Promotion of The Food uses of Jackfruit (*Artocarpus Heterophyllus*) through Jam production.

Abstract

Background: Jackfruits are seasonal fruit with high moisture content which predisposes them to spoilage. They are rich sources of dietary fiber, vitamins, minerals, antioxidants, phytochemical and also contains pectin.**Objective:** The objective of the study was to determine the nutrient, microbiological and sensory properties of jam made from jackfruit pulp.Method: The jam was produced using Ihediohanma *et al*.(2014) method and commercial jam used as control. The nutrient, microbiological and sensory properties was determined using standard method.**Result:** The result obtained from the proximate composition of the jackfruit jam were 73.40%, 1.74%, 1.60%, 0.40%, 3.10%, 19.76% and 89.60KJ for moisture, protein, fibre, fat, ash, carbohydrate and energy. The minerals value of the jackfruit jam were 1.46mg, 0.82mg, 25.64mg, 22.01mg, 38.20mg, 29.00mg, 272.00mg and 12.00mg for iron, zinc, copper, magnesium, calcium, phosphorus, potassium, and sodium. The microbial count showed that jackfruit jam and commercial jam had 16.76 cfu/g and 52.00cfu/g, and 20.34 cfu/g and 41.00 cfu/g for total plate count, and fungi count respectively. The sensory properties of the jackfruit and commercial jam were 8.50 and 7.50, 8.50 and 6.50, 8.50 and 7.50, 6.50 and 7.50, 8.50 and 8.50, and 8.50 and 6.50 for taste, flavor, appearance, consistency, colour and general acceptability respectively. The physicochemical properties showed that the pH were 3.25 and 4.50, TA 0.62g and 0.69g, and TSS 66.0°brix and 69.0°brix for jackfruit jam and commercial jam respectively.

Conclusion: The use of jackfruit in jam production is one way of conserving it from its perishable nature and extend its food use, thereby producing a highly acceptable jam with high nutrient content.

Keywords: Jackfruit, Jam, microbiological, fruit, physicochemical

1.0 Introduction

Jam is a product made from whole fruit, cut into pieces or crushed. The fruit is heated with sugar and water to activate the pectin in the fruit [1]. Generally, jam is produced by taking mashed or chopped fruit or vegetable pulp and boiled with sugar and water until a suitable consistency is obtained [2]. Jam varies in their nutritional and organoleptic properties as a result of different

process technology and types of fruit and vegetable used [3].A good jam has the following attributes: even consistency without distinct pieces of fruit, good fruit flavor, bright color, semi-jelled texture, easy to spread and have no free liquid, because it is neither a solid nor a liquid [4]. Jackfruit is one of the most commonly consumed foods in Sri Lanka from the ancient time. It is a non-seasonal fruit and had a major contribution to the food supply of the people and their livestock when there were short supplies of staple food [5;6]. It is mainly referred to as poor man's food [7].Jackfruit contains vitamin A, vitamin C, thiamin, riboflavin, calcium, potassium, iron, sodium, zinc, and niacin among many other nutrients. Jackfruit has a low caloric value of 94 calories [8].

Many jackfruit products have been developed, notably jackfruit juice, candy, and a fruit bar from ripe jackfruit. Unripe jackfruit pulp can be made into flakes, which can be preserved for a long time. The fruit pulp can be used to make jam. Many other fruit jams in supermarkets are mixed with a generous amount of sugar, which increases the risk for diabetes. On the contrary, jackfruit is full of natural sugars and low in calories making it an ideal food source to reduce body weight. The seeds may be boiled, or roasted and eaten or boiled and preserved in syrup like chestnuts. Roasted, dried seeds are ground to make flour that is blended with wheat flour for baking [9]. In addition to its ripe fruit, which has a unique flavor, the jackfruit seed is widely consumed as a dessert or an ingredient in Asian culinary preparations. The jackfruit seeds are used in cooked dishes and its flour is used for baking.

It has been reported that, in the developing countries like Nigeria, farmers suffer high postharvest losses of fruits and vegetables most especially during harvest time. This could be attributed to non-availability of storage facilities which normally involve large capital outlay, nonchalant attitude of government on agriculture, illiterate farming population among others. Processing these perishable produce into finished product such as jam, juice etc is one way of addressing these problems. This would minimize losses, optimize profit and provide variety of products before the consumer. Furthermore, what is obtained commercially in the market is jam made of pineapple, strawberry, cherry etc which contains too much sugar. Hence, jackfruit has been recommended as a high sugary fruit, which will help reduce the sucrose composition of the jam

and thereby increases the natural nutrients instead of the chemical refined sweetener in commercial jam products.

Source of Raw Materials

The jackfruits and other ingredients (sugar, pectin and citric acid) used for the study was purchased from Obollo Afor Market,Udenu Local Government, Enugu, Enugu State Nigeria.

Sample Processing

Preparation of Jackfruit Pulp

The jackfruit pulp was prepared according to the method of Ihediohanma *et al*.[10]with slightly modification. A big round head of Jackfruits of about seven kilogram (7kg)was washed thoroughly with portable water and peeled with clean stainless steel knife and afterward cut into small sizes. The seeds were carefully removed using the same knife, and the peeled jackfruit was slice then blended using Kenwood blender Model 5024ID. The juicefrom the jackfruitwas sieved with muslin cloth and the resultant fruit pulp packaged in plastic bowls and kept in arefrigerator.

