deviation	Std. Error
Jackfruit_Jam	Color	10	5.80	.422	.133
	Taste	10	6.10	.568	.180
	Aroma	10	4.80	.632	.200
	Texture	10	5.00	.667	.211
	Spreadability	10	4.90	.568	.180
	Sweetness	10	6.10	.568	.180
	Overall Acceptabilty	10	5.60	.516	.163
	Total	70	5.47	.756	.090
Mango_jam	Color	10	5.10	.568	.180
	Taste	10	5.90	.316	.100
	Aroma	10	5.20	.632	.200
	Texture	10	5.30	.483	.153
	Spreadability	10	5.20	.422	.133
	Sweetness	10	5.40	.516	.163
	Overall Acceptabilty	10	5.00	.667	.211
	Total	70	5.30	.574	.069

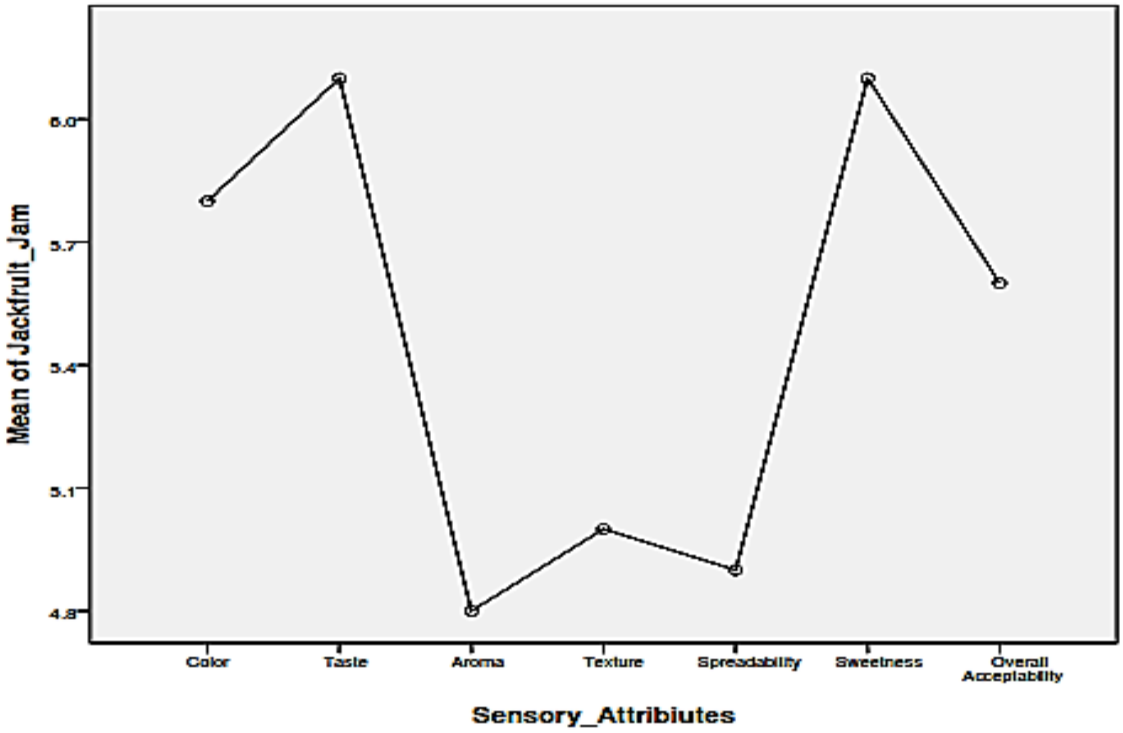

Figure 14 : Sensory Evaluation of Jackfruit Jam.

