VALUE ADDITION TO JACKFRUIT THROUGH JAM AND JELLY PREPARATION

SHAMIMA SULTANA

DEPARTMENT OF HORTICULTURE

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA-1207

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BY

SHAMIMA SULTANA

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Approved by

Prof. Dr. Md. Nazrul Islam
Department of Horticulture
SAU, Dhaka
Supervisor

Prof. Dr. Abul Hasnat M. Solaiman
Department of Horticulture
SAU, Dhaka
Co-supervisor

Prof. Dr. Mohammad Humayun Kabir
Chairman
Examination Committee

DEDICATED TO

MY BELOVED

PARENTS

DEPARTMENT OF HORTICULTURE

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka-1207

Ref: Date:

CERTIFICATE

This is to certify that thesis entitled, "tfALUE ADDITION TO JACKFRUIT THROUGH JAM AND JELLY PREPARATION" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (MS) in HORTICULTURE, embodies the results of a piece of bona fide research work carried out by SHAMIMA SULTANA, Registration No. 18-09109 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated: December, 2019
Dhaka, Bangladesh

Professor Dr. Md. Nazrul Islam
Supervisor
Department of Horticulture
Sher-e-Bangla Agricultural University
Dhaka-1207

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ABSTRACT

A study was conducted at the postharvest laboratory of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during March 2019 to November 2019 to prepare jackfruit jam and jelly and also to asses the quality of these products as influenced by different sugar concentrations with preservatives. The experiment consisted of two factors. Factor A: Sugar Concentrations per 500g fruit; S_1:200g sugar; S_2:250g sugar; S_3:300g sugar and Factor B: Preservatives per 500g fruit; P_0:no preservative; P_1:sodium benzoate (1.4g); P_2:potassium metabisulphite (0.8g). All the samples were kept in pre-sterilized glass bottles and stored at room temperature. Moisture content, pH, total soluble solids, titrable acidity, ascorbic acid and organoleptical (color, appearance, sweetness, stickiness, flavor and overall acceptability) test were done. A decreasing trend was recorded in moisture content (35.51 to 26.01%), pH (4.36 to 3.31), ascorbic acid content (1.88 to 0.79mg/100g) while an increasing trend was recorded in titrable acidity (0.06 to 0.26%) and TSS (61.00 to 73.01 brix). Results obtained from statistical analysis showed that different sugar concentrations and preservation had significant effect on physico-chemical and organoleptic characteristics. After 90 days of storage, both jam and jelly were found acceptable condition. Considering laboratory test, qualitative and organoleptic test, S_2P_2 was found the best in case of jam and S_3P_2 was found the best in case of jelly. The quality parameters of S_2P_2 viz. moisture content (26.01%), pH (4.12), TSS (70%), TA (0.26%), vitamin C (1.68mg/100g), and the quality parameters of S_3P_2 viz. moisture content (27.01%), pH (4.10), TSS (69%), TA (0.25%), vitamin C (1.57mg/100g). This suggested that 500g jackfruit pulp +250g sugar +0.8g potassium metabisulphite was the promising formulation for the preparation of good quality of jackfruit jam and 500g jackfruit rind +300g sugar+0.8g potassium metabisulphite was the promising formulation for the preparation of good quality of jackfruit jelly.

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ABBREVIATIONS AND ACRONYMS

The following abbreviations were used throughout this thesis

ANOVA	Analysis of Variance
AOAC	Association of Analytical Communities
DMRT	Duncan's Multiple Range Test
Cont'd.	Continued
CRD	Completely Randomized Design
Dw	Distilled Water
DAS	Days after storage
vit C	Vitamin C
%	Percentage
˚C	Celsius
e.g.	*Exempli gratia* (by way of example)
etc	et cetera
et al.	And others
Fig.	Figure
g	Gram
KMS	potassium metabisulphite
i.e.	*Edest (means That is)*
viz.	Namely
Wt.	Weight
TA	Titrable acidity
TSS	Total soluble solids

CHAPTER 1

INTRODUCTION

Jackfruit is a dicotyledonous compound fruit of the jack tree (*Artocarpus heterophyllus* L.) which belongs to the family Moraceae grows in many of the tropical countries of Southeast Asia but is particularly abundant in India and Bangladesh. Jackfruit is recognized as the National Fruit of Bangladesh. Jackfruit grows throughout the country in high land and homestead areas where rain and floodwater does not stand. It is also grown in Sri Lanka, Burma, Malaysia, Indonesia, Philippines and Brazil. A jackfruit tree is fortune in Srilanka, as a tree bears fruits over six months. Jackfruit is grown in all districts of Bangladesh but the leading growing areas are high land of greater Dhaka, Savar, Bhaluca, Madhupur, hilly areas of greater Syihet districts, Rangamati and Khagrachhari. It ranks next to banana and mango in acreage and production (BBS, 2017, Hossain *et al*., 1979).

At present, fruit cultivation area in Bangladesh is about 157,364.84 ha with the production of 5067798 metric tons in 2016–2017 (BBS, 2017). Jackfruit cultivation area is about 14 thousand ha with the production of 1050 tons (BBS, 2017). Among the jackfruit growing districts in 2016–2017 Gazipur produced 34757 metric tons in 30 thousand ha land (BBS, 2017). Jackfruit are rich in energy, dietary fiber, minerals and vitamins. Jackfruit contains Vitamin C and A. The jackfruit significantly contributes to the nutrition of the people of this country as a source of vitamins, minerals and calories (Mondal *et al*., 2013).

Jackfruit cotyledons are fairly rich in starch and protein (Singh *et al*., 1991). Jackfruit contains vitamin A, vitamin C, thiamin, riboflavin, calcium, potassium, iron, sodium, zinc, and niacin among many other nutrients. Vitamin A is also required for maintaining integrity of mucus membranes and skin. Consumption of natural fruits rich in vitamin-A, and carotenes have been found to work well against lung and oral cavity cancers.

The fruit is rich in carotene, potassium and carbohydrates, moderately rich in ascorbic acid (Quddus, 2000; Samaddar, 1985; Hossain *et al*., 1979). The fruit is a rich source of potassium with 303 mg / 100 g of jackfruit (Swami *et al.*, 2012; Mushumbusi 2015; Jackfruit nutrition facts). 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). Jackfruits have more protein, calcium, thiamine, riboflavin and carotene than banana but less nutrition than mango (Hossain *et al*., 1979).

Jackfruit is a relatively cheaper fruit, but the fruit's bulky nature makes it difficult to transport and store. The fruit is seasonal; there are peak seasons during which the fruit mainly rots away in the gardens or in the markets due to its perishable nature. The fruit 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) goes waste due to lack of proper postharvest knowledge during harvesting, transporting and storing both in quality and quantity (Haque, 2010). Proper postharvest technology for prolonging shelf life is, therefore, necessary. Besides, alternate ways of using jackfruits in no-seasons 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 (Singh *et al*., 1991)

In Bangladesh, Jackfruit is one of the important and popular fruits which has great potential for processing into value-added products. The ripe fruit is mainly used for its sweet and aromatic arils (bulb) as a desert or snack food. The ripe fruits bulbs (excluding seed) and the rind of the fruit (including perianth and unfertilized flowers) have been used for processing in number of products. Very few studies have been reported on the desirable convenience foods (Hossain *et al*., 2011). There is need to diversify utilization and reduce losses through appropriate processing into a variety of convenient and relatively shelf-stable and acceptable products like jam, jelly. Pureed jackfruit can be processed into baby food, juice, jam, jelly, and base for cordials (Roy and Joshi, 1995). Furthermore, it can be used to make pickle, squash, chips/papad, candies, fruit-rolls, marmalades, ice cream etc. Protocols for preparing jackfruit biscuit, flake, butter, toffee and powder were developed by Bangladesh Council of Scientific and Industrial Research (BCSIR) (Hossain *et al*., 2011).

Processing jackfruit into jam, jelly will help to make the nutrients that it provides available throughout the year. Jackfruit is also reach in pectin, thus making it favorable for processing into jam, jelly.

Jackfruit consists of three important parts namely, bulb, seed and rind. Bhatia *et al*., (1955) reported that the bulbs constitute 29%, seeds 12% and rind 59% of ripe fruit. All the parts of the jackfruit fruit are eatable and can be available all the year round by giving value to them by making jam, jelly, sqush, pickles etc. Narasimhan (1998) reported that jackfruit consists of 32% of the edible portion (pulp), 18% seed and about 50% rind (bio-waste) on weight basis. This rind is one of the major solid wastes generated by food industries, houses in Bangladesh. Unfortunately, more than 90% of the rind is discarded indiscriminately into the environment thereby constituting environmental challenges. This waste rind is not presently being utilized for any value added processes due to limited research activities focusing on the possible conversion of the waste to other valuable products thereby making it available for dumping as solid waste. Different value added products can be made from this rind. Therefore, Jackfruit based industry can be developed for local market as well as for export. This value added products are important while it minimizes postharvest losses, ensures nutritional improvement. In addition, it can be helpful for food and financial security of the people especially in the rural areas of Bangladesh and increase export potential of processed fruits and vegetables.

Considering the nutritional quality of jam, jelly the present study was undertaken with the following objectives:

i. To study the effect of different levels of sugar and preservatives on jam and jelly prepared from jackfruit

ii. To investigate physico-chemical qualities of prepared jackfruit jam and jelly

iii. To examine consumer acceptability of the prepared jam and jelly

CHAPTER II

REVIEW OF LITERATURE

The review of literature reveal that there is very limited research on some aspects of jackfruit particularly; diversified uses, value addition and storage stability. It highlights the need for research on these aspects for better utilization. Jackfruit offers potential for new and traditional goods and convenience foods. The literature cited here under are on various aspects of value addition to fruits, not only of jackfruit but also of some other fruits and vegetables.

Originality and Distribution of Jackfruit

The domesticated jackfruit tree, *Artocarpus heterophyllus* Lam., is important in tropical and sub-tropical regions, particularly in South and Southeast Asia. It is thought that jackfruit originated in the Western Ghats region of India (Soepadmo, 1992; Elevitch et al, 2006; Haq, 2006; Azad et al., 2007) but whether it is found wild or not is still debatable. Some authorities think there are related wild materials in the Andaman Islands (Haq, pers. comm.); others have proposed that jackfruit originated in Malaysia (Zielenski, 1955; Barrau, 1976). 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.

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). The family includes a number of economically important species. In the Asian tropics *Broussonetia* species are cultivated for paper pulp and the bast of *Artocarpus elasticus* Reinw. (and other *Artocarpus* spp.) is used locally for fibre for rope and paper (Purseglove, 1968). However, in warm temperate regions and in the tropics, the other members of Moraceae such as species of fig of the genus *Ficus* produce important fruits for humans and for animal fodder. In temperate North America *Maehura* species (a member of Moraceae) provide sour orange-like fruits and in Europe and Asia Morus species provide mulberry fruits and also food for silkworms. 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).

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.

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.

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 (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.

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. 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. 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).

Value-added products from jackfruit

The jackfruit is a multi-purpose species providing food, timber, fuel, fodder, medicinal and industrial products. The primary economic product of jackfruit is the fruit, used both when immature and mature. The fruit pulp is sweet and tasty and used as dessert or preserved in syrup. The seeds contained in the ripe fruits are also cooked. The fruits and seeds are also processed in a variety of ways for food and other products. In culinary use, the pulp of the fruit is made into various local delicious dishes including chutney and paste besides various types of curries. Additionally, jackfruit is used in traditional medicine (leaves, bark, inflorescence, seeds and latex). The wood of the tree is also used for various purposes. Jackfruit are rich in nutritive value containing 18.9g carbohydrates, 0.8g minerals, 30 IU vitamin A and 0.25mg thiamine for every 100g (Samaddar, 1985). For instance, jackfruit leather and jackfruit chips can be made from dried jackfruit pulp (Nakasone and Paull, 1998). Jackfruit can be made into jam, jelly, pickles, squash, papad, candies, fruit-rolls, marmalades, and ice cream. Other than canning, advances in processing technologies too, have pushed toward more new products (Narasimham, 1990). Bangladesh Agricultural Research Institute (BARI) has been so far developed technologies for preparing jackfruit chips, candy, pickles, leathers, sugar syrup preserves and jackfruit seed powder (Molla *et al*., 2011). Green jackfruit pickle and jackfruit sweet pickle were also prepared (Kabir *et al*., 2007).

Jackfruit seeds can be roasted like chestnuts. The fruit pulp is sweet and tasty and is used as a dessert or preserved in syrup. The fruits and seeds are also processed in a variety of ways for food and other products (Sidhu, 2012). Jackfruit seed flour has great potential in the food industry, especially as a thickener and binding agent in various food systems (Ocloo *et al*., 2010). The flour is prepared from seeds without removing the thin brown spermoderm with the crude fibre content. This flour has a good ability for water and oil absorption, thus is used in the biscuit industry (Tulyathan *et al*., 2002; Ejiofor *et al*., 2014). Jackfruit seed flour is of high demand for making various bakery products such as cookies (Chowdhury *et al*., 2012). The various products developed from jackfruit are candy, finger chips, fruit bars, fruit leather, halvah, papad, ready-to-serve beverages, toffee, and milk-based srikhand, ice cream, and kulfi. Half-ripened bulbs can be processed into bulb powder and this is then utilized for the preparation of traditional snacks such as pakoda, biscuits, and muffins **(**Tulyathan *et al*., 2002; Chowdhury *et al*., 2012)**.**

The unripe fruits are used in vegetable curries and pickles (Prakash *et al*., 2009). The ripe jackfruit is mainly used as a dessert for its sweet and aromatic arils (bulb). The ripe jackfruit bulbs are rich in sugars with about 90 calories per 100g fresh weight. Bhatia *et al*., (1955) reported that ripe bulbs contain 20.6% of total sugars with practically no starch. The edible bulbs are reported to contain 1.74% fructose, 5.96% glucose and 6.9% sucrose and calcium, potassium, iron and a fair amount of carotene (Chan *et al*., 1974), It was also reported that the principal sugar **–** sucrose in jackfruit was 6.90% and that of total sugar was 14.59%. Ripe jackfruit bulbs are canned in syrup, made into jams either pure or mixed with dehydrated bulbs, chutney, preserves, candy, and concentrate and powder.

Rind from the fruits (including the perianths of unfertilised fruits) can be mechanically processed for syrups and jellies. It can also be the basis for pectin extracts. Rinds and other waste parts of the fruits have a great opportunity for processing products like rind jelly, syrups etc. This offers potential for new and traditional goods and convenience foods. However, There has been a little research work mentioning to find possibility of processing of jackfruit rind into durable and nutritious food products.

Tender jackfruit leaves and young male flower clusters may also be cooked and served as vegetables (Morton, 1987). The leaves are used as a casing material for baking dishes. The leaves are also secured together in the form of a round plate and used as a single use biodegradable plate (Morton, 1987).

Jackfruit Jam & jelly

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 puree of one or more kinds of fruit and water (Isabel, 1990). 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.

Jelly is a product of gelatinous consistency prepared by boiling strained fruit extract with sugar. It is a sparkling product which is transparent with an attractive colour. Jackfruit rind contains fair amount of sugar and pectin could be used for pectin extraction. Siddappa and Bhatia (1956) standardized a method for preparing jelly and suggested an extract-sugar ratio of 1:1 with 0.6 and 0.8 acid preparing a good quality jelly. In the jelly, the nutrients will remain same and also it retains its own original color, flavor.

Requirements for Jam & Jelly Making

Fruits with high content of pectin and organic acids are best suited for jam making. The fruits such as guava, banana, mango, carambola, black berries, kiwifruit, muskmelon, custard apple, wood apple, apples, citrus peels and papaya are good source of pectin and used for jam preparation (Swamy *et al*., 1989).

Jam prepared from mango was free from spoilage by yeast and bacteria except moulds, spoilage by moulds may be minimized by maintaining a higher sugar content of 68.5° brix and by boiling to 107°C instead of 105°C (Singh, 1991).

Sanjeevkumar and Singh (1998) studied the recipe for preparation of papaya beverages like nectar, squash and jam were evaluated. Nectar with 20% pulp, 13% TSS and 0.3% acidity, squash with 25% pulp, 50% TSS and 1.1% acidity and jam with 45% pulp, 68% TSS and 0.5% acidity were found to be ideal. The jam and jelly were prepared from the jackfruit a total soluble solids (65.00%) was observed in jelly and (64.00%) to jam. The pH (5.04) was found in jelly. The pH content (4.11) was observed in jam. Jam showed the (9.607 mg/100 g) of carotenoids. Jelly contains amount 29.17% of moisture (Mondal *et al*., 2013).

Factors that have an influence on quality of jam or jelly 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 or jelly 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).

Good jam has a soft even consistency without distinct pieces of fruit, a bright colour, good flavour and a semi-jelled texture that is easy to spread but has no free liquid (Isabel and William, 1990). 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 colour, 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).

Product Development concept

Hakeem *et al*., (2017) found that the moisture content of all the treatments of apricot jam were decreased during preservation and increased with enhancement of sugar concentration in apricot pulp during 80 days of storage periods.