Formulation of Samples

The Jackfruit pulpwas thoroughly mixed together with its juice in the ratios of 90:10%, 80:20%, 70:30%, 60:40% and 50:50% of pulp to the juice in a Kenwood blender and used to producethe jam.

Preparation of Jam

The jam samples was prepared using the modified method of Ihediohanma *et al*. [10]. Five hundred and fifty millilitres (500ml) of water to 550g of sugar was used to prepare sugar syrup. The syrup was boiled at 100^0C and 4g of citric acid was added, and allowed to boil again until a slippery feel to gel formed, the acid was placed to cool. Four hundred and fifty grams (450g) of the fruit pulp was concentrated and the prepared syrup added while boiling, it was allowed to cook on constant boiling/stirring and the gelatinization temperature and the time was taken and recorded.At the end, the prepared jam wascarefully poured in steam sterilized jam bottles and corked immediately and the jam was allowed to cool.

Chemical Analysis

The proximate composition of the samples was determinedin triplicates using the method of AOAC [11].

The minerals were determined from the samples according to the dry ash extraction method of AOAC [12].

Microbiological Analysis

Preparation of Media

Potato Dextrose Agar (PDA) and Nutrient agar (N.A) were used as media. They were prepared usinginstruction manual. The meancounts of bacteria in colony forming fruits per gram ofsamples were determined.

Method of Culturespreparation.

The samples were diluted after maceration under aseptic conditions serially. The appropriate dilution was inoculated on the two agar media. The fungi were inoculated on Potato Dextrose Agar (PDA) at 28 + 2^{o}C for 24 hours while bacteria wereinoculated on Nutrient Agar for 24 -48 hours. Colonies on plates were counted and the dilution factor was multiplied.

Identification of isolates

Inoculation was aseptically transferred from 10^{-4} into platesof respective media using a pour plate technique and it wasgram stained. The isolates were purified by repeated pouring on their respective media. Bacteria plates were incubated at37^{0}C for 24 hours and identified to the genus level bycolony and cell morphology and biochemical tests accordingto 25^{0}C for 72 hours. A 24 hours old culture wasprepared from each plate for identification purposes,bacteria isolates were identified based on their cultural characteristics, gram staining reaction and variousidentifications tests. The isolates were identified using theircultural and morphological characteristics which were of vital importance in this process and were thus observed.Biochemical tests were also carried out.

Procedure for Total Plate Count

All glass ware were sterilized in an area (the media nutrient agar) was prepared by weighing 7g and was dissolved in250ml of distilled water, it was then sterilized in the ovenand was allow to cooled to 450c, the serial dilution of thefour samples were carried out by pipetting 1ml of each ofsample to already measured 9ml diluted water into a testtube labeled 10^1 – 10^5 and was covered with non-absorbentcotton wool to avoid contamination. Apprximately,1ml from 10^4 of each sample was aseptically transferred intoa sterile Petri dish for each plate was covered immediately. Approximately, 20ml of the cooled molten agar was poured into the Petri dish and rotated gently for thorough distribution of theinoculums throughout the medium and it was allowed tosolidify, the plate was inverted and incubated at 30^0C for 48hours.

Determination of pH

The pH of the samples was determined according to the method of AOAC [12]. About 100 ml of the filtrate sample was measured using a pH meter.

Determination of Total Titratable Acidity (TTA)

Approximately,10ml aliquots were pipetted and titrated against 0.1mlNAOH to phenolphthalein and point and the acidity was calculated as gram malic acid/100[12]

Determination of Total Soluble Solid (Brix %)

This was determined through the use of Abbe 60 refractometer corrected to 60^0C according to Pearson [13]. Before use, the refractometer was adjusted to zero readings using distilled water. Aliquots from the samples were placed on the prism surface of the refractometer and thetotal soluble solid directly as the sugar content.

Sensory Evaluation

The jam sample produced were cooled for 2 h at room temperature after preparation and was evaluated organoleptically by a panel of fifteen (20) semi-trained consumer panelists consisting of staff and students of the Department of Food Science and Technology, ESUT, Enugu, Nigeria.

The jam samples was separately coded and served to the panelist in white plastic plates of similar sizes along with slices of bread. The panelists were asked to taste, assess and score the samples using a nine (9) point Hedonic scale for which 9 is like extremely and 1 is dislike extremely to rank for the attributes of colour, texture, flavour, taste, and overall acceptability. A cup of drinking water was also provided to each panelist to rinse his or her mouth after tasting each sample to avoid residual effect. The panelists was told to evaluate and score the jam samples based on their acceptability of each sample.

Statistical Analysis

The data generated was subjected to one-way analysis of variance (ANOVA) using Statistical Package for Social Science (SPSS, version 20) software. Significant means was separated using the Turkey's Least Significance Difference (LSD) Test at $p<0.05$.