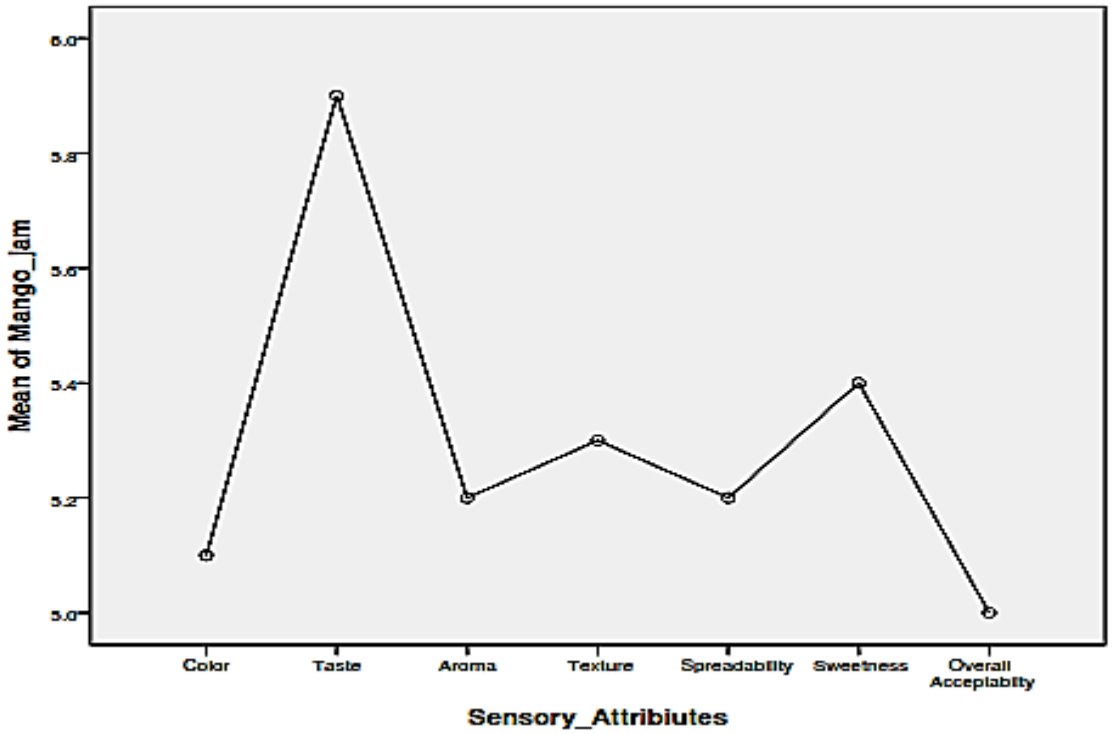

Figure 15 : Sensory Evaluation of Commercial Mango Jam.

4.5.3 Sensory Evaluation of Jackfruit Jam Cake

Table 7 shows the sensory evaluation of the developed jackfruit jam cake. The mean score for appearance, taste, aroma, texture, mouthfeel, sweetness and overall acceptability of the jackfruit jam cake and commercial cake were evaluated and the mean score of their responses are represented in Table. It was observed that the mean scores of hedonic scales were significantly different for appearance, taste, aroma, texture, mouthfeel, sweetness and overall acceptability for each samples. It was observed that aroma, mouthfeel and texture of jackfruit jam cake lower than commercial cake at hedonic scale score. Sensory characteristics of the developed jackfruit jam cake and the commercial cake showed that the overall acceptability of the samples got the hedonic scale like moderately. The results indicate that the formulated jackfruit jam cake are equally acceptable since it got the same hedonic scale of that commercial cake . However, no significant difference in terms of appearance, taste and sweetness of the formulated products with the commercial products, which indicates positive sign for the developed product.

Table 7 : Descriptives table of jackfruit jam cake.

Descriptives

		N	Mean	Std. Deviation	Std. Error
Commercial_Cake	Appearence	10	5.70	.675	.213
	Taste	10	5.90	.316	.100
	Aroma	10	5.20	.632	.200
	Texture	10	5.30	.483	.153
	Mouthfeel	10	5.20	.422	.133
	Sweetness	10	5.40	.516	.163
	Overall Acceptabilty	10	5.30	.483	.153
	Total	70	5.43	.554	.066
Jackfruit_Jam_cake	Appearence	10	6.10	.738	.233
	Taste	10	6.20	.632	.200
	Aroma	10	4.90	.738	.233
	Texture	10	5.00	.667	.211
	Mouthfeel	10	4.90	.568	.180
	Sweetness	10	6.10	.568	.180
	Overall Acceptabilty	10	5.50	.527	.167
	Total	70	5.53	.829	.099