The increase in total soluble solids from 68.20 to 77.20° brix was reported in guava-carrot jelly with the advancement of storage period (Singh and Chandra, 2012), and also in wood apple jelly from 65.15 to 66.60° brix (Kumar and Deen, 2017). They told that an increase in total soluble solids content in jelly during storage period probably was due to the conversion of polysaccharides into sugars in the presence of organic acids. Similar observations were also observed by Deen and Singh, (2013) in karonda jelly and Kuchi *et al*., (2014) in guava jelly bar. Damiani *et al.*, observed that the soluble solids content ranged from 68.40 to 72.18° brix during storage for marolo and strawberry guava jam.

Rababah *et al*., (2011) evaluated the cherry jam between 0 and 15 days and found pH and soluble solids values from 3.66 to 3.29 and 11.25% to 66.30%, respectively. Prati *et al*., (2009) detected a pH of 3.45 in yacon, guava, and acerola mixed jam, without added sugars, a content lower than that found in this present study. Damiani *et al*., (2012) found that the pH of marolo and strawberry guava jam, during the first

6 months of storage, presented a slight decrease from 3.31 to 3.27 and after 12 months the pH increased to 3.33.

Mesquita *et al*., (2013) evaluated sugar-free guava jam and found a sharp increase of acidity, of 1.2% to 1.9 during storage, values above those of this study.

Prati *et al*., (2009) studied the vitamin C content in yacon, guava, and acerola jam during storage time (180 days) and found a loss of 42.7%. Patras *et al*., (2010) evaluated the ascorbic acid content of strawberry jam stored at two temperatures, 4 and 15°C, and observed decrease in this parameter with the increase of temperature and storage time, leading to a ascorbic acid reduction percentage of 10% and 29.9% after 7 days and also found that after 28 days of storage this reduction percentage ranged from 49.7% to 70% at both temperatures, respectively. Mazur *et al*., (2014) observed a significant decrease of ascorbic acid concentration during storage (6 months at 20 °C) of strawberry jam.

Ripe, healthy and fresh strawberries were collected. The fruit was washed thoroughly with pure water. The fruits were crushed with a blender. The pulp was used for jam and squash preparation. It was included several steps. Sugar and pectin were mixed with the fruit pulp. The mixture was cooked slowly. Cooking was continued till the sheet test was satisfactory (up to 65° brix) and the products were kept for 8-12 hours for jam setting. Rahman (2018) concluded strawberry jam may be stored up to 6 months at room temperature because the nutritional changes of strawberry jam was found satisfactory up to 6 months.

Biochemical quality

Food quality is the sum of all desirable attributes which make a food acceptable for consumption. Quality attributes of a product may be divided into three major categories sensory, hidden and quantitative (Salunkhe *et al*., 1991). The sensory attributes are colour, flavor, texture, taste, etc. The hidden attributes are nutritive values, presence of dangerous contaminants and poisonous materials. The quantitative parameters are those, which contribute to the overall food quality such as the yield of a dried product. In order to determine the quality of the dried product, several parameters need to be examined through quality evaluation.

Moisture content

Generally, the moisture content of foods can be used as an indicator of its shelf life . Panchal *et al*., (2018) revealed that the moisture of dragon fruit jelly was decreased from 28.90% to 27.15% within storage period of 90 days at ambient temperature and also light decrease in moisture of jelly stored at the refrigerated temperature i.e. 28.90% to 27.56% was observed. The decrease in moisture content from 24.02 to 21.58 was observed in guava-carrot jelly during storage (Singh and Chandra, 2012) and in karonda jelly from 35.44 to 30.87% (Singh, 2010). This decrease in moisture may be due to reopening of the same pack during storage for analysis (Muhammad *et al*., 2008). Hakeem *et al*., *(*2017) found that the moisture content of all the treatments of apricot jam were decreased during preservation and increased with enhancement of sugar concentration in Apricot pulp, these decreasing of moisture content was happened during 80 days of storage periods. These findings are supported by different research works reported by (Gordon, et al., 2000, Nayak et al., 2011 and Wani et al., 2013). Muhammad *et al*., (2010) revealed that moisture content of diet apple jam was decreased during 90 days storage The results were in agreement with Ehsan *et al*., (2003) studied grape fruit apple marmalade and reported decreasing trend in % moisture. Anjum *et al*., (2000) observed decreased in % moisture from 79% to 77 % after 60 days of storage in dried apricot diet jam. This decrease may be due to reopening of the same pack during storage for analysis. An increase in TSS implies decrease in moisture content of the sample thus increase in the nutritional composition of the jam samples. Sutwal *et al*., (2017) found that moisture content of apple jam decreased in all samples during 28 days of storage period, moisture content was decreased from 76.99 to 75.33%. Similar observations were found by Ashaye and Adeleke in roselle jam.

Total soluble solids (TSS) content

The TSS is primarily represented by sugars, with acids and minerals contributing. According to the Codex Alimentarius standard (CODEX STAN, 2009), normal fruit must contain or preserves 60% soluble solids, the TSS of melon jam was 73%. Increase in TSS may be due to acid hydrolysis of polysaccharides especially pectin and gums. The increase in TSS contents of jam may also be due to solubilization of jam ingredients or components throughout storage. Similar increase in TSS was also recorded by (Singh *et al*., 2005 in beal/blended beal jam). Likewise, Safdar *et al*.,

(2012) also found a gradual increase in total soluble solids content of mango jam throughout the storage period of 150 days. An increase in total soluble solids content in jelly during storage period probably was due to the conversion of polysaccharides into sugars in the presence of organic acids. Singh *et al*., (2005) revealed that during storage of the beal/blended beal jam, the total soluble solids (TSS) and total sugars increased up to three months. Similar increase in TSS was also recorded by Vidhya and Narain (2011) in wood apple jam, Saravanan *et al*., (2004) in apricot jam, Koli (2004) in Sapota jam, Riaz et al. (1999) in strawberry jam. Increase of TSS during storage, might be due to conversion of polysaccharide into monosaccharide or soluble sugar. Jain *et al*., (1983) reported that the total soluble solid and the total sugars were found to increase in tamarind jam, while acidity showed a continuous fall during storage in aonla preserve. Hossain *et al*., (2012) found that total soluble solids (TSS) of mixed fruit marmalades did not show any remarkable change up to six month of storage period. Kuchi *et al*., (2014) revealed that there was a significant increase on total soluble solid of guava jelly bar on 60 days after storage. Similar findings were reported by Aradhita *et al*., 1996, Paul *et al*., 2007 while working on guava jelly. Result reported by Pandey *et al*., (2004) and Jain *et al*., (2011) was corroborated with the above mentioned findings. Kumar *et al*., (2017) showed that the total soluble solids of wood apple jelly gradually increased with storage period. The results of the study are in close conformity to the findings of Deen and Singh (2013) in karonda jelly. Shakir *et al*., (2008) reported that trend of TSS content of fruit jam increased from 68.5 to 71.2° brix during 3 months of storage. There was an increase in TSS of aonla jam during storage (Diwate *et al*., 2004). There was no significant change in TSS during the storage period of pomegranate jam (Pota *et al*., 1987).

Titrable acidity:

Titrable acidity is directly related to the concentration of organic acids present in the fruit. Organic acids exist as free acids, anions (malate) or combined as salt (potassium bitartrate) and esters such as isopropyl acetate (Keys, 1991). Total titrable acidity determines the strength of jam and there was a subsequent increase in total acidity of jam during preservation and storage. Titrable acidity possesses a firm texture and good setting property. Similar results were reported by (Wang 1999 and Singh, et al., 2000 and Wani et al., 2013). The TA is one of a number of physicochemical parameters which affect product quality; to a large extent, acidity protects against the development of microorganisms. Acidity is the measure of shelf-life of the product (Vidhya and Narain, 2011). Titratable acidity studied to ensure physico-chemical changes during preparation (Sandhu et al., 1998) and during storage (Kalra and Tandon, 1985). Titratable acidity of strawberry jam stored at ambient temperature increased steadily and varied significantly among the treatments and was partially corroborates with that reported by (Hossain, 2011). In his study titratable acidity in jackfruit jam increased from 0.35 % to 2.8 % after 6 months of storage. Sinhg *et al*., (2009) found that the acidity increased from the initial adjusted value up to 0.5 % after 30 days of storage. This findings are strongly in agreement with the present findings. Increase in acidity of fruit jams was reported earlier to be a result of ascorbic acid degradation or hydrolysis of pectin (Sogi and Singh, 2001). Total titratable acidity was slightly increased (Approximately 0.1 to 0.3 g) in the samples stored at 25±5°C and at 37°C may be due to de-esterification of pectin molecules during storage (Kertesz, 1951). The gradual increase in acidity might be due to the formation of acidic compounds by degradation or oxidation of reducing sugars present in the drink by the breakdown of peptic bodies (Warraki *et al*., 1976). In wood apple jam, acid content was found to be increased during storage (Vidhya and Narain, 2011). These results are in accordance with the findings of Shakir *et al*., (2007) who found that the mean values of titratable acidity for different treatments of apple and pear mixed fruit jam increased significantly from 0.63 to 0.75 during storage interval of 90 days. Hussain and Shakir (2010) also showed in their studies that mean value for acidity of apricot and apple jam during storage period at initial day (0.650) which increased at 60 days (0.743). Kumar *et al*., (2017) revealed that the titratable acidity of woodapple jelly was increase gradually during storage period. Total pectic substances have been reported to increase the acidity in fruit products (Conn and Stumf, 1976), hence degradation of pectin substances of pulp into soluble solids might have contributed towards an increase in acidity of products. The another reason for slight increase in titratable acidity might be due to formation of organic acids by the degradation of the ascorbic acid as it decreased with storage period of the jelly. This is in consonance with the findings of Deen and Singh (2013) in karonda jelly and Kuchi *et al*., (2014) in guava jelly bar. Shakir et al., (2008) found that an increase was noted in acidity from 0.60 to 0.78%, during 3 months storage.

pH

The pH must not be too low (>3.5) since it could induce deterioration of sensory quality: glucose crystallization; granular texture; excessive acidic flavour; and exudation phenomenon (Besbes *et al*., 2009); The pH of strawberry drink decreased due to an increase in acidity during storage period (Murtaza *et al*., 2004). A similar decreasing trend in pH during storage was observed in jackfruit jam by (Hossain, 2011) and in mixed fruit jam by (Shakir *et al*., 2008). This may be due to the formation of acidic compounds. Similar results were reported by Hussain and Shakir (2010) who found that mean value for pH of apricot and apple jam during storage period at initial day was 3.75 which decreased at 60 days to 3.10. pH of mixed fruit marmalades was slightly reduced throughout 180 days of storage period described by (Hossain *et al*., 2012). The variation of pH occurred due to the variation of acidity during storage period at room temperature. Hoque *et al*., (2012) found the pH of dragon fruit jellies were decreased during 4 months of storage. Rababah *et al*., (2011) stated that after processing, the pH of fruit jams became 2.71, and during storage it did not change significantly, which is partially in agreement with present results. Garcia-Viguera *et al*., (1999) found that pH of strawberry jam varied significantly ranging from 2.98 to 3.39 during jam preparation, and revealed a steadily decrease during storage. These findings were similar with the present findings. The pH of the samples decreased due to an increase in acidity during storage period (Murtaza *et al.*, 2004). Hakeem *et al*., (2017) found that there was a regular decrease of pH value of all the treatments of apricot jam during 80 days of storage. Similar findings were also obtained by some other scientists (Baker, 1989; Joseph, 1994; Lal, *et al*., 1998; Singh, *et al*., 2008 and Wani *et al*., 2013). Mudasir, B. and Anju, B. (2018) found that there was a decrease trend of pH of pumpkin guava belnded jam during 6 months of storage. The decrease in pH in all treatments which might be as a result of ascorbic acid degradation or hydrolysis of pectin as reported by Muhammad *et al*., (2008) in diet apple jam, Shakir *et al*., (2007) in apple and pear mixed fruit jam, Chopra *et al*., (2003) in wood apple jelly and Gowda *et al*., (1995) in guava fruit bar.

Ascorbic acid content

Ascorbic acid content showed a gradual decrease during preservation because of breakdown of ascorbic acid by antiascorbic acid compounds. The decreasing trend of ascorbic acid with the advancement of storage period might be due to conversion of dehydroascorbic acid to diketogluconic acid by oxidation (Rai and Saxena, 1988 and Lee *et al*., 2000) .The fall in ascorbic acid content might be due to oxidation of ascorbic acid to dehydro-ascorbic acid (DHA) or furfural or hydroxymethyl furfural in jam. Similar results were reported by Torezan (2002) in mango jam during storage and Riaz *et al*., (1999) in strawberry jam. Gupta (2000) also observed a decrease in ascorbic acid content during storage of sweet papaya chutney. This result partially agreed with that of Hossain (2011), who found a reducing trend in ascorbic acid of jackfruit jam and it decreased 18.79 % during 6 months of storage. Similar results were recorded by Jawaheer *et al*., (2003) who observed 37.5% retention of ascorbic acid in guava jam after processing. Shakir *et al*., (2008) reported that ascorbic acid content decreased from 17.40 to 9.19 mg/100 g in mixed fruit jam during 3 months of storage. A substantial reduction in ascorbic acid content of the sample during storage could be due to both oxidative and non oxidative changes as described by Eskin (1979) and Land (1962). Kumar *et al*., (2017) revealed that the reduction in ascorbic acid content of woodapple jelly could be due to oxidation by trapped oxygen in glass bottles which results a formation of highly volatile and unstable dehydro ascorbic acid followed by further degradation to 2, 3- diketogulonic acid and finally to furfural compounds. Mapson, *et al*., (1970) observed that oxidation due to temperature and greater catalytic activity of fructose in the catabolization of vitamin-C could be the reason for its decrease. The finding of present investigation matches with those as reported by Chaudhary *et al*., (2007) in karonda jelly and Deen and Singh (2013) in karonda jelly. Louaileche *et al*., (2016) found a significant reduction of ascorbic acid concentration in commercial orange jam after 30days storage. Similar results were reported by Patras *et al*., (2011) when studying changes in ascorbic acid content of strawberry jams stored at 15 °C for 28 days. In addition, Mazur *et al*., (2014) observed a significant decrease of ascorbic acid concentration during storage (6 months at 20 °C) of strawberry jam. Louaileche *et al*., (2016) found a significant reduction of ascorbic acid concentration in commercial orange jam after 30days storage. However, in another study, Pavlova *et al*., (2013) showed that vitamin C values of peach and raspberry jams stored under room temperature were maintained during 90 days. Loss of ascorbic acid in guava jelly bar samples during storage of 60 days described by (Kuchi *et al*., 2014).

2.12 Sensory attributes

Sensory analysis provides marketers with an understanding of product quality, directions for product quality, and profiles of competing products and evaluations of product reformulations from the consumer perspective (Stone and Sidel, 2010). Consumer affective tests are the most straight forward approach and panellists a choice between alternative products to watch if there is a clear preference from the majority of respondents. Data obtained from consumer affective tests are vital in product development, quality control, food product acceptance, and food service evaluation. Armanray *et al*., (1996) evaluated organoteptic quality of freshly prepared jelly to be highly acceptable and reduced significantly with the increased storage period. He also reported that colour, flavour, texture, and acceptability of jelly, from cultivar sardar has higher initial score but decreased significantly at 90 days of storage. There are two types of affective tests: quantitative and qualitative. The qualitative tests (i.e. focus group interviews, focus panels, one-on-one interviews) measure the subjective responses of a small group of representative consumers to the sensory properties of products by having them talking about their feelings in an interview or group setting (Meilgaard *et al*., 1999). The quantitative tests determine the responses of a large group of consumers to a set of questions regarding preference, liking, sensory attributes, etc. (Meilgaard *et al*., 1999).The most important quality attributes of a food product to consumers are its sensory characteristics (e.g. texture, flavor, aroma, shape and color).

Patel *et al*., (2015) showed decreasing trend of overall acceptability score considering texture, colour, flavour, and taste of banana - pineapple blended jam during the storage period due to the decline the colour, texture, taste and flavour with increasing storage period. Such identical findings were also observed by Priya *et al*., (2010) in mixed fruit jam and Relekar *et al*., (2011) in sapota jam. Processing cultivars changed color more rapidly while they maintained higher firmness ratings than non-processing cultivars, suggesting slower degradation of protopectin by the two enzymes pectinesterase and polygalacturonase than chlorophyll breakdown and pigment synthesis which is also in agreement with the findings of Mohammed et al. (1999) and Moraru *et al*., (2004). Hoque *et al*., (2012) stated that the color, flavor, texture and overall acceptability of dragon fruit jellies were significantly changed during 6 months of storage and all the samples were not equally acceptable.