RESULTS

Table 1: Proximate Composition of the samples (%)

Sample	Moisture	Protein	Fibre	Fat	Ash	Carbohydrate	Energy
A	$53.40^{a}\pm0.17$	$1.74^{b}\pm0.15$	$1.60^{b}\pm0.43$	$0.40^{b}\pm0.29$	$3.10^{a}\pm0.32$	$39.76^{c}\pm0.22$	$169.60^{c}\pm0.32$
B	$29.86^{c}\pm0.23$	$2.63^{a}\pm0.04$	$2.04^{a}\pm0.07$	$3.60^{a}\pm0.13$	$2.65^{b}\pm0.045$	$9.22^{b}\pm0.34$	$279.80^{a}\pm0.82$
C	$33.29^{b}\pm0.51$	$1.03^{c}\pm0.06$	$0.04^{c}\pm0.02$	$0.48^{b}\pm0.00$	$0.07^{c}\pm0.026$	$5.09^{a}\pm0.72$	$268.80^{b}\pm0.29$

Values are mean ± standard deviation of 3 replication
Key A = Jackfruit Jam
B = Jackfruit pulp,C = Commercial Jam.

Table 2: Mineral Composition of the samples (mg/100g)

Sample	Iron	Zinc	Cupper	Magnesium	Calcium	Phosphorus	Potassium	Sodium
A	$1.46^{a}\pm0.30$	$0.82^{a}\pm0.27$	$25.64^{a}\pm0.33$	$22.00^{b}\pm0.16$	$38.20^{a}\pm0.32$	$29.00^{a}\pm0.03$	$272.00^{b}\pm0.34$	$12.00^{b}\pm0.12$
B	$0.75^{b}\pm0.03$	$0.43^{b}\pm0.11$	$21.67^{b}\pm0.22$	$62.40^{a}\pm0.56$	$19.32^{b}\pm0.402$	$34.^{c}\pm0.03$	$20.^{c}\pm0.12$	$19.18^{a}\pm0.32$
C	$0.21^{c}\pm0.10$	$0.16^{c}\pm0.00$	$8.23^{c}\pm0.04$	$2.05^{c}\pm0.05$	$11.03^{c}\pm0.28$	$10.56^{b}\pm0.36$	$306.67^{a}\pm0.81$	$10.10^{c}\pm0.51$

Values are mean ± standard deviation of 3 replicate determination.
Key A = Jackfruit Jam
B = Jackfruit pulp,C = Commercial Jam.

Table 3: Vitamin Composition of the samples (mg/100g)

Sample	Beta-Carotene (µg)	Vitamin C	Vitamin B_1	Niacin
A	$130.00^{a}\pm0.46$	$9.72^{c}\pm0.23$	$44.00^{b}\pm0.52$	$320.00^{b}\pm0.14$
B	$130.33^{a}\pm0.72$	$12.87^{b}\pm0.21$	$52.65^{a}\pm0.06$	$340.55^{a}\pm0.22$
C	$36.38^{b}\pm0.38$	$43.66^{a}\pm0.17$	$23.67^{c}\pm0.12$	$64.90^{c}\pm0.05$

Values are mean ± standard deviation of 3 replicate determination.
Key A = Jackfruit Jam
B = Jackfruit pulp,C = Commercial Jam.

Table 4: Microbial Count of Jackfruit and Commercial Jams

Sample	Total Plate Count (cfu/g)	Fungi Count (cfu/g)
A	$16.76^{a}\pm0.30$	$20.34^{b}\pm0.27$
B	$52.00^{b}\pm0.08$	$41.00^{a}\pm0.65$
P-value	0.682	0.751
T-test	n=6	n=6

Values are mean ± standard deviation of 3 replicate determination.
Key: A = Jackfruit jam
B = Commercial jam

Table 5: Sensory Properties of Jackfruit and Commercial Jams

Sample	Taste	Flavour	Appearance	Consistency	Colour	General Acceptability
A	$8.5^{a}\pm0.16$	$8.5^{a}\pm0.06$	$8.5^{a}\pm0.11$	$6.5^{b}\pm0.04$	$8.5^{a}\pm0.54$	$8.5^{a}\pm0.19$
B	$7.5^{b}\pm0.50$	$6.5^{b}\pm0.38$	$7.5^{b}\pm0.56$	$7.5^{a}\pm0.25$	$8.5^{a}\pm0.03$	$6.5^{b}\pm0.67$
P-value	0.002	0.041	0.024	0.006	0.00	0.041
T-test	n=6	n=6	n=6	n=6	n=6	n=6

Values are mean ± standard deviation of 3 replicate determination.
Key: A = Jackfruit jam
B = Commercial jam

Table 6: Physicochemical Properties of Jackfruit and Commercial Jam

Sample	pH Value	Titratable Acidity (g)	Total Soluble Solid (°brix)
A	3.25^{a}±0.16	0.62^{a}±0.85	66^{a}±0.42
B	4.50^{a}±0.54	0.69^{a}±0.50	69^{a}±0.83
P-value	0.010	0.001	0.351
T-test	n=6	n=6	n=6

Values are mean ± standard deviation of 3 replicate determination.
Key: A = Jackfruit jam
B = Commercial jam

Discussion

Proximate Analysis

Table 1 presents the proximate composition of the samples. It had 53.40%, 29.86 and 33.29% moisture, 1.74%,2.63 and 1.03% protein, 1.60%, 2.04 and 0.04% fibre, 0.40%, 3,60 and 0.48% fat, 3.10%, 2.65 and 0.07% ash, 39.76%, 59.22 and 65.09% carbohydrate and 169.60KJ, 279.80 and 268.80 energy for A, B and C.