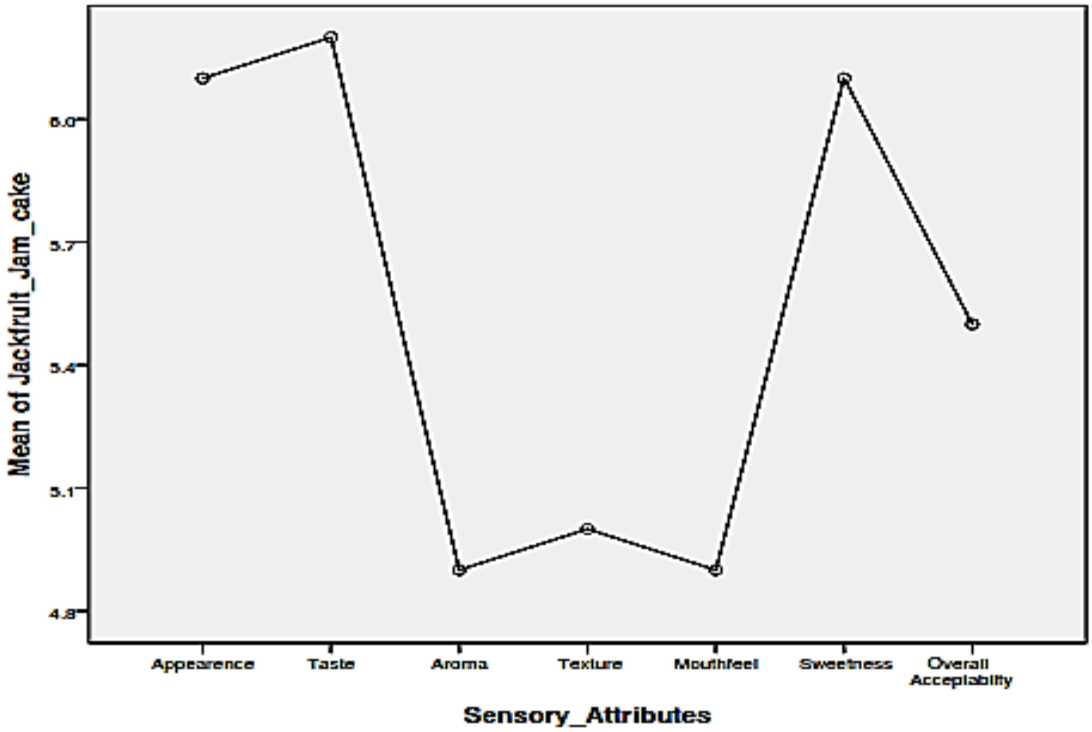

Figure 16 : Sensory Evaluation of Jackfruit Jam Cake.