Kuchi *et al*., (2014) revealed that overall acceptability score decreased from initial score of 8.56 to 6.21 and 3.57 in guava jelly bar at room temperature after 60 days. Organoleptic score of jelly were decreased gradually with storage period at ambient temperature as described by Kumar *et al*., (2017). The acceptability of jelly was maintained up to 6 month of storage. Losses in organoleptic quality of jelly after certain period are obvious because of undesirable changes in the product. Temperature plays an important role in inducing certain undesirable biochemical changes in the jelly which leads to development of off flavour as well as discoloration (browning) and there by masking the original colour and flavour of the product. Similarly, reduction in organoleptic quality has also been reported in guava jelly (Paul *et al*., 2007) and in karonda jelly (Chaudhary *et al*., 2007 and Deen and Singh 2013). Muhammad *et al*., (2008) showed that the overall acceptability (determine with the average grading of color, taste and texture) of diet apple jam gradually decreased in all samples during storage. Hosain *et al*., (2010) showed all the pickles of okra became softer with the passing of time. Singh and Chandra (2012) reported there was decrease in most of physico-chemical and sensory qualities of guava-carrot jelly during the storage. The overall acceptability score decrease from 7.34 to 6.14 in guava-carrot jelly. Chauhan *et al*., (2012) reported that the sensory attributes for color, appearance, flavor and overall acceptability of the coconut jam samples showed a decreasing trend during storage.

CHAPTER III

MATERIALS AND METHODS

Collection and preparation of experimental materials

The experiment was conducted at postharvest laboratory of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during March 2019 to November 2019 to develop value added jackfruit products (jam and jelly) using preservatives like KMS, sodium benzoate and measure the storage study of these products during 90 days of storage. The maximum and minimum relative humidity of the room was 84% and 74%, respectively under the room temperature of 28-32 °C.

Fully matured and disease free ripe jackfruits (*Artocarpus heterophyllus Lam*) were collected from Horticulture Research field, SAU, Dhaka. Jam bottles were purchased from Agargaon bazar, Dhaka. Analytical food grade reagents and chemicals were obtained from Chemistry and Soil Science laboratories at SAU. Sugar, lemons, plastic basin, muslin cloth and sieves were all purchased from Bou bazar market, SAU. Formulations and other ingredients are listed in Tab. 1

Tools and Equipments used

Knife, muslin cloth, wooden spoon, tea spoon, glass jar, glass bottles, butter paper, plastic jar, tasting salt, palm oil, saucepan, thermometer, weighing mechine, mixer grinder, pH meter, refrectometer, burette, and oven were used in the experiment.

Table 1. Formulations of different preparations

Ingredients	**Jam**	**Rind jelly**
Jackfruit rind (g)	-	500
Jackfruit bulb (g)	500	-
Sugar (g)	S_1-200, S_2 -250, S_3-300	S_1-200, S_2 -250, S_3-300
Citric acid (g)	2	-
Pectin (g)	5	5
Agar (g)	-	1
KMS (g)	0.8	0.8
Lemon (piece)	Half	1
Water (cup)	1	1 & ½
Sodium benzoate (g)	1.4	1.4

Treatments

The experiment was designed to study the effect of different levels of sugar and preservatives on jam and jelly prepared from jackfruit.

The experiment had two factors, which are as followes:

Factor A: Sugar Concentrations/500g fruit

i. S_1-200g sugar
ii. S_2-250g sugar
iii. S_3-300g sugar

Factor B: Preservatives/500g fruit

i. P_0-no preservative
ii. P_1-sodium benzoate (1.4g)
iii. P_2-potassium metabisulphite (0.8g)

There were 9 (3x3) treatment combinations both for jam and jelly, such as S_1P_0, S_1P_1, S_1P_2, S_2P_0, S_2P_1, S_2P_2, S_3P_0, S_3P_1, S_3P_2. These treatments were replicated three times in this study. Formulations of sugar and preservatives are listed in Tab. 1

Experimental design and method of analysis:

The two factorial experiment was laid out in the Completely Randomized Design (CRD) with two replications. The postharvest treatments were assigned randomly in each replication. The collected data on various parameters were statistically analyzed using MSTAT statistical software.

Experimental materials

Fruits

Well matured jackfruits were selected and ripened in two days after harvest. The fruits were collected carefully to avoid the latex of the rind. Then, it was washed reasonably with fresh water and the bulbs and cores were separated.

Procedure for making jackfruit jam and rind jelly:

Production of Jam: Fresh ripened jackfruits were washed thoroughly with tap water to remove all the dirts. Then they were cut diagonally and fresh bulbs were separated from seeds and other fruit parts.

Plate 1. Pieces of jackfruit

The bulbs were blended with fruit grinder (prestige super blender, model no: MXT-17, China) and then sieved with a 2mm mesh sieve. Then sieved pulp was boiled for about 10 minutes to soften the mixture for easy homogenization.

After boiling pulp was weighed to 500g for each samples. Then different combination of sugars like, 200g, 250g and 300g and lemon juice (half piece) were added together to the pulp, where the lemon juice was used in order to lower pH and increase pectin in jam.

Plate 2. Blending of bulbs

Plate 3. Boiling pulp mixture

Pulp mixture was boiled for approx. 35 min and stopped when it become relatively thicker in nature which may denotes jam.

Selection the fully ripe jackfruit

↓

Washing with clean water

↓

Lengthwise cutting the fruit into half

↓

Taking bulb and removing seeds

↓

Blending the bulb and boiling for 10 minutes and extract juice

↓

Adding sugar as per treatment and 5g pectin with 500g juice

↓

Cooking until the TSS reach to 64 °Brix and adding citric acid (2g)

↓

Determining the end point of cooking

↓

Pouring into sterilized bottle and then waxing

↓

Labeling and storing the product at temperature (28-32 °C)

Fig. 1: Flow diagram for jam preparation

Plate 4. Jackfruit jam stored in glass bottles at room temp (28-32 °C)

Production of Rind Jelly: Well matured jackfruits were selected, so that it ripen and became soft within one or two days after harvest. The fruits were collected carefully to avoid the latex of the rind.

Plate 5. Small pieces of jackfruit rind

Plate 6. Blended rinds

Then 1.5 L water and 1 lemon were added for each 500g rind. For making jelly, different combination of sugars like, 200g, 250g and 300g were taken. Boiling continued around 40 minutes and end point was determined.

Plate 7. Boiling of rind

Selection fully matured ripe jackfruit

↓

Washing with clean water

↓

Separating rind and cutting into small pieces

↓

Adding 1.5 L water and 1 lemon for each 500g rind

↓

Boiling 35 minutes and extracting juice

↓

Adding sugar as per treatment and 5g pectin with juice and start cooking

↓

Cooking until the TSS reach to 65 °Brix and adding citric acid

↓

Determining the end point of cooking & pouring into sterilized bottle

↓

Labeling and storing the product at room temperature (28-32 °C)

Figure 2: Flow diagram for rind jelly preparation

 

Plate 8. Jackfruit rind jelly stored in glass bottles at room temp (28-32 °C)

Chemical analysis of jam, jelly:

After preparation of jam and jelly, the quality attributes viz. moisture content (%), soluble solid concentration (SSC), pH, titratable acidity (TA) and ascorbic acid content (Vit-C) were studied in this present experiment.

Determination of Moisture content: The moisture content of the fruit is normally used as indicator of its shelf life. The moisture content of fresh jackfruit was 77.03% and The moisture content of jackfruit jam & jelly were lower than that fresh jackfruit content. This difference in moisture between processed and unprocessed jackfruit is expected because of the sugar added and heating process involved during jam, jelly making that caused moisture evaporation. The difference may be due to geographical location and different existing varieties. Higher moisture content suggests that the jam, jelly have a short shelf life.

Experimental samples were subjected to moisture and dry matter analysis as per Association of Analytical Communities [AOAC] protocols. Here, 10 gm fruit was taken in crucible and placed in an oven, the moisture content was determined by measuring weight loss of measured sample in a moisture box by desiccation in an oven maintained at 80°C for 72 hours until constant weight attained. The dry matter content was estimated as the difference of sample weight and moisture content.

$$\text{Moisture content (\%)} = \frac{(\text{Initial weight} - \text{Final weight}) \times 100}{\text{Initial weight}}$$

Determination of pH: The pH was determined using a phs-25 pH meter as described in AOAC (2007). An electrolytic cell composed of two electrodes (calomel electrode and glass electrode) was standardized with buffer solution of pH 4. Buffer solution of any known pH may be used. Then the electrodes were dipped into the test sample (jam & jelly). A voltage corresponding to the pH of the solution indicated by the instrument.

Determination of TSS: Juice extracted from 100 g of sample of jam/jelly of each treatment was used to determine the TSS. Total soluble solids (TSS) were determined by hand refractometer (ERMA made Japan) of 58-92 % range, at room temperature (Ranganna, 2010). By aiming the front end of the refractometer in the direction of a bright light, the adjusting ring of the diopter was adjusted until the reticle could be seen clearly. Adjustment of null was done by opening the cover plate and putting one or two drops of distilled water on the prism. The cover plate was closed and pressed lightly and then the correcting screw was adjusted to make the light/dark boundary coincide with the null line. The cover plate was opened and the surface of the prism was cleaned with a piece of soft cotton flannel. 1 or 2 drops of the juice from processed jackfruit jam was placed on the prism surface. The cover plate was closed and pressed lightly and then the corresponding scale of light and dark boundary was read off. This reading was taken as the TSS (o Brix) of the jackfruit jam. The same quality attributes were evaluated for day 0 (day at which minimal processing was performed) and during the storage at periodic intervals. In case of rind jelly, the same procedure was followed.

Determination of Titratable acidity:

The titratable acidity of jackfruit bulb samples was determined by the visual titration method (Ranganna, 1986).

Preparation of sample

A 10 g sample of pulp was taken in a 100 ml beaker and a little quantity of distilled water was added to it. The mixture was then gently boiled in a water bath for 1 hour with occasional stirring and frequently replacing water which was lost due to evaporation. After cooling, the mixture was transferred to 100 ml volumetric flask and the volume made up with distilled water. This was then filtered through Whatman No. 4 filter paper and the filtrate was used for analysis.

Procedure

A 10 ml of filtrate was taken in a conical flask and titrated against 0.1N NaOH solution in a burette using 1 or 2 drops of phenolphthalein indicator. Formation of pink colour was reckoned at the end point of titration. The titration was repeated till consistent titre values were obtained.

Calculation

Titratable acidity, % =

$$\frac{\text{Titre value x N of NaOH (0.1M)x Volume made up(50 ml) x Equivalent weight of citric acid (64g) x 100}}{\text{Aliquot taken for titration (10ml)x weight of sample(10g)} \times 1000}$$

Determination of Vitamin C (Ascorbic Acid) content: The ascorbic acid content of jackfruit was determined by 2, 6-dichlorophenol indophenol visual titration method (Ranganna, 1986) as detailed here under.

Preparation of 4 percent oxalic acid

A 4 g of oxalic acid was placed in a beaker and dissolved in 100 ml of distilled water.

Preparation of 2, 6-dichlorophenol indophenol dye solution

In a beaker, 52 mg of 2, 6-dichlorophenol indophenol dye and 42 mg $NaHCO_3$ were dissolved and the volume made up to 200 ml using hot distilled water.

Preparation of stock standard solution

A 100 mg of ascorbic acid was dissolved in 100 ml of 4 percent oxalic acid.

Standard ascorbic acid

A 10 ml of stock standard solution was diluted to 100 ml using the acid (4 percent oxalic acid) mixture. Therefore the standard ascorbic acid contained 0.1 mg of ascorbic acid per ml solution.

Determination of vitamin C equivalent of 10 ml dye

A 1 ml of vitamin C solution containing 1 mg of vitamin C was added to 5 ml of 4 percent oxalic acid and titrated against dye solution taken in the burette. The titre value was noted down and the titration repeated till identical values were obtained.

Calculation of Dye factor

Dye factor = $\frac{X}{(\quad)}$ Here, X= 0.5

Preparation of sample

A 10g of processed pulp of jackfruit bulbs/rinds was taken in a 100 ml volumetric flask and thoroughly mixed with 50 ml of 4 percent oxalic acid. The mixture was filtered through a thin cloth, and the filtrate volume made up to 100 ml using 4 percent oxalic acid. 10 ml of this was pipetted out and titrated against 2, 6 dichlorophenol indophenol dye solution.

Procedure

A 10 ml of filtered sample and 5 ml of 4 % oxalic acid were taken in a conical flask and titrated against the 2, 6 dichlorophenol indophenol dye solution in a burette. The end point was light pink colour that persisted for 5-10 seconds.

Calculation

Ascorbic acid, mg/100g =

$$\frac{\text{Value titre(ml)} \times \text{Dye factor (0.081)} \times \text{Volume made up (100ml)} \times 100}{\text{Volume taken for titration (10ml)} \times \text{Weight of pulp sample(10g)}}$$

Sensory evaluation of jam and jelly:

Sensory evaluation of the jam samples were conducted as described by Iwe (2002) using 10-members panel randomly selected from the university community. The samples were packaged in a glass bottles and presented in a coded manner. The sensory quality attributes of the samples were color, appearance, sweetness, stickiness, flavor and acceptability. In the questionnaire presented to the panelists, they were requested to observe and taste each sample as coded with bread provided and grade them based on a 1-7 point hedonic scale showing dislike extremely to like extremely in all attributes. They were also provided with potable water to rinse their mouth after evaluating each sample to check taste interference.

Plate 9. Sensory evaluation by selected member

Storage Study:

All the prepared samples were stored at room temperature (28-32 °C) for a period of 3 months. The stored samples were examined monthly. Quality parameters like colour, taste, flavor, texture and overall acceptability were examined during the storage period for about 3 months. During storage the changes in moisture content, pH, TSS, titrable acidity and vitamin- C were observed. The analyses of the parameters were done according to standard analytical methods summarized by (AOAC, 2000) and (Rangana, 2003).

Statistical Analysis:

The data collected from storage materilas was statistically analyzed. The mean values for all the treatments was calculated and the analysis of variance for most of the characters was accomplised by F variance test. The significance of difference between pair of means was tested by Duncan's Multiple Range Test (DMRT) test at 1% probability (Gomez and Come, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

Jackfruit jam and jelly were prepared from well matured ripen jackfruit. Different composition and acceptability of jam and jelly were investigated. The results of various experiments conducted during the study period are discussed below:

Composition of the fresh jackfruit

The moisture, carbohydrate, protein, crude fat, ash, pH, Titrable acidity, TSS, Vitamin C content of jackfruit are presented on the tab. 2.

Table 2. Composition of fresh jackfruit pulp used in this study:

Parameters	Quantity
1. Moisture (%)	77.03
2. Carbohydrate (%)	16.19
3. Protein (%)	1.65
4. Crude fat (%)	0.03
5. Ash (%)	0.41
6. pH	5.41
7. Titrable acidity(g/100g)	0.05
8. TSS (%)	23.80
9. Vitamin C (mg/100g)	5.99

Biochemical changes during storage of jam & jelly at different treatments:

Moisture content (%)

Effect of different sugar concentrations and preservatives on moisture content of jackfruit jam and jelly

Moisture content of jam and jelly at different treatments were varied significantly. The changes were occured after 30 to 90 days of storage time. The moisture content was decreased during storage. After 90 days jam had the lowest moisture content and jelly had slight higher than jam. The moisture content of jam was (29.02%), and in jelly the value was (29.68%). Low moisture content indicates that the jams have a long shelf life, the highest moisture is more susceptible to spoilage than the other samples by microbial invasion especially fungi and mould (Ihekoronye and Ngoddy, 1985). Similar results were also found by Panchal *et al*., (2018) revealed that the moisture of dragon fruit jelly was decreased from 28.90% to 27.15% within storage period of 90 days at ambient temperature.

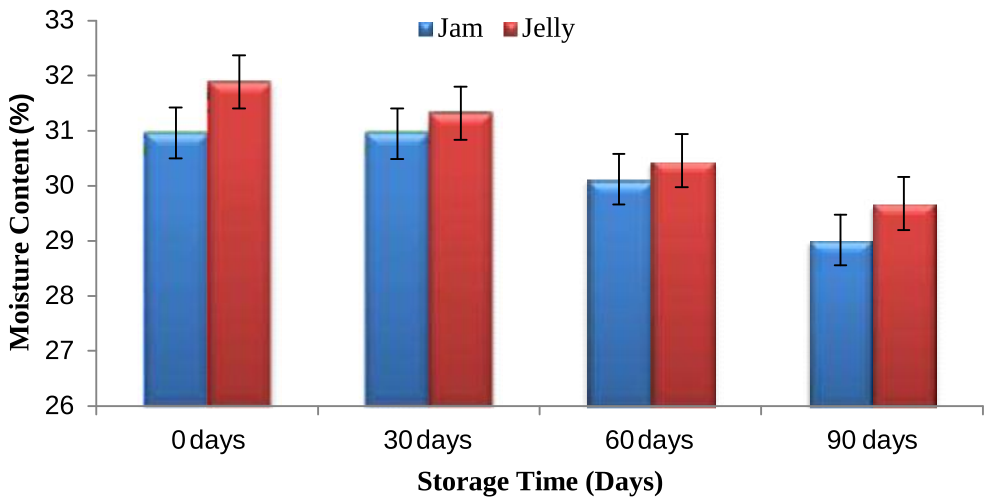

Fig. 3. Effect of storage period on the moisture content of jackfruit jam and jelly (vertical bars represents standard error)

Effect of different sugar concentrations and preservatives on moisture content of jackfruit jam and jelly

Sugar concentrations had significant influence on moisture content of jackfruit jam (Fig. 4 and Appen-I). During 90 days of storage, moisture content was decreased gradually. The highest moisture content was in S_3 and it was (31.35%), the lowest in S_1 (27.71%) and S_2 had also lower (28.01%). In all storage condition, S_3 had the higher moisture content which might be due to moisture absorbed by sugar component of jam.