Moisture: The moisture content of the jackfruit jam was 53.40%. The value of moisture content recorded in this study was low when compared to the values (90.8% and 96.3%) recorded by Umeh and Nwadialu [14] for orange and *C. parchycarpa* jams, respectively but higher than the value (33.29%) commercial jam. Naturally, jam is a semi-liquid jelly like paste use as bread spread. Studies shows that high moisture food has low shelf life and are susceptible to spoilage microorganism but the sugar used in the production of jam help to extend the shelf life.

Protein: Jam is known to provide a negligible source of protein[14], this is as a result of the fact that jam are made from fruits which are poor sources of protein. According to the jams Nutrition labelling, common ingredients are fruits, sugar, pectin and citric acid. None of the ingredients used isa good source of protein; hence, the low protein content of jams found in this study. The value of protein obtain in the jackfruit jam was 1.74%. This value of protein in this study was similar to the values (1.46% to 1.78%) reported by Eke-Ejiofor and Owuno [15] in pineapple and avocado jam samples and 1.03% observed in commercial jam. Protein is an indispensable part of

the food for humans as it is the chief constituent of the protoplasm which forms the vital part of every living cell. Protein repairs body tissue by continuous catabolism in the body and synthesize new proteins from the amino acids. Plasma protein regulates water balance [16]. Therefore, one should not depend on jam for the daily protein need which is essential for the body.

Fibre: The fibre content of the jackfruit jam was 1.60% while that of the jackfruit pulp was 2.04%. Fibre is found naturally in plant foods like whole grains, beans, nuts, fruit and vegetables and is sometimes added to foods or drinks. It helps to regulate the body's use of sugars, helping to keep hunger and blood sugar in check. The value obtained in this study was higher than the value (0.36) reported by Okudu and Ene-Obong [17] in *C. parchycarpa*. Therefore, jackfruit is a good source of fibre.

Fat: Fat improves flavour and increases the mouthfeel of foods and it is a significant factor in food formulation [18;19]. The fat content of the jackfruit jam was 0.4%. Jackfruit like every other fruit is not a good source of fat. The value of fat contents in this study was similar to the value (0.40%) recorded by Umeh and Nwadialu [14]for *C. parchycarpa*.

Ash: The ash content of the jam sample was 3.1%. The finding wassignificantly ($p<0.05$) higher than the ash content of commercial jam (0.07 %). The value is higher than the ash content of apricot jamand Orange jam (0.2g and 1.2g/100g) [20;21]. Generally, high ash content indicates that the food is a rich source of minerals.

Carbohydrate: Jam is an excellent sources of carbohydrates. The carbohydrate content of the jam was 39%which is significantly different from the commercial jam 65.06%. It was comparable with the findings 14g/100 to 48 g/100 g for pineapple and jackfruit jams [15]. High carbohydrate content in commercial jams can be associated with the large presence of sugar (>50 g/ 100 g) as observed from the nutrition labelling on its packaging but the actual value is 65.09%. The lower carbohydrate content of jackfruit is because no sugar was added to it except the natural sugar in jackfruit.

Energy: The energy content of the jackfruit jam was 169.60KJ while jackfruit pulp was 279.80kj. The energy content of food is the reflection of protein, carbohydrate and fat value in the food. The low energy content of the jackfruit jam is as a result of processing and the use of natural sugar in jackfruit without additive.The bodyneeds energy, which is supplied bythe diet in the form of calories.

Energy fuels the body's internal functions, repairs, builds and maintains cells and body tissues, and supports the external activities that enable one to interact with the physical world.

Mineral Composition of the sample

Table 2 presents the mineral composition of the samples. The sample had 1.46mg,0.75 and 0.21mg iron, 0.82mg, 0.43 and 0.16mg zinc, 25.64mg, 21.67 and 8.23mg copper, 22.00mg,62.40 and 2.05 mg magnesium, 38.20mg, 19.32 and 11.03mg calcium, 29.00mg, 2.34 and 10.56mg phosphorus, 272.00mg, 20.20 and 306.67mg potassium and 12.00mg, 19.18 and 10.70mg sodium for A, B and C.

Iron: The iron content of the jackfruit jam was 1.46mg. There was increase in iron from 0.75 to 1.45mg after processing to jam. This could be from the pot during cooking. Iron is a component of many proteins and enzymes, notably haemoglobin and cytochrome P450 (a family of enzymes containing heme as a cofactor that functions as monooxygenases). The recommended daily allowance (RDA) of iron in adults is between 15, 20-30mg for children and pregnant women [22].