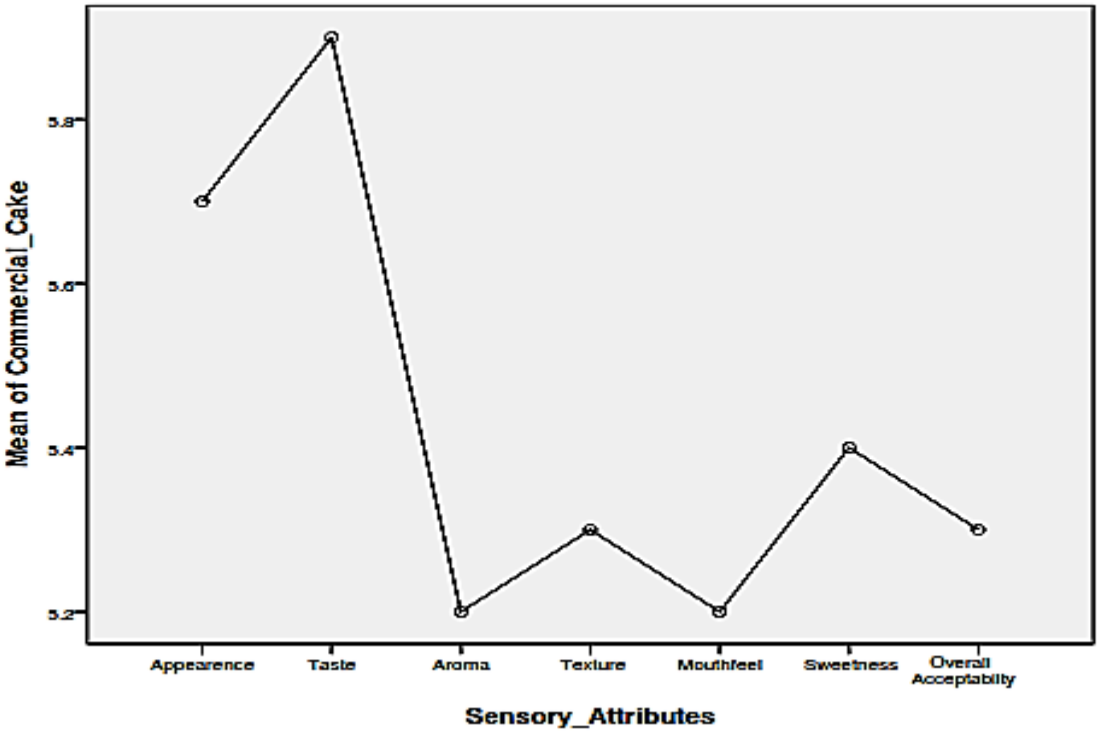

Figure 17 : Sensory Evaluation of Commercial Cake.

4.5.4 Overall Acceptability Test of Jackfruit Jam

Mean hedonic scores of commercial mango jam and developed jackfruit jam are shown in (Table 8). The results show that there is no significant difference at ($p>0.05$) between commercial mango jam and the jackfruit jam although jackfruit jam seemed to have a higher mean value (5.60). This means the panelists had accepted both the developed jackfruit jam and commercial mango jam at levels of between like and like moderately.

Table 8 : Scores for overall acceptability of jam products

Product	Overall Acceptability
Jackfruit Jam	**5.60±0.51[a]**
Commercial Mango Jam	**5.00±0.66[a]**

4.5.5 Overall Acceptability Test of Jackfruit Jam Cake

Mean hedonic scores of commercial cake and developed jackfruit jam cake are shown in (Table 9). The results show that there is no significant difference at ($p>0.05$) between commercial cake and the jackfruit jam cake although jackfruit jam seemed to have a higher mean value (5.50). This means the panelists had accepted both the developed jackfruit jam cake and commercial cake at levels of between like and like moderately.

Table 9 : Scores for overall acceptability of jam products

Product	Overall Acceptability
Jackfruit Jam Cake	**5.50±0.52[a]**
Commercial Cake	**5.30±0.48[a]**

CHAPTER V

5.0 CONCLUSIONS

Jam is a popular food product in ready-to-eat foods. It is being more popular in world-wide because of its health benefits. From the results of the study, it is concluded that jackfruit has lots of nutrients both macro and micronutrients even when processed into jam. The quality of Jam prepared has significant nutritive values required for growth of human being in terms of total soluble solids, ascorbic acid content etc. Products were also found stable on storage at ambient temperature for 12 months as the physico-chemical, sensory and microbiological parameters were not changed significantly. It indicates that the jackfruit can be utilized for the commercial production of standard quality products like jam.

The developed jackfruit jam has shown to be accepted by consumers. When compared with commercial mango jam there was no significant differences at ($p>0.05$) between the two jams in color, taste and texture attributes. Moreover, jackfruit jam showed high score in aroma and spreadability. The developed jackfruit jam cake has shown to be accepted by consumers. When compared with commercial cake there was no significant differences at ($p>0.05$) between the two cake in appearance, taste and sweetness attributes. Moreover, jackfruit jam cake showed high score in aroma and mouthfeel. Jam use in cake, it can be added an economic value. It is an opportunity for exploring the possibility of producing other value added food products in order to preserve the fruit during off seasons and also to reduce post-harvest losses. Thus this research work would help in creating a new field for fortification of food sector with reducing unemployment problem in Bangladesh.

CHAPTER VI

6.0 RECOMMENDATIONS AND FUTURE PERSPECTIVES

I. The developed new jackfruit jam and jackfruit jam cake has been well accepted however some improvement can be made to make it more attractive to consumers. The color and flavor are some of the attributes that can be improved to make it more acceptable.