Different preservatives had significant influence on moisture content of jackfruit jam (Fig. 5 and Appen-I). During 90 days of storage, moisture content was decreased gradually. The highest moisture content was in P_0 and it was (30.70%), and the lowest in P_2 (27.35%). In all storage condition, P_2 had the lower moisture content. The difference in moisture was expected because preservative added in optimized jam (KMS) acted as a firming agent strengthening the quality of jam and also acted as glazing agent thus providing a waxy coating to prevent water loss. Singh (2010) also observed similar results.

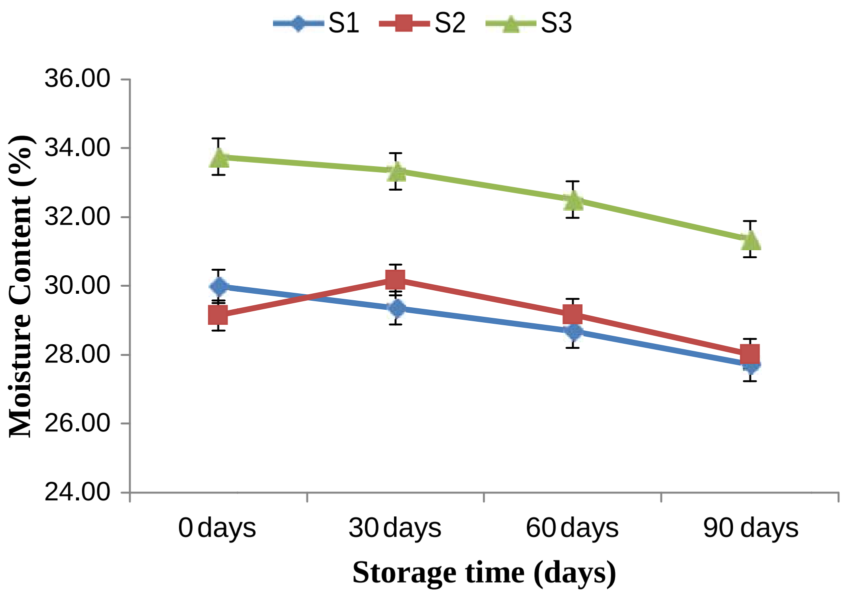

Fig. 4. Effect of sugar concentrations on moisture content of jackfruit jam at different days after storage

S_1:200g sugar, S_2:250g sugar, S_3:300g sugar

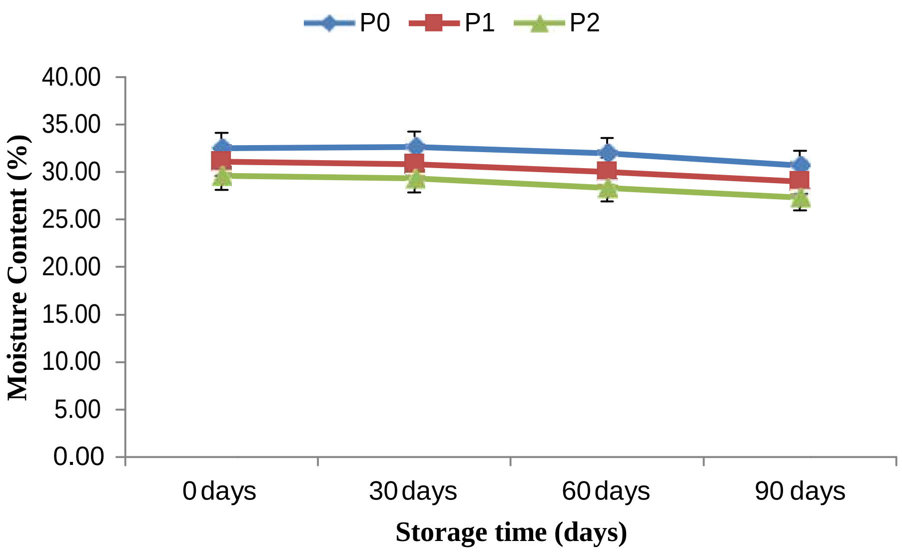

Fig. 5. Effect of preservatives on moisture content of jackfruit jam at different days after storage

P_0:no preservative, P_1:sodium benzoate, P_2:potassium metabisulphite

Sugar concentrations had significant influence on moisture content of jackfruit jelly (Fig. 6 and Appen-I). During 90 days of storage, moisture content was decreased gradually. The moisture content of S_3 was the highest (30.34%), and the lowest in S_1 (29.03%).

Different preservatives had significant influence on moisture content of jackfruit jelly (Fig. 7 and Appen-I). During 90 days of storage, moisture content was decreased gradually. The highest moisture content was in P_0 (30.70%), and the lowest in P_2 (28.34%). In all storage condition, P_2 had the lower moisture content. The difference in moisture was expected because preservative added in optimized jam (KMS) acted as a firming agent strengthening the quality of jam and also acted as glazing agent thus providing a waxy coating to prevent water loss. Panchal *et al.*, (2018) revealed that the moisture of dragon fruit jelly was decreased from 28.90% to 27.15% within storage period of 90 days at ambient temperature.

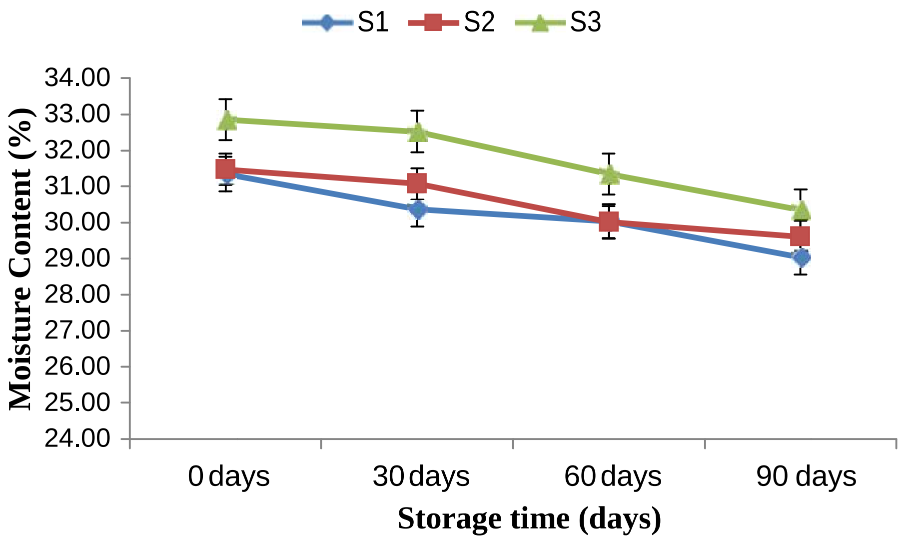

Fig. 6. Effect of sugar concentrations on moisture content of jackfruit jelly at different days after storage

S_1:200g sugar, S_2:250g sugar, S_3:300g sugar

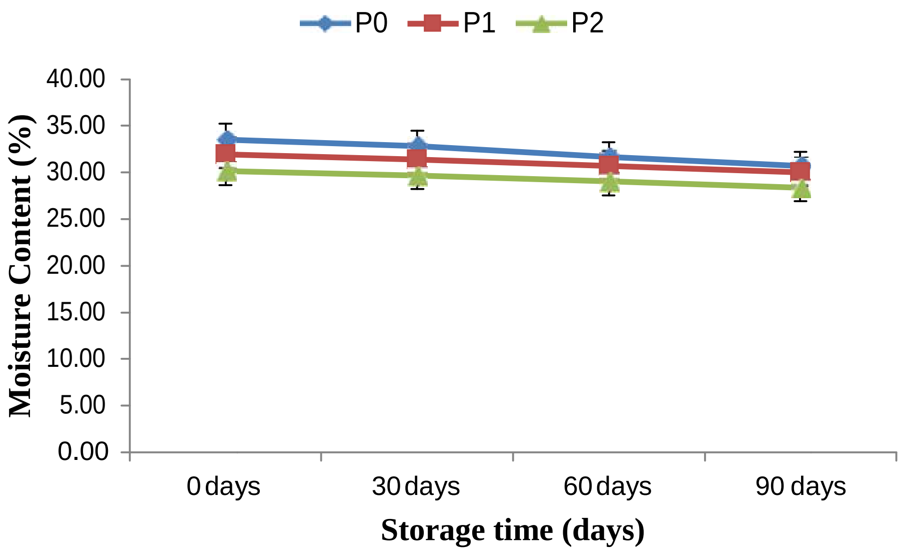

Fig. 7. Effect of preservatives on moisture content of jackfruit jelly at different days after storage

P_0:no preservative, P_1:sodium benzoate, P_2:potassium metabisulphite

4.3.1.3 Combined effect of different sugar concentrations and preservatives on moisture content of jackfruit jam and jelly

The moisture content of jackfruit jam and jelly at different treatments varied significantly (Tab. 3). In case of jam, S_2P_2 and in case of jelly, S_3P_2 gave lowest value (26.01%) and (27.01%) after 90 days of storage. Results from Muhammad *et al*., (2010) revealed that moisture content of diet apple jam was decreased during 90 days storage.

Table 3. Combined effect of different sugar concentrations and preservatives on moisture content of jackfruit jam and jelly

Products	Treatments	Moisture content at different days after storage			
		0 day	30 days	60 days	90 days
Jam	S_1P_0	31.03g	30.01h	30.05f	29.06e
	S_1P_1	29.02l	29.02j	28.03i	27.05g
	S_1P_2	29.91j	29.03j	28.01ii	27.03eg
	S_2P_0	29.92ij	33.00d	32.00d	31.01c
	S_2P_1	29.52k	29.51i	28.51h	27.03gg
	S_2P_2	28.00i	28.00k	27.01j	26.01h
	S_3P_0	35.51a	35.00a	34.00a	32.04b
	S_3P_1	34.70c	34.01c	33.50b	33.00a
	S_3P_2	31.04g	31.00f	30.01 f	29.01e
Jelly	S_1P_0	33.01e	32.01e	31.03e	30.04d
	S_1P_1	31.02g	30.03h	30.04f	29.05e
	S_1P_2	30.0i1	29.04j	29.03g	28.01cf
	S_2P_0	32.61f	32.03e	31.01e	30.03d
	S_2P_1	30.80h	30.20g	29.01g	29.03e
	S_2P_2	31.02g	31.00f	30.03f	30.01d
	S_3P_0	35.01b	34.50b	33.03c	32.03b
	S_3P_1	34.01d	34.02c	33.00c	32.00b
	S_3P_2	29.53k	29.05j	28.01i	27.01g
Level of Significance		*	*	*	*
CV (%)		0.06	0.06	0.03	0.05
LSD at 1%		0.09102	0.09102	0.09102	0.09102

* Significant at 1% level of probability, CV= Co-efficient of variation,

(S_1P_0:200g sugar+no preservative, S_1P_1:200g sugar+sodium benzoate, S_1P_2:200g sugar+potassium metabisulphite, S_2P_0:250g sugar+no preservative, S_2P_1:250g sugar+ sodium benzoate, S_2P_2:250g sugar+potassium metabisulphite, S_3P_0:300g sugar+no preservative, S_3P_1:300g sugar+sodium benzoate, S_3P_2:300g sugar+potassium metabisulphite)

pH value

Effect of different sugar concentrations and preservatives on pH of jackfruit jam and jelly

The pH of jam and jelly at different treatments were varied significantly. The changes were occured after 30 to 90 days of storage time. The pH was decreased during storage. After 90 days jam had the highest pH and jelly had slight lower than jam. The pH of jam was (3.87), and in jelly the value was (3.81). Muhammad *et al.*, (2008) also observed a decrease in pH of diet apple jam from 4.34 to 3.01 during 90 days storage.

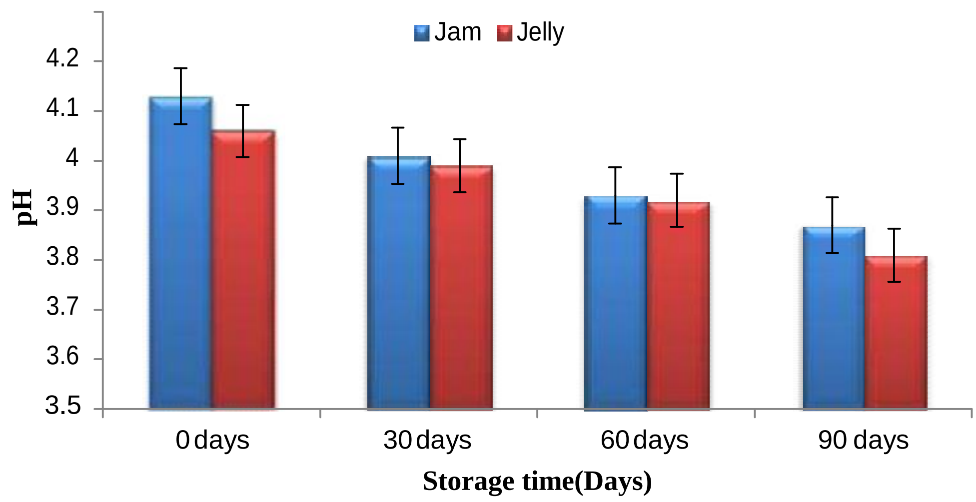

Fig. 8. Effect of storage period on pH of jackfruit jam and jelly (vertical bars represents standard error)

Effect of different sugar concentrations and preservatives on pH of jackfruit jam and jelly

Sugar concentrations had significant influence on pH of jackfruit jam (Fig. 9 and Appen- II). The pH was decreased gradually during storage. After 90 days of storage, the highest pH was in S_3 (3.95), S_2 had also higher (3.82) and the lowest in S_1 (3.64). The pH of S_3 and S_2 was almost similar but S_1 had very lower pH.

Different preservatives had significant influence on pH of jackfruit jam (Fig. 10 and Appen- II). During 90 days of storage, pH was decreased gradually. The highest pH was in P_2 (3.99), and the lowest in P_0 (3.65). In all storage condition, P_2 had the higher pH. During storage intervals pH decreases due to increase in acidity during storage. Shakir *et al*., (2008) also observed similar results.

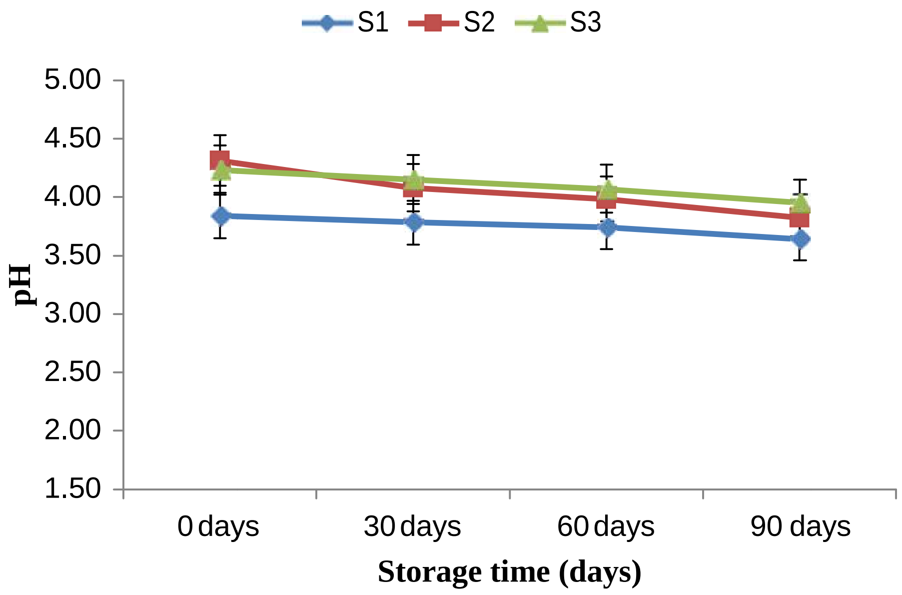

Fig. 9. Effect of sugar concentrations on pH of jackfruit jam at different days after storage

S_1:200g sugar, S_2:250g sugar, S_3:300g sugar

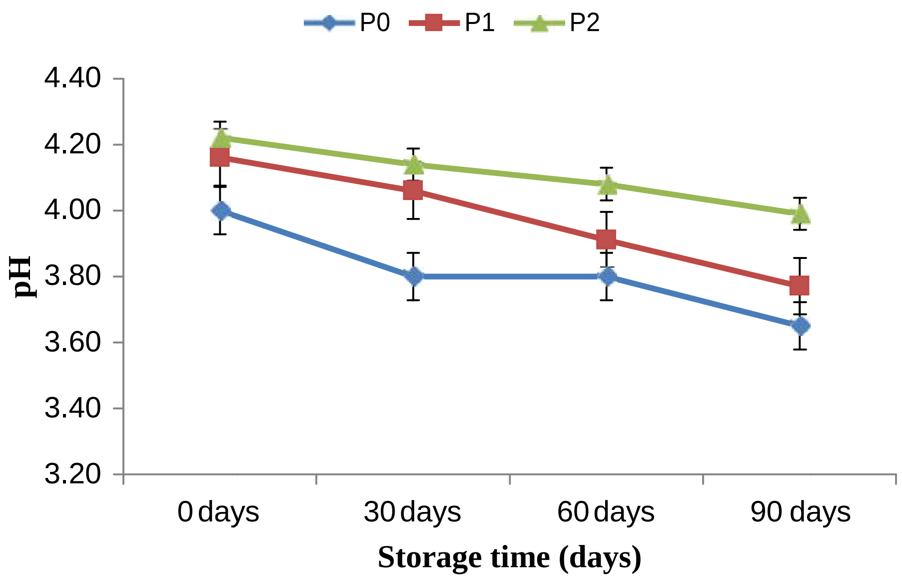

Fig. 10. Effect of preservatives on pH of jackfruit jam at different days after storage

P_0:no preservative, P_1:sodium benzoate, P_2:potassium metabisulphite

Sugar concentrations had significant influence on pH of jackfruit jelly (Fig. 11 and Appen- II). The pH was decreased gradually during storage. After 90 days of storage, the highest pH was in S_3 (3.99) and the lowest in S_1 (3.72). In all storage condition, S_3 had the higher pH.