Zinc: The zinc level (0.82mg/100g) of the jackfruit jam was significantly different from the level (0.16mg/100g) in the commercial jam. Zinc is needed for the body's defensive (immune) system to properly work. It plays a role in cell division, cell growth, wound healing and the breakdown of carbohydrates. It also enhances the action of insulin [23].

Copper: The copper content of the jackfruit jam was 25.64mg which was higher than the commercial jam 8.23mg. The high copper content of jackfruit jam is of interest because copper is an important mineral for survival. It is found in the tissues of the body and plays a role in making red blood cells and maintaining nerve cells and the immune system. It also helps the body form collagen and absorb iron, and plays a role in energy production[24].

Magnesium: The magnesium content of the jackfruit jam was 22.00mg while that of commercial jam was 2.50mg. Giampieri *et al*. [25] reported the Mg content of jackfruit jam (12.5 mg/100 g) which was lower than the findings of this study. The higher Mg content for jackfruit jam found in the present study could be attributed to the different in the mineral content of the soil where

both samples were collected. Magnesium is important for bone formation. The other health benefits of magnesium include relieving constipation, strengthening of bones, treating health migraines and also helps to management of diabetes [24].

Calcium: The calcium content of the jackfruit jam was 38.20mg and the commercial jam was 11.33mg. The different in the calcium content may bedifferent in the fruit, location sand age of the samples used. Calcium is a very important mineral. It is a structural component of bones and teeth. Calcium plays a vital role in the development and sustenance of strong bones and teeth (especially in fetus, infants, children and elderly people), regulation of muscular contraction and relaxation, regulation of absorption of cyanocobalamin (vitamin B_{12}) [26].

Vitamin Composition of the samples

The vitamin composition of the samples is shown in table 3.The result showed 130.00µg, 130.33 and 36.38µg β-carotene, 9.72mg, 12.87 and 43.60mg vitamin C, 44.00mg, 52.65 and 23.67mg vitamin B_1 and 320.00mg, 340.55 and 64.90mg niacin for A,B and C respectively.

Beta-Carotene: The beta-carotene content of the jackfruit jam was 130.00µg while that of the commercial jam was 36.38µg. The highBeta-carotene content of the jackfruit jam is imperative although there wasloss of Beta-carotene from 130.33 in jackfruit pulp to 130.00 in the jam due to heat during processing. Beta-carotene is a powerful antioxidant. Beta-carotene is converted into vitamin A (retinol) in the body. The body need vitamin A for good vision and eye health, for a strong immune system, and for healthy skin and mucous membranes[27]. High consumption of vitamin A is toxic, but the body can converts beta-carotene to vitamin A depending on the body need [25].

Vitamin C: The vitamin C content of the samples were 9.72mg jackfruit jam, 12.87mg jackfruit pulp and 43.60mg commercial jam. The vitamin C content of the jackfruit jam is lower than the result of the commercial jam. The lower level of the vitamin C content of jackfruit jam compared to the pulp is not a surprise because vitamin C is water soluble and heat labile. The result is in line with the report ofUckiah *et al*. [28] who observed thatprocessing of fruits into jams was revealed to be most damaging towards vitamin C. Vitamin C (ascorbic acid) is needed for the repair of tissues in all parts of the body. The important functions of vitamin C include the formation of protein used to make skin, tendons, ligaments, and blood vessels for healing

wounds and forming scar tissues, for repairing and maintaining cartilage, bones, and teeth and aid in the absorption of iron [29]. Valente *et al*. [30]reported that vitamin C is integral in biochemical process in human body and also a potent antioxidant.

Thiamin: The thiamin (Vitamin B_1) content of the jackfruit jam was 44.00mg and that of the pulp and commercial jam were 52.65 and 23.67mg respectively. The findings washigher when compared with thethiamin content of grape, strawberry and blueberry jam (0.02–0.03 mg/100 g) [20]. Likewise Ismail *et al*. [31] reported that the thiamin content of guava to be of similar range (0.06 mg/100 g). The high content of thiamin in both the jackfruit jam and pulp shows that it is a good source ofvitamin B_1. Thiamin is essential for glucose metabolism, and plays a key role in nerve, muscle, and heart function [25].

Niacin: The niacin (vitamin B_3) content of the jackfruit jam was 320.00mg and that of jackfruit pulp and commercial jam were 340.55 and 64.90mg/100g. The result is in line with the findings of Leccese *et al*. [32] who reported that jackfruit is a rich source of vitamin B_3 (niacin). Niacin is essential in the treatment of cardiovascular disease and prevent progression of atherosclerosis [33]. It is used by the body to convert food into energy.

Microbial Count of Jackfruit and Commercial Jam

Table 4 presents the microbial count of the jackfruit and commercial jam samples. The jackfruit jam had 16.76cfu/g total plate count and 20.34cfu/g fungi count while the commercial jam had 52.00cfu/g total plate count and 41.00cfu/g fungi count.The P-value of the samples showed that there was significant ($p>0.05$) different between them in both total count and fungi count respectively

Total Plate Count: The total plate count of the jackfruit and commercial jam were 16.76cfu and 52.00cfu respectively. The result indicates that micro-organism was lesser in the jackfruit jam than the commercial jam. The finding could be as a result of the different quality techniques in handling of the raw materials during jam making. However, the total plate counts do not exceed the standard (×106 cfu/g) (ICMSF, 2002). The reduction in the microbial levels may be due to the intense heat application involved in jam production as well as the high pH and the sugar content of the product which act as preservative.