II. Because of its highly perishable in nature, to preserve the jackfruit for longer period should be promoted through production of many other value added food products such as jelly, jackfruit juice, squash, leather, wine, candy bar, ice cream, yoghurt, pickle, vinegar, jackfruit chips, jackfruit preserve bulbs, all these can be processed by simple techniques so as to reduce postharvest losses and can be sold in domestic as well as external market to increase income. Government through extension workers and NGOs should promote the cultivation of this jackfruit on a commercial scale in order to increase farmer's income and improve their livelihood.

III. Raw materials involved in the production should be of proper maturity, good quality variety and free from any source of contamination since the quality of the final product depends on the quality of the raw materials.

IV. A regular training of the small scale farmers and entrepreneurs and other stakeholders on how to process by simple technologies jackfruit and its advantages in order to allow them have a full knowledge of the technology that will always strengthen their economic status by creating employment for them.

V. Huge amount jackfruit are spoiled in every year in Bangladesh. If we preserve jackfruit and produce jackfruit jam, jackfruit jam cake etc. that time we can supply these food product in off season. We also export these food product to foreign countries and can earn foreign currency.

VI. Further research is needed in order to understand more about jackfruit because it has many species so one can identify which species are good for developing specific processed food products which are of healthy benefits potential. Advantage should be taken of the potentiality of this fruits which is rich in many important nutrients.

CHAPTER VII

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APPENDICES

Appendix A : Chemical Composition of Jackfruit and Jackfruit Jam.

Analysis name	Jackfruit	Jackfruit Jam
1.Moisture Content(%)	A. 74.85 B. 74.94 C. 74.90	A. 33.40 B. 33.60 C. 33.20
2.Crude Protein(%)	A. 3.80 B. 3.83 C. 3.79	A. 3.50 B. 3.40 C. 3.30
3.Crude Fiber(%)	A. 0.94 B. 0.95 C. 0.98	A. 0.80 B. 0.85 C. 0.75
4.Ash Content(%)	A. 0.58 B. 0.60 C. 0.62	A. 0.46 B. 0.44 C. 0.45
5.Crude Fat(%)	A. 1.88 B. 1.91 C. 1.92	A. 1.97 B. 1.95 C. 2.00
6.Carbohydrate(%)	A. 17.96 B. 17.74 C. 17.81	A. 59.95 B. 59.64 C. 60.34
7.TSS(%)	A. 23.60 B. 23.70 C. 23.80	A. 68.00 B. 70.00 C. 69.00
8. Titratable acidity (g/100g)	A. 0.06 B. 0.08 C. 0.07	A. 0.42 B. 0.45 C. 0.43
9.pH	A. 5.3 B. 5.1 C. 5.2	A. 3.9 B. 3.7 C. 3.8
10. Vitamin C (mg/100g)	A. 6.23 B. 6.25 C. 6.22	A. 13.0 B. 13.5 C. 12.5

Appendix B : Mineral Composition of Jackfruit and Jackfruit Jam.

Mineral	Jackfruit	Jackfruit Jam
1.Calcium (Concentration in mg/100g)	A. 30.85 B. 30.90 C. 30.88	A. 29.55 B. 29.60 C. 29.58
2.Sodium (Concentration in mg/100g)	A. 8.34 B. 8.37 C. 8.32	A. 6.96 B. 7.01 C. 6.98
3.Iron (Concentration in mg/100g)	A. 0.55 B. 0.52 C. 0.56	A. 0.31 B. 0.33 C. 0.29
4.Zinc (Concentration in mg/100g)	A. 0.32 B. 0.34 C. 0.30	A. 0.19 B. 0.21 C. 0.23
5.Potassium (Concentration in mg/100g)	A. 259.10 B. 259.18 C. 259.15	A. 256.78 B. 256.67 C. 256.73

Appendix C : Sensory Evaluation Data of Jackfruit Jam and Mango Jam.