Different preservatives had significant influence on pH of jackfruit jelly (Fig. 12 and Appen- II). During 90 days of storage, the pH was decreased gradually. The highest pH was in P_2 (3.97), and the lowest in P_0 (3.74). During storage intervals pH decreases due to increase in acidity during storage. Hoque *et al*., (2012) found the pH of dragon fruit jellies were decreased during 4 months of storage.

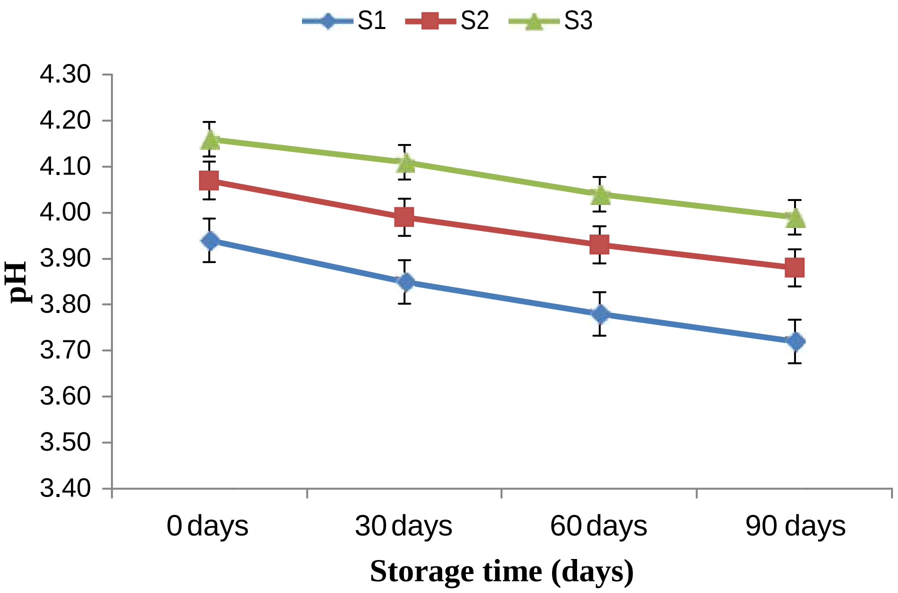

Fig. 11. Effect of sugar concentrations on pH of jackfruit jelly at different days after storage

S_1:200g sugar, S_2:250g sugar, S_3:300g sugar

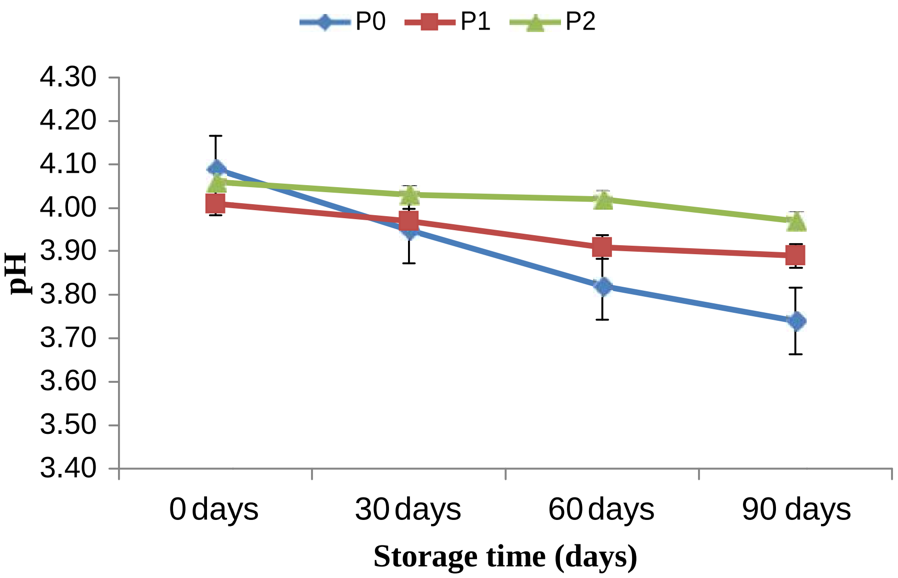

Fig. 12. Effect of preservatives on pH of jackfruit jelly at different days after storage

P_0:no preservative, P_1:sodium benzoate, P_2:potassium metabisulphite

4.3.1.3 Combined effect of different sugar concentrations and preservatives on pH of jackfruit jam and jelly

The pH of jackfruit jam and jelly at different treatments varied significantly (Table 4). In case of jam, S_2P_2 and in case of jelly, S_3P_2 gave highest value (4.12) & (4.10) among the combined effect after 90 days of storage. Hakeem *et al*., (2017) found that there was a regular decrease of pH value of all the treatments of apricot jam during 80 days of storage.

Table 4. Combined effect of different sugar concentrations and preservatives on pH of jackfruit jam and jelly

Products	Treatments	pH content at different days after storage			
		0 day	30 days	60 days	90 days
Jam	S_1P_0	3.41g	3.36j	3.34gh	3.31i
	S_1P_1	3.85f	3.78i	3.74h	3.58h
	S_1P_2	4.26ab	4.20bc	4.16cde	4.05ab
	S_2P_0	4.27ab	3.80hi	3.90fgh	3.65gh
	S_2P_1	4.30ab	4.12cd	3.80b	3.70g
	S_2P_2	4.36a	4.34a	4.25a	4.12a
	S_3P_0	4.32ab	4.25ab	4.16bc	4.00bc
	S_3P_1	4.34ab	4.30ab	4.20bc	4.05ab
	S_3P_2	4.05cd	3.90fg	3.85e	3.80f
Jelly	S_1P_0	4.08cd	3.88gh	3.72gh	3.64gh
	S_1P_1	3.80f	3.76i	3.70c	3.66gh
	S_1P_2	3.95e	3.92fg	3.92de	3.88ef
	S_2P_0	4.07cd	3.91fg	3.78fg	3.68g
	S_2P_1	4.15c	4.10d	4.05a	4.03abc
	S_2P_2	4.00de	3.98ef	3.98ab	3.94cde
	S_3P_0	4.13c	4.08d	3.96bcd	3.90de
	S_3P_1	4.10c	4.05de	4.00ef	3.98bcd
	S_3P_2	4.25b	4.20bc	4.17b	4.10ac
Level of Significance		*	*	*	*
CV (%)		0.26	0.22	0.28	0.28
LSD at 1%		0.09102	0.09102	0.09102	0.09102

* Significant at 1% level of probability, CV= Co-efficient of variation,

(S_1P_0:200g sugar+no preservative, S_1P_1:200g sugar+sodium benzoate, S_1P_2:200g sugar+potassium metabisulphite, S_2P_0:250g sugar+no preservative, S_2P_1:250g sugar+ sodium benzoate, S_2P_2:250g sugar+potassium metabisulphite, S_3P_0:300g sugar+no preservative, S_3P_1:300g sugar+sodium benzoate, S_3P_2:300g sugar+potassium metabisulphite)

4.2.3 Total soluble solids concentration

Effect of different sugar concentrations and preservatives on TSS of jackfruit jam and jelly

Total Soluble Solids (TSS) of fruit and fruit products represents various chemical substances present in it in soluble form. Total Soluble Solids of jam and jelly at different treatments were varied significantly during 30 to 90 days of storage time. After 90 days TSS was increased and jam had the highest total soluble solid concentration. The TSS of jam was (69.46%), and in jelly the value was (69.01%). There was a significant increase in TSS irrespective of treatments during 90 days of storage period which might be due to the conversion of starch and other insoluble carbohydrates into sugars. Similar results were found by Muhammad *et al.*, (2008) who developed diet apple jam using different non-nutritive sweeteners and reported that TSS of diet jam significantly increased from 11.54 to 17.70 during 90 days storage.

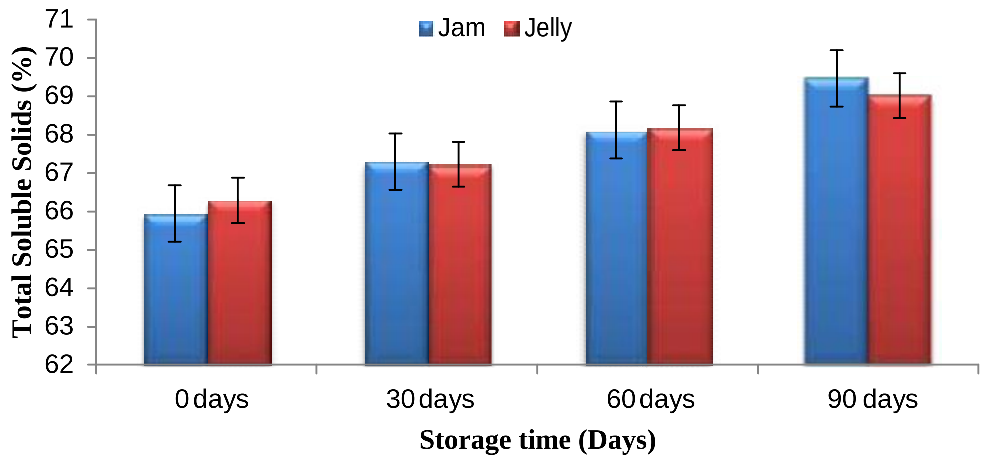

Fig. 13. Effect of storage period on TSS of jackfruit jam and jelly (vertical bars represents standard error)

Effect of different sugar concentrations and preservatives on TSS of jackfruit jam and jelly

Sugar concentrations had significant influence on TSS of jackfruit jam (Fig. 14 and Appen- III). The TSS was increased gradually during storage. After 90 days of storage, the highest TSS was in S_3 (71.35%), and the lowest in S_1 (68.01%).

Different preservatives had significant influence on TSS of jackfruit jam (Fig. 15 and Appen- III). During 90 days of storage, TSS was increased gradually. The highest TSS was in P_2 (70.67%) and the lowest in P_0 (68.35%). The TSS of P_0 and P_1 was almost similar but P_2 had higher TSS. Singh *et al.*, (2005) revealed that during storage of the beal/blended beal jam, the total soluble solids (TSS) and total sugars increased up to three months.

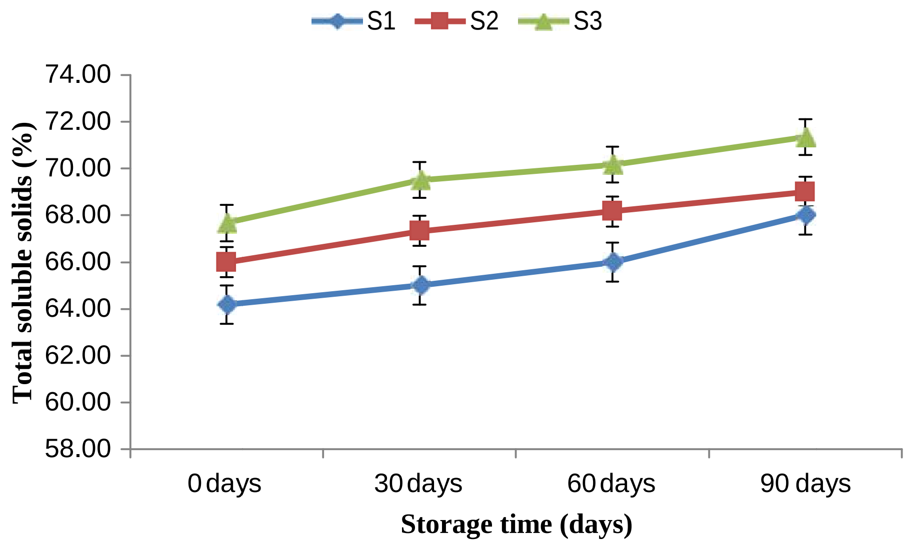

Fig. 14. Effect of sugar concentrations on TSS of jackfruit jam at different days after storage

S_1:200g sugar, S_2:250g sugar, S_3:300g sugar

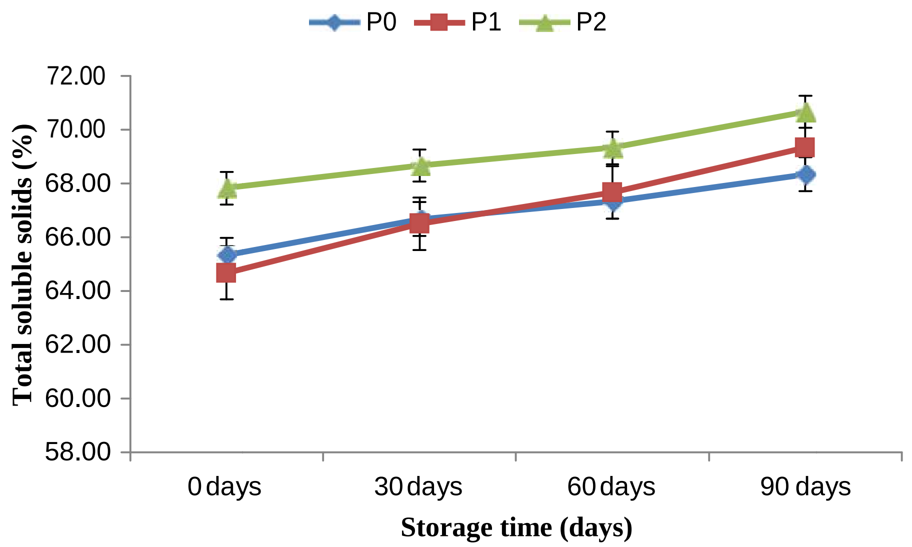

Fig. 15. Effect of preservatives on TSS of jackfruit jam at different days after storage

P_0:no preservative, P_1:sodium benzoate, P_2:potassium metabisulphite

Sugar concentrations had significant influence on TSS of jackfruit jelly (Fig. 16 and Appen- III). The TSS was increased gradually during storage. After 90 days of storage, the highest TSS was in S_3 (70.33%) and the lowest in S_1 (68.01%). In all storage condition, S_3 had the higher TSS.

Different preservatives had significant influence on TSS of jackfruit jelly (Fig. 17 and Appen- III). During 90 days of storage, TSS was increased gradually. The highest TSS was in P_2 (70.00%) and the lowest in P_0 (68.34%). In all storage condition, P_2 had higher TSS. The results of present study are in close conformity to the findings of Deen and Singh (2013) in karonda jelly.