Fungi Count: The total fungi count of the jackfruit and commercial jam were 20.34cfu and 41.00cfu respectively. However, the total plate counts do not exceed the standard (×106 cfu/g) [34]. The reduction in the microbial levels may be due to the intense heat application involved in jam production as well as the high pH and the sugar content of the product

Sensory Properties of Jackfruit and Commercial Jam

The sensory properties of jackfruit and commercial jam is shown in table 5. The jackfruit jam scored 8.5 in taste, 8.5 in flavour, 8.5 in appearance, 6.5 in consistency, 8.5 in colour and 8.5 in general acceptability whilst the commercial jam scored 7.5 in taste, 6.5 in flavour, 7.5 in appearance, 7.5 in consistency, 8.5 in colour and 6.5 in general acceptability. The P-value of the samples showed that there were significant ($p<0.05$) different between them in taste, flavour, appearance, consistency and general acceptability.

Taste: The taste of the jackfruit and commercial jam were 8.5 and 7.5 respectively. Taste is the primary factor that determines the acceptability of any product, which has the highest impact as far as market success of the product is concerned [35]. The result revealed that the commercial jam is more sugary but the panellist rated jackfruit jam higher in terms of taste.

Flavour: The flavour of the jackfruit and commercial jam were 8.5 and 6.5 respectively.Flavour is a complex mixture of volatile compounds whose composition is specific to species and often variety [36]. The high score observed on the flavour of jackfruit jam is expected because jackfruit has a natural unique and sweet flavour accrued to it.Sample A wasrated like extremely while sample B wasratedlike moderately.

Appearance: The appearance of the jackfruit and commercial jam samples were 8.5 and 7.5 respectively. Appearance is an important sensory attribute of any food because of its influence on acceptability[2]. Appearance according to Sharrif *et al.*, [36] is the first characteristics perceived by the human senses which plays important role in the identification and final selection of food. The variations in the appearance of the samples could be due to the raw materials used in the jam production. Sample A wasrated likeextremely while sample B wasrated likevery much.

Consistence: The consistence of the jackfruit and commercial jam samples were 6.5 and 7.5 respectively. Food consistence is perceived by the consumer as an assessment of product freshness, for example, bread crispiness, vegetable hardness, or jam spreadability [35]. In turn, the lack of these features suggests poor quality and may make the product unacceptable. The consistence significantly affects the final assessment of food product. Improper texture can make the product unacceptable to the consumer, even if it tastes very good [37]. Sample A wasrated liked moderate while sample B wasrated liked very much.

Colour: The colour of the jackfruit and commercial jam samples were 8.5 and 8.5 respectively.The most important attribute of any food's appearance is its colour, especially when it is directly associated with other food-quality attributes, for example the changes that take place during the ripening of fruit or the loss in colour quality as food spoils or becomes stale[36].The mean rate for colour of the two samples were 8.5 which means like extremely.

General Acceptability: The overall acceptability of the jackfruit and commercial jam samples were 8.5 and 6.5 respectively. Food acceptability is affected by many factors, which may be related to the individual, the food, or the environment in which the food is consumed [38]. Acceptability is a subjective measure based on hedonics (pleasure), which in turn is influenced by the sensory properties of the food, previous exposure to it and subsequent expectations, contextual factors, an individual's culture, physiological status (i.e., hunger, thirst, and presence/absence of illness), and many other variables [39]. The observations indicated that sample A was rated higher than the commercial sample B. Sample A was liked extremely while sample B was liked moderate.

Physicochemical Properties of Jackfruit and Commercial Jam

The physicochemical properties of jackfruit is shown in table 6.The jackfruit jam had 3.25 pH value, 0.62g titratable acidity and 66ºbrix total soluble solid while the commercial jam had 4.50 pH value, 0.69g total titratable acidity and 69ºbrix total soluble solid.The P-value of the samples showed thatthere were no significant ($p<0.05$) different between them in pH value and Total titratable acidity.

pH Value: The pH value of the jackfruit and commercial jam samples were 3.25 and 4.50 respectively. The pH of jam is an important factor to obtain optimum gel condition. The pH in the present study is slightly lower than that reported by Hussain and Shakir [40]4.20-5.50 for apricot and apple jam. These values are within the prescribed limit of FAO [41]. The result also is similar to those recorded in a previous work [42] for jam produced with jackfruit. Low pH in foods generally is imperative because it help to prevent microbial growth.

Total Titratable Acidity: The total titratable acidity of the jackfruit and commercial jam samples were 0.62g and 0.69g respectively. The result obtained is in agreement with those reported by Devotha [42] for jam produced with jackfruits. The importance of high acidity in food products shows that such foods can be stored for sometimes before spoilage or deterioration set in. Acidity is also useful to correct acid/sugar ratio in jam production.