Sensory Attribute	Jackfruit Jam	Commercial Mango Jam
1.Color	Panelist 1 = 6 Panelist 2 = 6 Panelist 3 = 5 Panelist 4 = 6 Panelist 5 = 5 Panelist 6 = 6 Panelist 7 = 6 Panelist 8 = 6 Panelist 9 = 6 Panelist 10 = 6	Panelist 1 = 5 Panelist 2 = 5 Panelist 3 = 4 Panelist 4 = 5 Panelist 5 = 6 Panelist 6 = 5 Panelist 7 = 5 Panelist 8 = 6 Panelist 9 = 5 Panelist 10 = 5
2.Taste	Panelist 1 = 6 Panelist 2 = 6 Panelist 3 = 6 Panelist 4 = 7 Panelist 5 = 5 Panelist 6 = 6 Panelist 7 = 6 Panelist 8 = 7 Panelist 9 = 6 Panelist 10 = 6	Panelist 1 = 6 Panelist 2 = 6 Panelist 3 = 6 Panelist 4 = 5 Panelist 5 = 6 Panelist 6 = 6 Panelist 7 = 6 Panelist 8 = 6 Panelist 9 = 6 Panelist 10 = 6
3.Aroma	Panelist 1 = 5 Panelist 2 = 5 Panelist 3 = 6 Panelist 4 = 4	Panelist 1 = 5 Panelist 2 = 5 Panelist 3 = 5 Panelist 4 = 4

	Panelist 5 = 5 Panelist 6 = 5 Panelist 7 = 5 Panelist 8 = 4 Panelist 9 = 5 Panelist 10 = 4	Panelist 5 = 5 Panelist 6 = 6 Panelist 7 = 6 Panelist 8 = 5 Panelist 9 = 5 Panelist 10 = 6
4.Texture	Panelist 1 = 5 Panelist 2 = 5 Panelist 3 = 5 Panelist 4 = 4 Panelist 5 = 4 Panelist 6 = 6 Panelist 7 = 5 Panelist 8 = 5 Panelist 9 = 5 Panelist 10 = 6	Panelist 1 = 6 Panelist 2 = 6 Panelist 3 = 5 Panelist 4 = 5 Panelist 5 = 5 Panelist 6 = 5 Panelist 7 = 5 Panelist 8 = 6 Panelist 9 = 5 Panelist 10 = 5
5.Spreadibility	Panelist 1 = 5 Panelist 2 = 5 Panelist 3 = 5 Panelist 4 = 5 Panelist 5 = 4 Panelist 6 = 5 Panelist 7 = 5 Panelist 8 = 5 Panelist 9 = 4 Panelist 10 = 6	Panelist 1 = 5 Panelist 2 = 5 Panelist 3 = 6 Panelist 4 = 5 Panelist 5 = 5 Panelist 6 = 5 Panelist 7 = 6 Panelist 8 = 5 Panelist 9 = 5 Panelist 10 = 5
6.Sweetness	Panelist 1 = 7 Panelist 2 = 5 Panelist 3 = 6 Panelist 4 = 6 Panelist 5 = 6 Panelist 6 = 6 Panelist 7 = 6 Panelist 8 = 6 Panelist 9 = 7 Panelist 10 = 6	Panelist 1 = 6 Panelist 2 = 6 Panelist 3 = 6 Panelist 4 = 5 Panelist 5 = 5 Panelist 6 = 6 Panelist 7 = 5 Panelist 8 = 5 Panelist 9 = 5 Panelist 10 = 5
7.Overall Acceptability	Panelist 1 = 6 Panelist 2 = 6 Panelist 3 = 6 Panelist 4 = 5 Panelist 5 = 6 Panelist 6 = 6 Panelist 7 = 5 Panelist 8 = 5 Panelist 9 = 5 Panelist 10 = 6	Panelist 1 = 5 Panelist 2 = 6 Panelist 3 = 4 Panelist 4 = 6 Panelist 5 = 5 Panelist 6 = 5 Panelist 7 = 4 Panelist 8 = 5 Panelist 9 = 5 Panelist 10 = 5

Appendix D : Sensory Evaluation Data of Jackfruit Jam Cake and Commercial Cake.