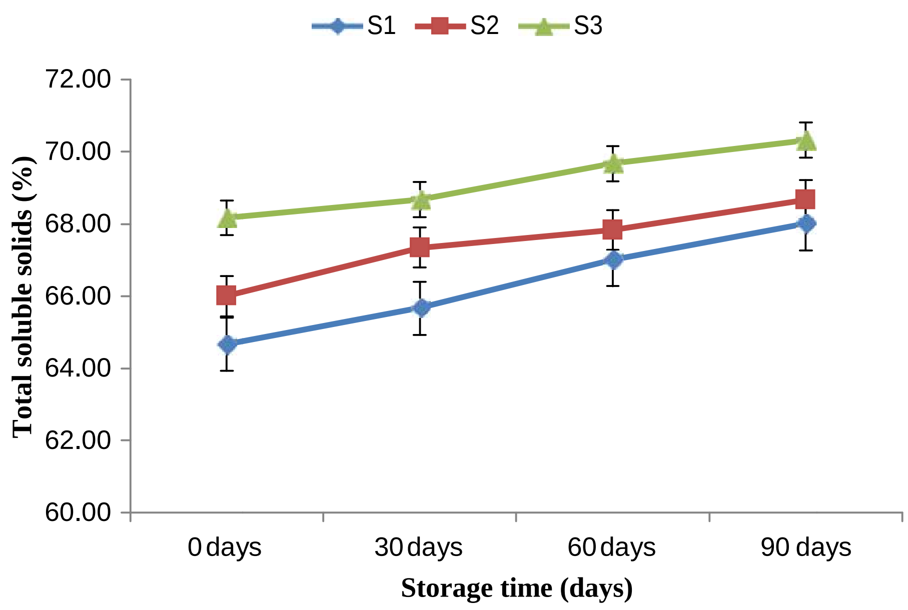

Fig. 16. Effect of sugar concentrations on TSS of jackfruit jelly at different days after storage

S_1:200g sugar, S_2:250g sugar, S_3:300g sugar

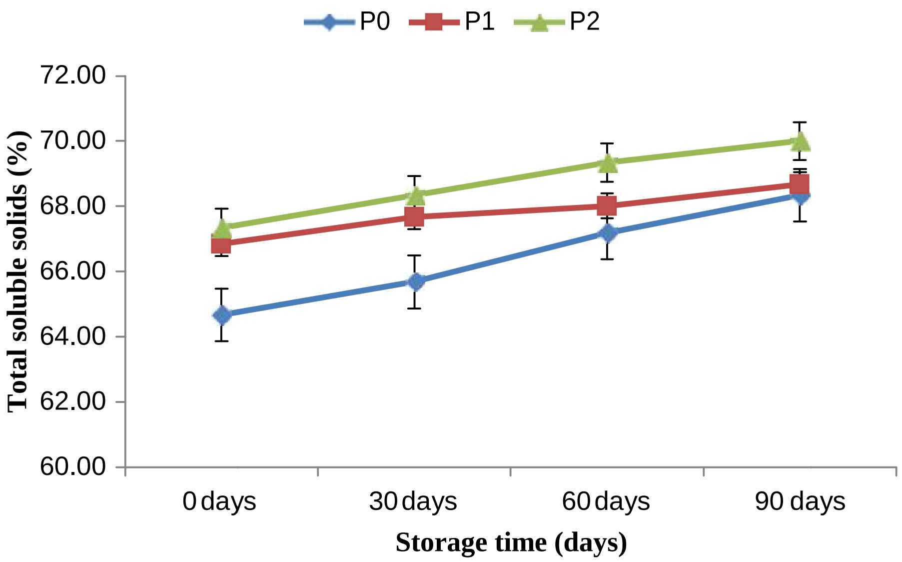

Fig. 17. Effect of preservatives on TSS of jackfruit jelly at different days after storage

P_0:no preservative, P_1:sodium benzoate, P_2:potassium metabisulphite

4.3.1.3 Combined effect of different sugar concentrations and preservatives on TSS of jackfruit jam and jelly

The TSS of jackfruit jam and jelly at different treatments varied significantly (Table 5). In case of jam, S_2P_2 and in case of jelly, S_3P_2 gave the best value (70.00%) & (69.00%) after 90 days of storage. The TSS content of S_2P_2 and S_3P_2 was good and that was > 68.00%. According to FPO specifications, a jam should contain a minimum of 68% TSS in the final product and the fruit content in the final product should not be more than 45 % (w/w). The results of present study are in close conformity to the findings of Kuchi *et al*., (2014) in guava jelly bar. Safdar *et al*., (2012) also found a gradual increase in total soluble solids content of mango jam throughout the storage period of 150 days.

Table 5. Combined effect of different sugar concentrations and preservatives on TSS of jackfruit jam and jelly

Products	Treatments	Total soluble solids % at different days after storage			
		0 day	30 days	60 days	90 days
Jam	S_1P_0	63.02i	64.01i	65.01i	66.01h
	S_1P_1	64.02h	65.00h	66.00h	69.04e
	S_1P_2	65.50g	66.00g	67.01e	69.00e
	S_2P_0	66.01f	67.01f	67.50j	69.01e
	S_2P_1	64.00h	66.02g	68.01h	68.00f
	S_2P_2	68.00d	69.01c	69.00b	70.00d
	S_3P_0	67.00e	69.03c	69.50d	70.03d
	S_3P_1	66.03f	68.50d	69.02e	71.02c
	S_3P_2	70.00a	71.00a	72.00a	73.01a
Jelly	S_1P_0	61.00j	63.00j	65.02hi	66.02h
	S_1P_1	66.01f	66.01g	67.01h	68.01f
	S_1P_2	67.02e	68.01e	69.01g	70.02d
	S_2P_0	63.00i	64.02i	65.50f	67.00g
	S_2P_1	66.04f	68.02e	67.02e	68.02f
	S_2P_2	69.00b	70.01b	71.01b	71.00c
	S_3P_0	70.02a	70.02ab	71.02b	72.00b
	S_3P_1	68.50c	69.02ab	70.00c	70.00d
	S_3P_2	66.02f	67.02f	68.02f	69.00e
Level of Significance		*	*	*	*
CV (%)		0.03	0.02	0.02	0.03
LSD at 1%		0.09102	0.09102	0.09102	0.09102

* Significant at 1% level of probability, CV= Co-efficient of variation,

(S_1P_0:200g sugar+no preservative, S_1P_1:200g sugar+sodium benzoate, S_1P_2:200g sugar+potassium metabisulphite, S_2P_0:250g sugar+no preservative, S_2P_1:250g sugar+ sodium benzoate, S_2P_2:250g sugar+potassium metabisulphite, S_3P_0:300g sugar+no preservative, S_3P_1:300g sugar+sodium benzoate, S_3P_2:300g sugar+potassium metabisulphite)

Titrable acidity

Effect of different sugar concentrations and preservatives on titrable acidity of jackfruit jam and jelly

The titrable acidity of jam and jelly at different treatments were varied significantly. The changes were occured af7ter 30 to 90 days of storage time. The titrable acidity was increased during storage. After 90 days jam had the highest titrable acidity and jelly had slight lower than jam. The titrable acidity of jam was (0.18%), and in jelly the value was (0.17%). The reason for slight increase in titratable acidity might be due to formation of organic acids by the degradation of the ascorbic acid as it decreased with storage period of the jelly. This is in consonance with the findings of Deen and Singh (2013) in karonda jelly and Kuchi *et al*., (2014) in guava jelly bar.

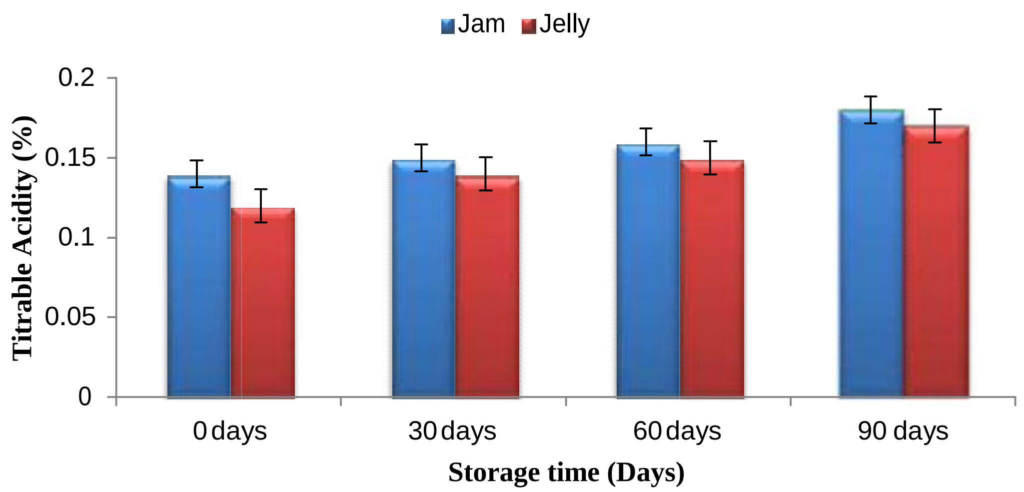

Fig. 18. Effect of storage period on titrable acidity of jackfruit jam and jelly (vertical bars represents standard error)

Effect of different sugar concentrations and preservatives on titrable acidity of jackfruit jam and jelly

Sugar concentrations had significant influence on titrable acidity of jackfruit jam (Fig. 19 and Appen-IV). The titrable acidity was increased gradually during storage. After 90 days of storage, the highest titrable acidity was in S_3 (0.21%), S_2 had also higher (0.18%)and the lowest in S_1 (0.15%).

Different preservatives had significant influence on titrable acidity of jackfruit jam (Fig. 20 and Appen-IV). During 90 days of storage, titrable acidity was increased gradually. The highest titrable acidity was in P_2 (0.21%) and the lowest in P_0 (0.16%). In all storage condition, The titrable acidity of P_0 and P_1 was almost similar and P_2 had slight higher titrable acidity. Singh *et al*., (2009) also observed similar results.

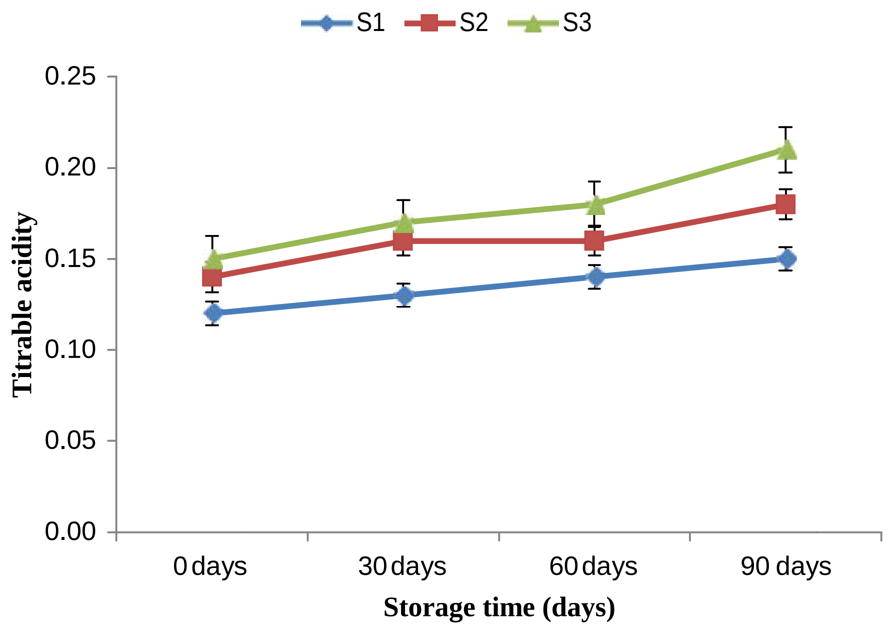

Fig. 19. Effect of sugar concentrations on titrable acidity of jackfruit jam at different days after storage

S_1:200g sugar, S_2:250g sugar, S_3:300g sugar

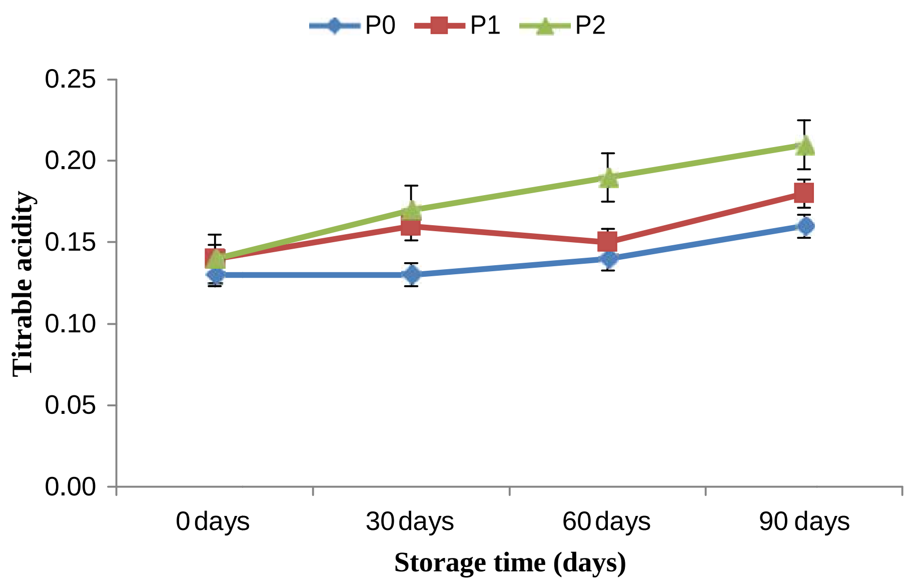

Fig. 20. Effect of preservatives on titrable acidity of jackfruit jam at different days after storage

P_0:no preservative, P_1:sodium benzoate, P_2:potassium metabisulphite

Sugar concentrations had significant influence on titrable acidity (TA) of jackfruit jelly (Fig. 21 and Appen-IV). The titrable acidity was increased gradually during storage. After 90 days of storage, the highest titrable acidity was in S_3 (0.19%), S_2 had also higher (0.18%) and the lowest in S_1 (0.14%).

Different preservatives had significant influence on titrable acidity of jackfruit jelly (Fig. 22 and Appen-IV). During 90 days of storage, titrable acidity was increased gradually. The highest titrable acidity was in P_2 (0.21%) and the lowest in P_0 (0.14%). In all storage condition, the titrable acidity of P_0 and P_1 was almost similar and P_2 had the higher titrable acidity. pH of mixed fruit marmalades was slightly reduced throughout 180 days of storage period described by Hossain *et al*., (2012).

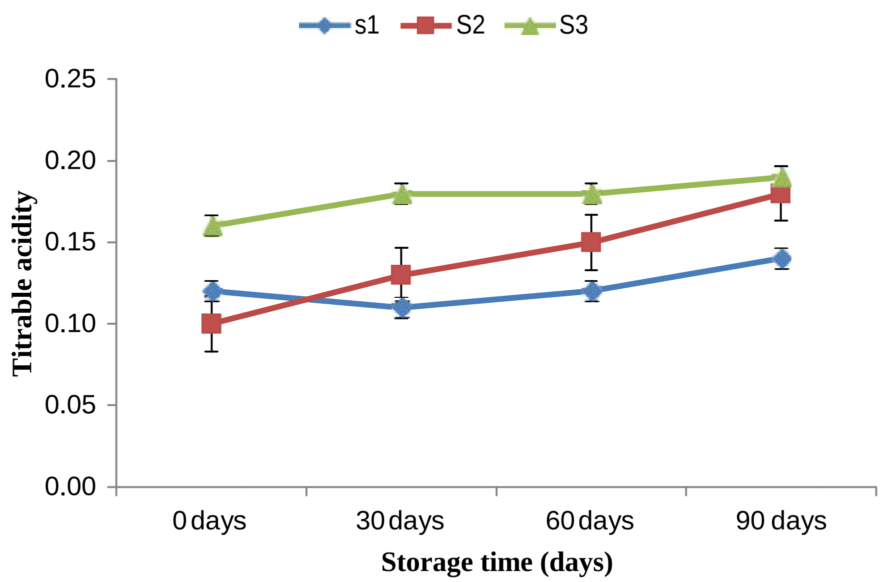

Fig. 21. Effect of sugar concentrations on titrable acidity of jackfruit jelly at different days after storage

S_1:200g sugar, S_2:250g sugar, S_3:300g sugar

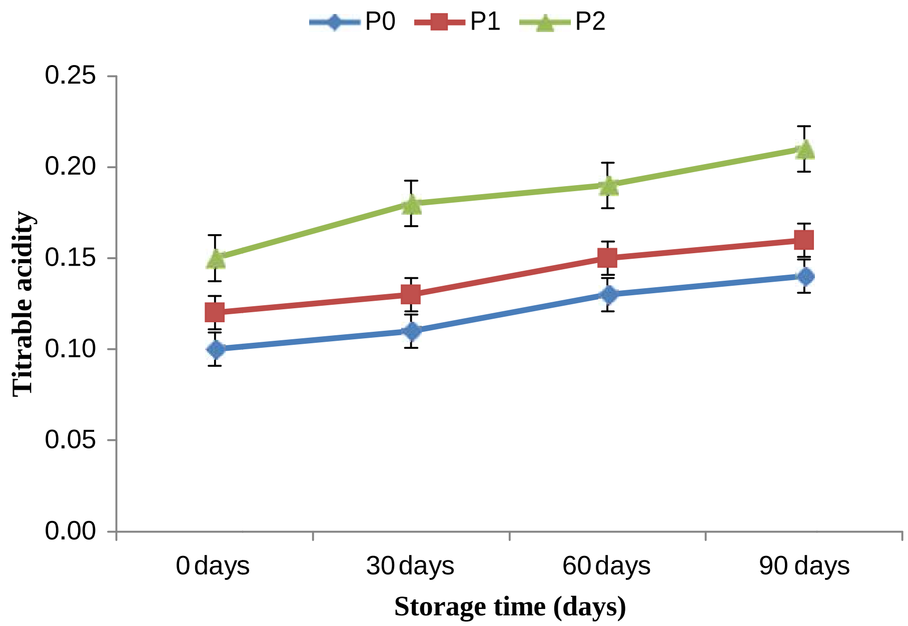

Fig. 22. Effect of preservatives on titrable acidity of jackfruit jelly at different days after storage

P_0:no preservative, P_1:sodium benzoate, P_2:potassium metabisulphite

4.3.1.3 Combined effect of different sugar concentrations and preservatives on titrable acidity of jackfruit jam and jelly

The titrable acidity of jackfruit jam and jelly at different treatments varied significantly (Tab. 6). In case of jam, S_2P_2 and in case of jelly, S_3P_2 gave highest value (0.26%) and (0.25%) after 90 days of storage. Shakir *et al*., (2007) found that the mean values of titratable acidity for different treatments of apple and pear mixed fruit jam increased significantly from 0.63 to 0.75 during storage interval of 90 days.