Total Soluble Solid: The total soluble solid content of the jackfruit jam and commercial jam samples were 66ºbrix and 69ºbrix respectively. Jam should contain approximately 67-68% total soluble solids (TSS) along with 45% fruit pulp at least, while according to the Codex Alimentarius Commission, jam need to contain TSS approximately greater than 65% [43]Sugar generally contributes to soluble solids in jam production which is an effect that is essential for the physical and chemical properties [44].

Conclusion

The study showed that Jackfruit an underutilized fruit was successfully used in the production of high quality jam.It was also observed that jackfruit contains a significant amount of nutrient especially micronutrients and are safe from microorganism. The use of this fruit in jam making is one way of conserving it from its perishable nature and extend its use which will help toreduce wastage of these fruit and also boost its utilization as well as source of income to farmers and reduce the pressure on the use of other fruits for jam production.

Reference

1. Ihekoronye AI Manual on small-scale food processing. First ed. Fijac Academic 2009 Press Nsukka: Nigeria. P. 12.

2. Kordylas JM Processing and preservation of tropical and sub-tropical foods. Macmillan Education Limited: London.2011 P. 25.
3. Ashaye OA, Adeleke TO Quality attributes of stored roselle jam. *International Food Research Journal*, 2009,16:363-371.
4. Fatih Ö Emin Y. Evaluation of green tomato jams prepared from two kinds of tomatoes. *Academic Food Journal*, 9(2):19-25, 2011.
5. Sim MN, Ahmad Z.A, Aziz CP, Ju MYCheen, CC. "Classifcation of *Artocarpus heterophyfus* L. (Jackfruit) Maturity Using Disposable Screen-Printed Strips Based on Chemomeuic Analysis," *Asian Conference on Sensors*, Pp. 135–142, 2003.
6. Rahman N, NaharA, Jabbar-Mian MA Mosihuzza M. "Variation of carbohydrate composition of two forms of fruit from jack tree (*Artocarpus heterophyllus* L.) with maturity and climatic conditions," *Food Chemistry*, vol. 65, no. 1, pp. 91– 97, 1999.
7. Singh S, Krishnamurthi S Katyal S. Fruit Culture in India, ICAR, New Delhi, India. Pp 35-40,1963.
8. Mukprasirt A Sajjaanantakul K. Physico-Chemical Properties of Flour and Starch from Jackfruit Seeds (Artocarpus heterophyllus Lam.) Compared with Modified Starches. International Journal of Food Science and Technology, 39, 271-276, 2004,http://dx.doi.org/10.1111/j.1365-2621.2004.00781.x
9. Morton J. Jackfruit: Fruits of Warm Climates, M. F. Julia and F. L. Miami, Eds., Pp 81-87, 1987.
10. Ihediohanma NC, Okafor DCAdeboye, AS. Sensory Evaluation of Jam Produced From Jackfruit (*Artocarpus heterophyllus*). *IOSR Journal of Agriculture and Veterinary Science*; 7(5): 2319-2380,2014.

11. AOAC. Official Methods of Analysis. Association of Analytical Chemists. 18th Edition, Washington, D.C. USA. 614-621,2010.

12. A0AC. Official Method of Analysis, Association of Official Analytical Chemists, Washington DC USA.2000.9.

13. Pearson D. The Chemical Analysis of Food. Churchill Livingstone, Edinburgh, 1981; 504-530.10.

14. Umeh AS Nwadialu MA**.** Production and proximate analysis of jam (food spread) prepared from Cola pachycarpa. *Journal of Hydro Environmental Research*; 13: 152-158,**2010**.

15. Eke-Ejiofor J, Owuno F**.** The physico-chemical and sensory properties of jackfruit (*Artocarpus heterophilus*) jam. *International Journal of Nutritional Food Science*; 2: 149–152,**2013**

16. Lokonuzzaman IM. Effect of ripening on the composition and the suitability for jam processing of different varieties of mango (*Mangifera indica*). *African Journal of Biotechnology*; 2: 301– 306,**2015**.

17. Okudu HOEne-Obong H**.** The chemical and sensory properties of jam developed from two varieties of monkey kola (*Cola parchycarpa, Cola lepidota*). *American Journal of Food Nutrition*; 5: 16-22. 16,**2015**.

18. Eke EO, Kobundu AV**.** Quality Characteristics of Biscuits Produced From Composite Flour of Wheat and Quality Protein Maize. *African Journal of Food Science and Technology*; 1(5) 116-119,**1993**.

19. Iwe SC, Egwuekwe C. The quality and sensory attributes of cookies supplemented with fluted pumpkin (*Telfairia occidentalis* Hook) seed flour. *International journal of food science & technology*, 40(6): 613-620,**2010**.