Sensory Attribute	Jackfruit Jam Cake	Commercial Cake
1.Appearance	Panelist 1 : 6 Panelist 2 : 6 Panelist 3 : 5 Panelist 4 : 6 Panelist 5 : 5 Panelist 6 : 6 Panelist 7 : 6 Panelist 8 : 6 Panelist 9 : 6 Panelist 10 : 6	Panelist 1 : 5 Panelist 2 : 5 Panelist 3 : 4 Panelist 4 : 5 Panelist 5 : 6 Panelist 6 : 5 Panelist 7 : 5 Panelist 8 : 6 Panelist 9 : 5 Panelist 10 : 5
2.Taste	Panelist 1 : 6 Panelist 2 : 6 Panelist 3 : 6 Panelist 4 : 7 Panelist 5 : 5 Panelist 6 : 6 Panelist 7 : 6 Panelist 8 : 7 Panelist 9 : 6 Panelist 10 : 6	Panelist 1 : 6 Panelist 2 : 6 Panelist 3 : 6 Panelist 4 : 5 Panelist 5 : 6 Panelist 6 : 6 Panelist 7 : 6 Panelist 8 : 6 Panelist 9 : 6 Panelist 10 : 6
3.Aroma	Panelist 1 : 5 Panelist 2 : 5 Panelist 3 : 6 Panelist 4 : 4 Panelist 5 : 5 Panelist 6 : 5 Panelist 7 : 5 Panelist 8 : 4 Panelist 9 : 5 Panelist 10 : 4	Panelist 1 : 5 Panelist 2 : 5 Panelist 3 : 5 Panelist 4 : 4 Panelist 5 : 5 Panelist 6 : 6 Panelist 7 : 6 Panelist 8 : 5 Panelist 9 : 5 Panelist 10 : 6
4.Texture	Panelist 1 : 5 Panelist 2 : 5 Panelist 3 : 5 Panelist 4 : 4 Panelist 5 : 4 Panelist 6 : 6 Panelist 7 : 5 Panelist 8 : 5 Panelist 9 : 5 Panelist 10 : 6	Panelist 1 : 6 Panelist 2 : 6 Panelist 3 : 5 Panelist 4 : 5 Panelist 5 :5 Panelist 6 : 5 Panelist 7 : 5 Panelist 8 : 6 Panelist 9 : 5 Panelist 10 : 5
5.Mouthfeel	Panelist 1 : 5	Panelist 1 : 5

	Panelist 2 : 5 Panelist 3 : 5 Panelist 4 : 5 Panelist 5 : 4 Panelist 6 : 5 Panelist 7 : 5 Panelist 8 : 5 Panelist 9 : 4 Panelist 10 : 6	Panelist 2 : 5 Panelist 3 : 6 Panelist 4 : 5 Panelist 5 : 5 Panelist 6 : 5 Panelist 7 : 6 Panelist 8 : 5 Panelist 9 : 5 Panelist 10 : 5
6.Sweetness	Panelist 1 : 7 Panelist 2 : 5 Panelist 3 : 6 Panelist 4 : 6 Panelist 5 : 6 Panelist 6 : 6 Panelist 7 : 6 Panelist 8 : 6 Panelist 9 : 7 Panelist 10 : 6	Panelist 1 : 6 Panelist 2 : 6 Panelist 3 : 6 Panelist 4 : 5 Panelist 5 : 5 Panelist 6 : 6 Panelist 7 : 5 Panelist 8 : 5 Panelist 9 : 5 Panelist 10 : 5
7.Overall Acceptability	Panelist 1 : 6 Panelist 2 : 6 Panelist 3 : 6 Panelist 4 : 5 Panelist 5 : 6 Panelist 6 : 6 Panelist 7 : 5 Panelist 8 : 5 Panelist 9 : 5 Panelist 10 : 6	Panelist 1 : 5 Panelist 2 : 6 Panelist 3 : 4 Panelist 4 : 6 Panelist 5 : 5 Panelist 6 : 5 Panelist 7 : 4 Panelist 8 : 5 Panelist 9 : 5 Panelist 10 : 5

Appendix E : Questionnaire for Hedonic test of jackfruit jam.

Sensory Evaluation Form

Consumer test for jam

Panelist No…….. Sex……..

Age group (a) 20-30 (b) 30-40 (c) 45 and above

Time…….. Date……..... Education level

(a) Bachelor degree (b) Master's degree (c) other

specify…….....

Please taste each of the (2) coded products. Indicate how much you like or dislike each sample by checking the appropriate sample attribute and indicate your reference (1-7) in the column against each attribute. Put the appropriate number against each attribute.

7 = Like very much
6 = Like moderately
5 = Like slightly
4 = Neither like nor dislike
3 = Dislike slightly
2 = Dislike moderately
1 = Dislike very much

Attributes	111	222
Color		
Taste		
Aroma		
Spreadability		
Sweetness		
Texture		
Overall acceptability		
Would you prefer to buy a product?	Yes No	Yes No

Are you the frequent user of this product? (a) Yes
(b) No
Comments :
.....
.....
.....