Table 6. Combined effect of different sugar concentrations and preservatives on titrable acidity of jackfruit jam and jelly

Products	Treatments	Titrable acidity % at different days after storage			
		0 day	30 days	60 days	90 days
Jam	S_1P_0	0.12ef	0.13d	0.14g	0.14f
	S_1P_1	0.19bc	0.18e	0.17g	0.20de
	S_1P_2	0.06f	0.09df	0.11h	0.13h
	S_2P_0	0.14cd	0.14d	0.16f	0.19e
	S_2P_1	0.07ef	0.11e	0.08i	0.11hi
	S_2P_2	0.21a	0.23a	0.24a	0.26a
	S_3P_0	0.13d	0.12d	0.13hg	0.17e
	S_3P_1	0.18c	0.19c	0.21d	0.23d
	S_3P_2	0.16b	0.21b	0.22c	0.24c
Jelly	S_1P_0	0.08df	0.07f	0.09hi	0.10i
	S_1P_1	0.11def	0.08ef	0.10hg	0.12h
	S_1P_2	0.17de	0.20d	0.19e	0.21de
	S_2P_0	0.09cde	0.10e	0.12h	0.15f
	S_2P_1	0.12ef	0.16e	0.20f	0.22d
	S_2P_2	0.10de	0.14de	0.15g	0.18e
	S_3P_0	0.15d	0.17c	0.18e	0.18ef
	S_3P_1	0.14d	0.15d	0.15g	0.16f
	S_3P_2	0.20b	0.22b	0.23b	0.25b
Level of Significance		*	*	*	*
CV (%)		1.02	1.12	2.16	2.08
LSD at 1%		0.09102	0.09102	0.09102	0.09102

* Significant at 1% level of probability, CV= Co-efficient of variation,

(S_1P_0:200g sugar+no preservative, S_1P_1:200g sugar+sodium benzoate, S_1P_2:200g sugar+potassium metabisulphite, S_2P_0:250g sugar+no preservative, S_2P_1:250g sugar+ sodium benzoate, S_2P_2:250g sugar+potassium metabisulphite, S_3P_0:300g sugar+no preservative, S_3P_1:300g sugar+sodium benzoate, S_3P_2:300g sugar+potassium metabisulphite)

Vitamin C

Effect of different sugar concentrations and preservatives on vitamin C of jackfruit jam and jelly

The vitamin C of jam and jelly at different treatments were varied significantly. The changes were occured after 30 to 90 days of storage time. The vitamin C was decreased during storage. After 90 days jam had the highest vitamin C and jelly had slight lower than jam. The vitamin C of jam was (1.29mg/100g), and in jelly the value was (1.25mg/100g). Vitamin-C content in dragon fruit jelly prepared from dragon fruit juice was found to be very low as described by Hoque *et al*., (2012). It may be due to the most of the vitamin-C present in the pulp was destroyed during long heating at high temperature.

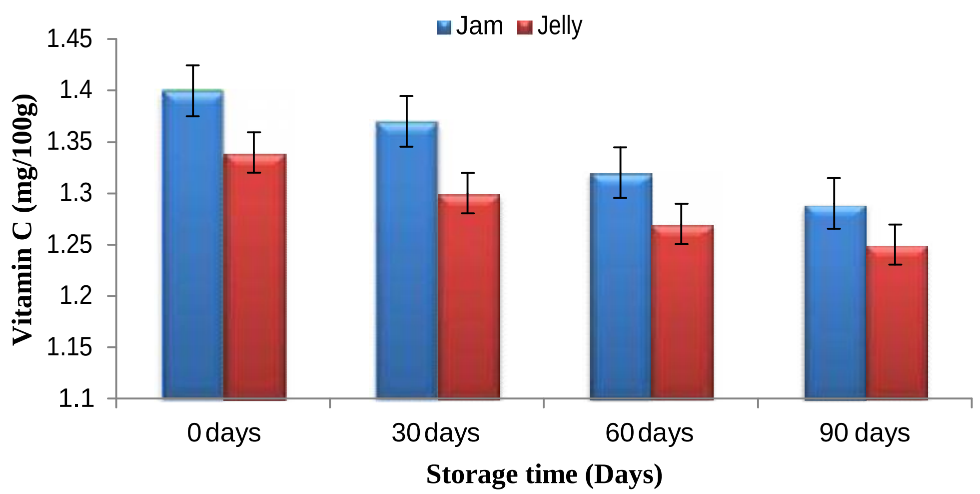

Fig. 23. Effect of storage period on vitamin C of jackfruit jam and jelly (vertical bars represents standard error)

Effect of different sugar concentrations and preservatives on vitamin C of jackfruit jam and jelly

Sugar concentrations had significant influence on vitamin C content of jackfruit jam (Fig. 24 and Appen-V). The vitamin C was slightly decreased gradually during storage. After 90 days of storage, S_3 had the lowest vitamin C (1.20mg/100g) and S_1 and S_2 had almost similar higher value and it was (1.35mg/100g) and (1.32mg/100g). In all storage condition, S_2 had the higher vitamin C.

Different preservatives had significant influence on vitamin C of jackfruit jam (Fig. 25 and Appen-V). During 90 days of storage, vitamin C was decreased gradually. The highest vitamin C was in P_2 (1.49mg/100g) and the lowest in P_0 (1.11mg/100g). In all storage condition, P_2 had the higher vitamin C. Mazur *et al*., (2014) observed a significant decrease of ascorbic acid concentration during storage (6 months at 20 °C) of strawberry jam.

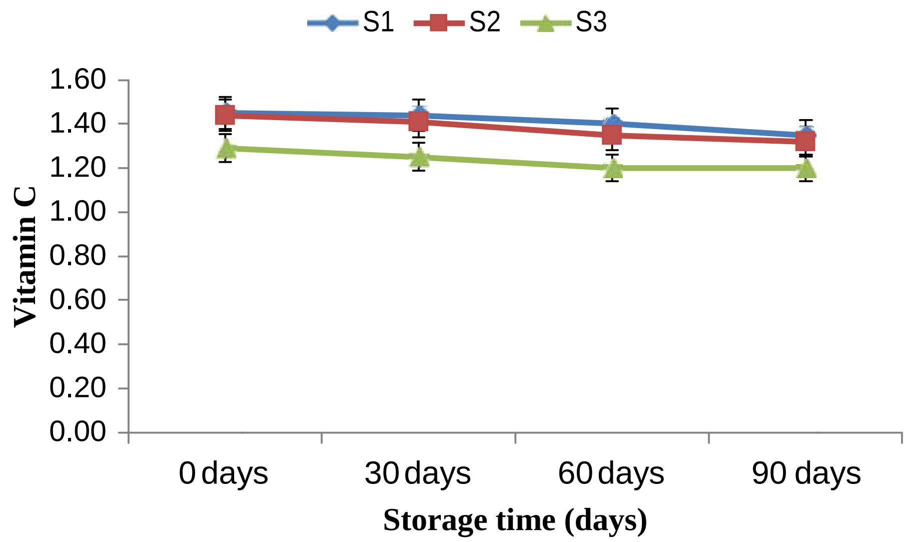

Fig. 24. Effect of sugar concentrations on vitamin C of jackfruit jam at different days after storage

S_1:200g sugar, S_2:250g sugar, S_3:300g sugar

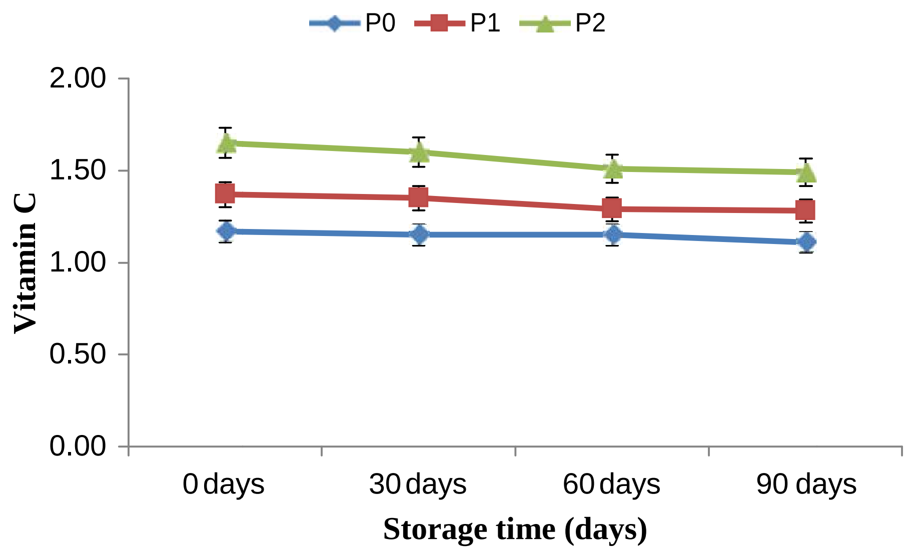

Fig. 25. Effect of preservatives on vitamin C of jackfruit jam at different days after storage

P_0:no preservative, P_1:sodium benzoate, P_2:potassium metabisulphite

Sugar concentrations had significant influence on vitamin C content of jackfruit jelly (Fig. 26 and Appen-V). The vitamin C was slightly decreased gradually during storage. After 90 days of storage, S_3 had the lowest vitamin C (1.11mg/100g) and S_1 and S_2 had the higher value that is almost similar, such as (1.35mg/100g) and (1.29mg/100g).

Different preservatives had significant influence on vitamin C of jackfruit jelly (Fig. 27 and Appen-V). During 90 days of storage, vitamin C was decreased gradually. The highest vitamin C was in P_2 (1.46mg/100g) and P_0 and P_1 had the lower and almost similar value and it was (1.15mg/100g) and (1.14mg/100g). In all storage condition, P_2 had the higher vitamin C. The decrease in moisture content from 24.02 to 21.58 was observed in guava-carrot jelly during storage (Singh and Chandra, 2012).

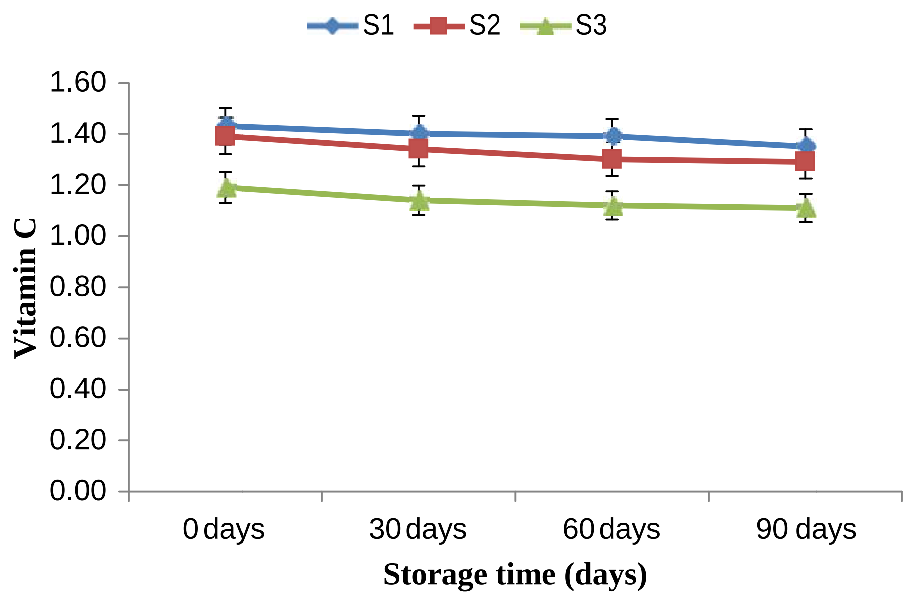

Fig. 26. Effect of sugar concentrations on vitamin C of jackfruit jelly at different days after storage

S_1:200g sugar, S_2:250g sugar, S_3:300g sugar

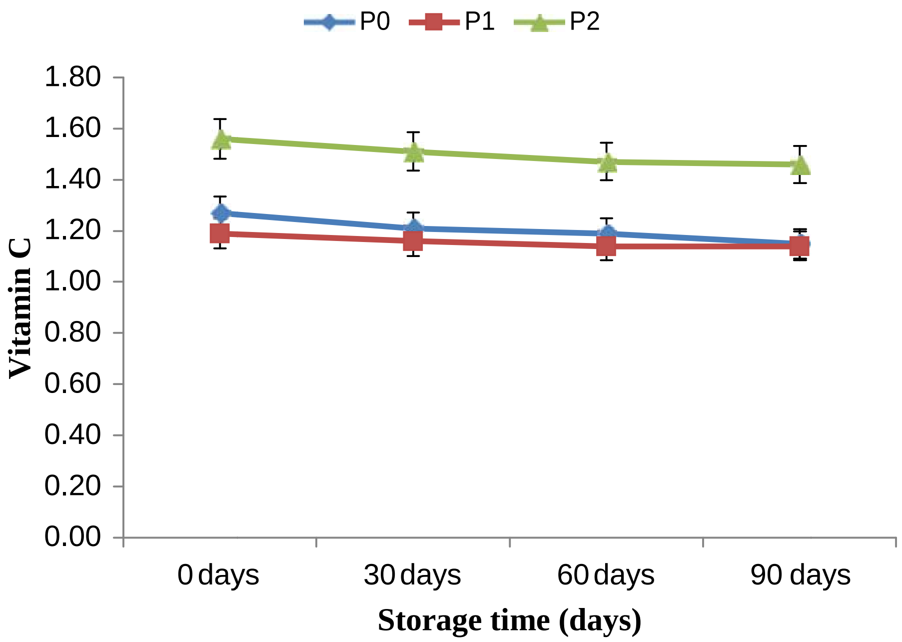

Fig. 27. Effect of preservatives on vitamin C of jackfruit jelly at different days after storage

P_0:no preservative, P_1:sodium benzoate, P_2:potassium metabisulphite

4.3.1.3 Combined effect of different sugar concentrations and preservatives on vitamin C of jackfruit jam and jelly

The vitamin C of jackfruit jam and jelly at different treatments varied significantly (Tab. 7). In case of jam, S_2P_2 and in case of jelly, S_3P_2 gave the highest value (1.68mg/100g) and (1.57mg/100g) after 90 days of storage. Likewise, Shakir *et al.*, (2007) found that the mean values of ascorbic acid content of apple and pear mixed fruit jam significantly decreased from 12.38 at initial day to 14.86 at 90 days.

Table 7. Combined effect of different sugar concentrations and preservatives on vitamin C of jackfruit jam and jelly

Products	Treatments	Vitamin C mg/100g at different days after storage			
		0 day	30 days	60 days	90 days
Jam	S_1P_0	1.62b	1.61b	1.59b	1.50b
	S_1P_1	1.08d	1.07d	1.03d	1.02d
	S_1P_2	1.66b	1.64b	1.58b	1.55b
	S_2P_0	1.07d	1.06d	1.06d	1.04d
	S_2P_1	1.39c	1.35c	1.29c	1.26c
	S_2P_2	1.88a	1.82a	1.70a	1.68a
	S_3P_0	0.82e	0.78e	0.80e	0.79e
	S_3P_1	1.65b	1.63b	1.57b	1.57b
	S_3P_2	1.42c	1.34c	1.25c	1.24c
Jelly	S_1P_0	1.34c	1.31c	1.27c	1.23c
	S_1P_1	1.34c	1.32c	1.35c	1.32c
	S_1P_2	1.61b	1.59b	1.55b	1.52b
	S_2P_0	1.37c	1.29c	1.28c	1.26c
	S_2P_1	1.40c	1.36c	1.30c	1.30c
	S_2P_2	1.41c	1.37c	1.33c	1.31c
	S_3P_0	1.10d	1.04d	1.04d	0.98d
	S_3P_1	0.83e	0.80e	0.78e	0.80e
	S_3P_2	1.66b	1.59b	1.55b	1.57b
Level of Significance		*	*	*	*
CV (%)		1.77	2.03	1.18	1.10
LSD at 1%		0.09102	0.09102	0.09102	0.09102

* Significant at 1% level of probability, CV= Co-efficient of variation,

(S_1P_0:200g sugar+no preservative, S_1P_1:200g sugar+sodium benzoate, S_1P_2:200g sugar+potassium metabisulphite, S_2P_0:250g sugar+no preservative, S_2P_1:250g sugar+ sodium benzoate, S_2P_2:250g sugar+potassium metabisulphite, S_3P_0:300g sugar+no preservative, S_3P_1:300g sugar+sodium benzoate, S_3P_2:300g sugar+potassium metabisulphite)

Sensory attributes:

A consumer acceptability sensory trial was coducted. The panelist comprised of 10 volunteers who were students of the university. The sensory quality attributes of the samples were color, appearance, sweetness, stickiness, flavor and acceptability (Table 8). A 7-point hedonic scale was used. Therefore, the respondents answers were coded 1-7 with 7 being 'like extremely' and 1 being 'dislike extremely'.

Table: 8. Mean score for color, appearance, sweetness, stickiness, flavor and acceptability point of jackfruit jam was:

Treatments and products	Color	Apperance	Stickiness	Sweetness	Flavour	Acceptability
S_1P_0	3.12 i	3.21 i	3.40 i	3.23 i	3.82 i	3.72 i
S_1P_1	3.22 h	3.31 h	3.46 h	3.33 h	3.92 h	3.82 h
S_1P_2	3.32 g	3.51 g	3.60 g	3.73 g	3.95 g	3.92 g
S_2P_0	3.52 f	3.63 f	3.70 f	3.83 f	4.02 f	3.72 f
S_2P_1	3.72 e	3.72 e	3.80 e	3.92 e	4.12 e	4.22 a
S_2P_2	5.75 a	5.72 a	5.07 a	5.42 a	5.67 a	5.52 a
S_3P_0	4.82 c	4.27 c	4.40 b	4.50 b	4.77 b	4.80 b
S_3P_1	4.25 b	4.35 b	4.27 c	4.32 c	4.65 c	4.72 c
S_3P_2	4.08d	4.12 d	4.17 d	4.22d	4.52d	4.65d
LSD at 5%	0.35	0.17	0.20	0.22	0.26	0.28
LSD at 1%	0.45	0.26	0.29	0.36	0.33	0.40
CV (%)	2.85	2.29	2.44	4.34	2.64	3.22

* Significant at 1% level of probability, CV= Co-efficient of variation,

(S_1P_0:200g sugar+no preservative, S_1P_1:200g sugar+sodium benzoate, S_1P_2:200g sugar+potassium metabisulphite, S_2P_0:250g sugar+no preservative, S_2P_1:250g sugar+ sodium benzoate, S_2P_2:250g sugar+potassium metabisulphite, S_3P_0:300g sugar+no preservative, S_3P_1:300g sugar+sodium benzoate, S_3P_2:300g sugar+potassium metabisulphite)

Table: 9. Mean score for color, appearance, sweetness, stickiness, flavor and acceptability point of jackfruit jelly was:

Treatments and products	Color	Apperance	Stickiness	Sweetness	Flavour	Acceptability
S_1P_0	3.14 i	3.29 i	3.38 i	3.29 i	3.59 i	3.62 i
S_1P_1	3.25 h	3.42 h	3.49 h	3.43 h	3.82 h	3.72 h
S_1P_2	3.42 g	3.61 g	3.69 g	3.70 f	3.85 g	3.82 g
S_2P_0	3.62 f	3.67 f	3.81 f	3.69 g	4.12 f	3.92 f
S_2P_1	3.82 e	3.79 e	3.89 e	3.95 e	4.22 e	4.31 a
S_2P_2	4.12d	4.32 d	4.42 d	4.34d	4.59d	4.69d
S_3P_0	4.75 c	4.85 c	4.90 c	4.55 b	4.79 b	4.89 b
S_3P_1	4.85 b	5.02 b	5.07 b	4.36 c	4.65 c	4.70 c
S_3P_2	5.25a	5.32 a	5.42 a	5.46 a	5.69 a	5.71 a
LSD at 5%	0.25	0.07	0.21	0.32	0.16	0.38
LSD at 1%	0.35	0.16	0.39	0.26	0.35	0.20
CV (%)	2.55	2.30	1.44	3.34	2.74	3.53

* Significant at 1% level of probability, CV= Co-efficient of variation,

(S_1P_0:200g sugar+no preservative, S_1P_1:200g sugar+sodium benzoate, S_1P_2:200g sugar+potassium metabisulphite, S_2P_0:250g sugar+no preservative, S_2P_1:250g sugar+ sodium benzoate, S_2P_2:250g sugar+potassium metabisulphite, S_3P_0:300g sugar+no preservative, S_3P_1:300g sugar+sodium benzoate, S_3P_2:300g sugar+potassium metabisulphite)

The highest hedonic scale of color, appearance, sweetness, stickiness, flavor and acceptability point was recorded with S_2P_2 in case of jam and the highest hedonic scale of color, taste, appearance, sweetness, flavor and acceptability point was recorded with S_3P_2 in case of jelly. The results obtained for all the monitored sensory parameters are in agreement with findings of Muhammad *et al*., (2009).

CHAPTER V

SUMMARY AND CONCLUSIONS

In this study, Chemical parameters of jackfruit jam and jelly were analyzed to provide useful information in determining optimum quality for jackfruit. The jackfruit jam & jelly have different moisture content, pH, TSS, Titrable acidity, Vitamin-C content and diffrent acceptability in case of color, appearance, sweetness, stickiness and flavor and etc. at different storage periods. It can tells us that different sugar concentrations, storage interval and preservation had significant effect on physicochemical and organoleptic characteristics of jackfruit jam and jelly. 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.

In case of jam, the moisture content of S_2P_2 was (28.00%) at 0 days and after 90 days it was (26.01%), it was the lowest value among all the treatments. In case of jelly, S_3P_2 had the lowest moisture content, it was (29.53%) at 0 days and after 90 days it was (27.01%). The lowest moisture content can suggest that it can be stored for longer time. Besides S_3P_0 had the highest moisture content both for jam and jelly and that was (35.51%) and (35.01%) that can suggests us that it can be spoiled rapidly.

In case of jam, the pH of S_2P_2 was (4.36) at 0 days and after 90 days it was (4.12), it was the highest value among all the treatments. In case of jelly, S_3P_2 had the highest pH, it was (4.25) at 0 days and after 90 days it was (4.10). Besides S_1P_0 had the lowest pH both for jam and jelly and that was (3.31) and (3.64) that can suggests us that it became very acidic after 90 days of storage.

The TSS of S_2P_2 was (68.00%) and after 90 days of storage that was (70.00%) and The TSS of S_3P_2 was (66.02%) and after 90 days of storage that was (69.00%). The highest value (73.01%) of TSS was found in S_3P_2 in case of jam and (72.00%) of TSS was found in S_3P_0 in case of jelly but According to FPO specifications, a jam should contain a minimum of 68% TSS in the final product suggests us that the S_2P_2 and S_3P_2 had the good thickness quality among all the treatments.

The TA value of S_2P_2 was (0.21%) and the value was gradually increased at 90 days and the highest value (0.26%) of TA was found in S_2P_2 and The TA value was also high (0.20%) in S_3P_2 at 0 days and after 90 days of storage it was (0.25%). Titrable acidity possesses a firm texture and good setting property.

Vitamin C content of S_2P_2 was (1.88mg/100g) at 0 days and the value was gradually decreased at 90 days and the highest value (1.68mg/100g) of vitamin C was found in S_2P_2 and Vitamin C content of S_3P_2 was (1.66mg/100g) at 0 days and after 90 days it was (1.57mg/100g). The lowest value (0.79 mg/100g) of vitamin C was found S_3P_0 in case of jam and (0.80 mg/100g) of vitamin C was found in S_3P_1 in case of jelly.

The highest hedonic scale of color, taste, appearance, sweetness, flavor and acceptability point was recorded with S_2P_2, in case of jam and in case of jelly, the highest hedonic scale of color, appearance, sweetness, stickiness, flavor and acceptability point was recorded with S_3P_2. So it indicated that S_2P_2 and S_3P_2 prepared jam and jelly was “Like very much” among all prepared samples.

From this study it was concluded that addition of sugar and preservatives strongly affect the products shelf life and consumer acceptability. During this study I found S_2P_2 (500g jackfruit pulp + 250g sugar + 0.8g potassium metabisulphite), in case of jam and S_3P_2 (500g jackfruit rind + 300g sugar + 0.8g potassium metabisulphite), in case of jelly remained very acceptable during storage while S_1P_0, S_2P_0, S_3P_0 (Jackfruit pulp + no preservative) was found very bad. Future study is recommended on microflora assessment and micronutrients assessment. Further study is recommended on refrigeration temperature and mixing of more than two fruits is also recommended to make the product more nutritious.

It can be concluded from the present findings that the better quality of jackfruit jam can be prepared by using (500g jackfruit pulp + 250g sugar + 0.8g potassium metabisulphite) and the better quality of jackfruit jelly can be prepared by using (500g jackfruit rind + 300g sugar + 0.8g potassium metabisulphite) with better organoleptic properties as well as chemical composition and good storage stability at ambient storage conditions up to 3 months storage period.

Products were also found stable on storage at ambient temperature for 3 months as the physico-chemical, sensory parameters were not changed significantly. It indicates that the jackfruit can be utilized for the commercial production of standard quality products like jam and jelly.

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APPENDICES

Appendix I: Analysis of variance (mean square) results for moisture content of jackfruit jam and jelly at different days after storage (DAS)

Sources of Variation	Degrees of freedom	Mean square value of moisture content for Jam at different DAS			
		0 days	30 days	60 days	90 days
Factor A (Sugar)	2	17.171*	17.936*	16.296*	14.489*
Factor B (Preservative)	2	7.775*	1.210*	1.037*	3.973*
AB	4	2.639*	2.290*	2.581*	3.491*
Error	9	0.002	0.001	0.003	0.001

Sources of Variation	Degrees of freedom	Mean square value of Moisture Content for Jelly at different DAS			
		0 days	30 days	60 days	90 days
Factor A (Sugar)	2	16.131*	16.836*	14.396*	13.089*
Factor B (Preservative)	2	5.775*	1.510*	1.341*	2.083*
AB	4	2.046*	2.187*	3.463*	3.791*
Error	9	0.004	0.002	0.001	0.007

Appendix II: Analysis of variance (mean square) results for pH of jackfruit jam and jelly at different days after storage (DAS)

Sources of Variation	Degrees of freedom	Mean square value of ph for Jam at different DAS			
		0 days	30 days	60 days	90 days
Factor A (Sugar)	2	0.130*	0.160*	0.155*	0.161*
Factor B (Preservative)	2	0.044*	0.003*	0.001*	0.034*
AB	4	0.104*	0.084*	0.066*	0.044*
Error	9	0.001	0.001	0.001	0.001

Sources of Variation	Degrees of freedom	Mean square value of ph for Jelly at different DAS			
		0 days	30 days	60 days	90 days
Factor A (Sugar)	2	0.230*	0.156*	0.149*	0.171*
Factor B (Preservative)	2	0.064*	0.012*	0.003*	0.024*
AB	4	0.123*	0.064*	0.069*	0.059*
Error	9	0.003	0.004	0.002	0.002

Appendix III: Analysis of variance (mean square) results for TSS of jackfruit jam and jelly at different days after storage (DAS)

Sources of Variation	Degrees of freedom	Mean square value of TSS for Jam at different DAS			
		0 days	30 days	60 days	90 days
Factor A (Sugar)	2	19.112*	17.930*	14.448*	11.752*
Factor B (Preservative)	2	1.020*	0.025*	0.034*	1.827*
AB	4	6.821*	4.632*	4.140*	3.291*
Error	9	0.002	0.003	0.001	0.001

Sources of Variation	Degrees of freedom	Mean square value of TSS for Jelly at different DAS			
		0 days	30 days	60 days	90 days
Factor A (Sugar)	2	18.013*	17.530*	13.048*	12.012*
Factor B (Preservative)	2	1.100*	0.205*	0.014*	1.039*
AB	4	6.561*	3.835*	5.130*	4.095*
Error	9	0.002	0.001	0.001	0.019

Appendix IV: Analysis of variance (mean square) results for TA of jackfruit jam and jelly at different days after storage (DAS)

Sources of Variation	Degrees of freedom	Mean square value of TA for Jam at different DAS			
		0 days	30 days	60 days	90 days
Factor A (Sugar)	2	0.003NS	0.005*	0.004*	0.005*
Factor B (Preservative)	2	0.002*	0.001*	0.003*	0.001*
AB	4	0.005NS	0.005*	0.005*	0.005*
Error	9	0.001	0.001	0.001	0.001

Sources of Variation	Degrees of freedom	Mean square value of TA for Jelly at different DAS			
		0 days	30 days	60 days	90 days
Factor A (Sugar)	2	0.010NS	0.001*	0.003*	0.006*
Factor B (Preservative)	2	0.018*	0.023*	0.033*	0.011*
AB	4	0.005NS	0.016*	0.035*	0.025*
Error	9	0.003	0.002	0.001	0.004

Appendix V: Analysis of variance (mean square) results for Vitamin C of jackfruit jam and jelly at different days after storage (DAS)

Sources of Variation	Degrees of freedom	Mean square value of Vitamin C for Jam at different DAS			
		0 days	30 days	60 days	90 days
Factor A (Sugar)	2	0.211*	0.209*	0.167*	0.163*
Factor B (Preservative)	2	0.030*	0.045*	0.019*	0.015*
AB	4	0.155*	0.149*	0.143*	0.137*
Error	9	0.001	0.001	0.001	0.001

Sources of Variation	Degrees of freedom	Mean square value of Vitamin C for Jelly at different DAS			
		0 days	30 days	60 days	90 days
Factor A (treatment)	2	0.305*	0.218*	0.197*	0.155*
Factor B (Preservative)	2	0.025*	0.037*	0.021*	0.019*
AB	4	0.165*	0.170*	0.136*	0.169*
Error	9	0.004	0.001	0.001	0.002

Appendix VI: Interview schedule for sensory evaluation of jackfruit jam and jelly

Details of the respondent

Name:…………………………Gender:Male…………Female………Position:B.Sc.Ag.(hons.)Student……….MSStudent………PhDStudent……..Teacher…………

(Please give tick mark for the answers)

Ranking scale / Trait	Like extremely	Like very much	Like moderately	Neither like nor dislike	Dislike moderately	Dislike very much	Dislike extremely
Jam							
Jelly							
Color							
Overall appearance							
Touch/Stickiness							
Sweetness							
Flavour							
Overall Acceptability							

Concluding remarks:

Please give some comments or remarks which you think can help to give a better scenario of the experiment.

……………………………………………………………………………………………
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Thanks you for your active co-operation

Pictorial board:

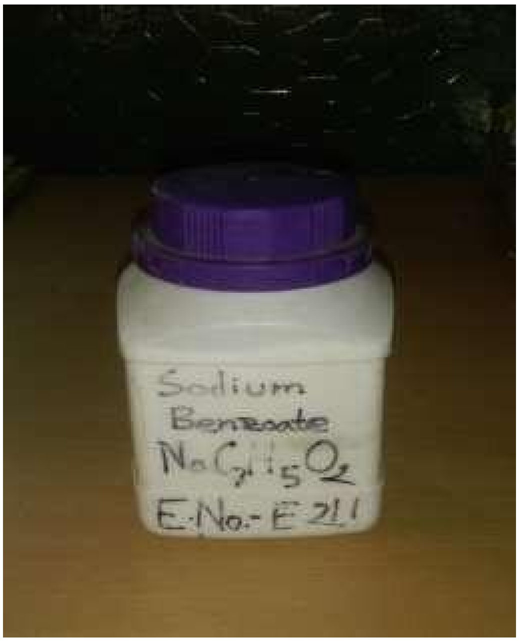
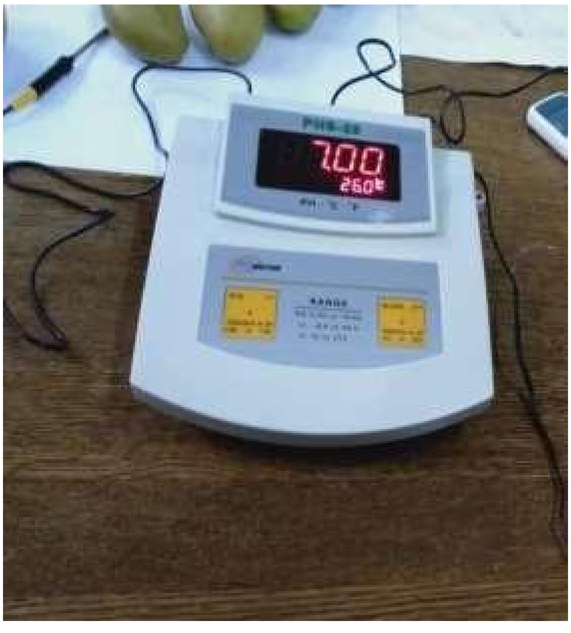


Plate 1 & 2: Different chemicals

Plate 3: Different chemicals

Plate 4: Determination of moisture content at central lab



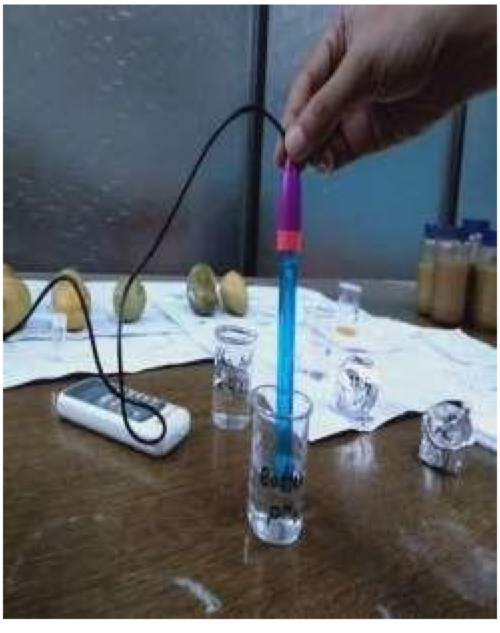


Plate 5 & 6: Determination of pH

Plate 7: Determination of TSS


Plate 8 & 9: Determination of titrable acidity

Plate 10 & 11: Determination of vit C at different days