Appendix F : Questionnaire for Hedonic test of jackfruit jam cake.

Sensory Evaluation Form

Consumer test for jackfruit jam cake

Panelist No…….. Sex……..

Age group (a) 20-30 (b) 30-40 (c) 45 and above

Time…….. Date……..... Education level

(a) Bachelor degree (b) Master's degree (c) Other

specify…….....

Please taste each of the (2) coded products. Indicate how much you like or dislike each sample by checking the appropriate sample attribute and indicate your reference (1-7) in the column against each attribute. Put the appropriate number against each attribute.

7 = Like very much
6 = Like moderately
5 = Like slightly
4 = Neither like nor dislike
3 = Dislike slightly
2 = Dislike moderately
1 = Dislike very much

Attributes	111	222
Appearance		
Taste		
Aroma		
Mouthfeel		
Sweetness		
Texture		
Overall acceptability		
Would you prefer to buy a product?	Yes No	Yes No

Are you the frequent user of this product? (a) Yes
(b) No
Comments :
.....
.....
.....

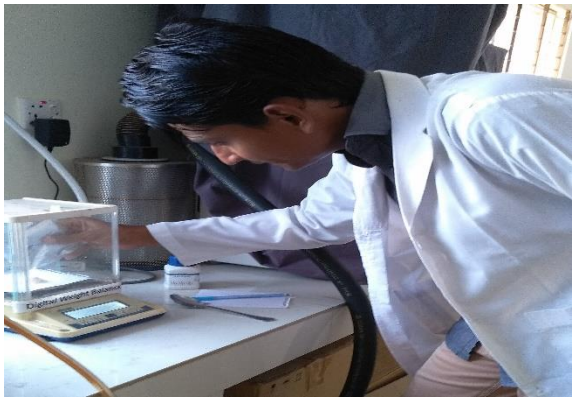
Appendix G : Photo Gallery.

Boiling.

Blending.

Straining.

Cooking.



Raw Material Measurement.

Brix Determination.

Raw Materials.

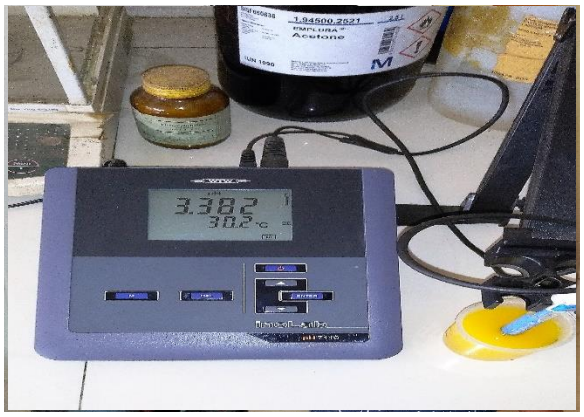
Mixing.

Dough Dosing At Cup.

Placing at Tunnel Oven.

After Baking.

Produced Cake.



pH Determination.

Vitamin C Determination.

Titratable Acidity Determination.

Sample Preparation.

Sample Digestion.

Crude Fiber Determination.

Fat Determination.

Ash Determination.

Moisture Determination.

Protein Digestion.

Protein Distillation.

Titration (Protein Determination).

Panelist Doing Sensory Test of Jackfruit Jam.

Panelist Doing Sensory Test of Jackfruit Jam Cake.

BRIEF BIOGRAPHY

Mr. S M F Jinnah passed the Secondary School Certificate Examination in 2008 and then Higher Secondary Certificate Examination in 2010 from B A F Shaheen School & College, Chattogram, Bangladesh. Mr. S M F Jinnah obtained her B.Sc. (Hons.) in Food Science & Technology in 2016 from Chittagong Veterinary and Animal Sciences University (CVASU), Bangladesh. Now, he is a candidate for the degree of MS in Department of Applied Chemistry and Chemical Technology in Food Chemistry and Quality Assurance under Food Science & Technology Faculty, CVASU. He has immense interest to work in food safety issues including food chemistry and microbiology, product development, malnutrition, reduction of nutritional changes in food processing etc.