20. FSANZ**.** FSANZ Nutrient Table for Use in Australia (NUTTAB). From (accessed on 20.3.2022),**2010**.http://www.foodstandards.gov.au/science/monitoringnutrients/nutrientables/nuttab/Pages/default.aspx

21. Sartaj A, Tariq M, Sarfraz AK. Physico-chemical characteristics of apricot (Prunus armeniaca L.) grown in northern areas of Pakistan. *Science of Horticulture*; 130: 386–392.
22. Vasudevan, D.M. and Sreekumari, J.P. **(2007).** Textbook of Biochemistry for Medical Student. Jaypee Brothers Publisher ltd. New Delhi. Pp. 311-329,**2011**.
23. THL**.** THL Fineli Finnish Food Composition Database. From <http://www.fineli.fi/index.php?lang=en> (accessed on 20.3.2022), **2013**.
24. Sexana OA, Onilude AA,Idowu, O A**.** Quality characteristics of bread produced from composite flour of wheat, Plantain and Soybean. *African Journal of Biotechnology*; 5: 1102-1106,**2010.**
25. Giampieri F, Tulipani S, Alvarez-Suarez JM, Quiles JL, Mezzetti B, Battino M**.** The strawberry: composition, nutritional quality, and impact on human health. *Nutrition*; 28: 9– 19,**2012**.
26. Otitoju KH, Ouedraogo JB, Resurreccion AV, Hung YCPhillips RD**.** Physical and sensory characteristics of sugar cookies containing mixtures of wheat, fonio (*Digitaria exilis*) and cowpea (*Vigna unguiculata*) flours. *International journal of food science & technology*; 38(4): 403- 410,**2014**.
27. Sartaj A, Tariq M,Sarfraz AK**.** Physico-chemical characteristics of apricot (Prunus armeniaca L.) grown in northern areas of Pakistan. *Science of Horticulture*; 130: 386–392.**2011**.
28. Uckiah A, Goburdhun D,Ruggoo A**.** Vitamin C content during processing and storage of pineapple. Nutritional Food Science, 39: 398–412,**2009**.
29. Sudha JDReshma LR**.** Vitamin C: source, Functions, Sensing and Analysis, Vitamin C, Amal H. Hamza, IntechOpen, Doi: 10.5772/intechopen.70162, **2017**. Available from: https://www.intechopen,com/books/vitamin-c/vitamin-c-sources-functions-sensing-and-analysis.
30. Valente A, Sanches-Silva A, Albuquerque TGCosta HSDevelopment of an orange juice in-house reference material and its application to guarantee the quality of vitamin C determination in fruits, juices and fruit pulps. *Food Chemistry*; 154: 71–77,**2014**.

31. Fatima Ismail FN, Talpur Memon AN,. Determination of Water Soluble Vitamin in Fruits and Vegetables Marketed in Sindh Pakistan. *Pakistan Journal of Nutrition, 12: 197-199,* 2013.
32. Leccese JC, MillerJN Pereira AV Aniceto C**.** Statistics for Analytical Chemistry, 3rd ed. Horwood, Chichester, UK. Pp. 190-193, **2011**.
33. Majewski GF Lebiedzinska HB**.** Methods of vitamin assay, 3rd ed., Interscience Publishers, New York. Chapter 6, Pp. 123-142,**2014**.
34. ICMSF**.** Food Production and Safety. International Commission on Microbiological Specifications for Foods. Pp. 80-85,**2002**.
35. Sukhcharn E, La Guardia M Giammanco S, Di Majo D,Giammanco M. Citrus flavonoids: Molecular structure, biological activity and nutritional properties: *A review, Food Chemistry*; 104: 466–47,**2007**.
36. Sharrif R, Glamoclija D, Demin M, Radovic BV, Jovanoic ZMilojkovic D**.** Agronomical and nutritional evaluation of quinoa seeds as an ingredients in bread formulation. *Journal of cereal science*; 55:132-138,**2017**.
37. Levaj B, Dragović-Uzelac V, Dančević T, Liber S, Repajić MBursać KD**.** Quality of clementine jam influenced by purée pretreatment, sugar type and pectin addition. *Agriculturae Conspectus Scientificus*; 74(3):227-231,**2009**.
38. Muhammad A, Durrani Y, Ayub M, Zeb A, Ullah J**.** Organoleptic evaluation of diet apple jam from apple grown in Swat valley. *Sarhad Journal of Agriculture*; 25(1): 81-86,**2009**.
39. Patten **.** Stuffed & Starved from Farm to Fork: The Hidden Battle for the World Food System. London: Portobello Books Ltd. pp. 169–73, **2011**.
40. Hussain IShakir I**.** Chemical and Organoleptic Characteristics of Jam prepared from Indigenous Varieties of Apricot and Apple. *World Journal of Dairy and Food Sciences*; 5(1):73-78,**2010**.
41. FAO **.**Food and Agriculture Organization of the United Nations Worldwide Dates Production statistics. <http://faostat.fao.org/faostat/servlet/XteServlet3,**2006**.
42. Devotha GM**.**Production and Characterization of Jackfruit Jam. Master of Science in Food Science of Sokoine University of Agriculture, Morogoro, Tanzania 2015. Pp. 15-64.

43.Baker RA, Berry N, Hui YH & Barret DM (2005). Food Preserves and jams. Processing fruits 2nd ed., p 113-125. USA:CRS press LLC,**2015**.

44.Hyvönen LTörmä R**.**Examination of Sugars, Sugar Alcohols, and Artificial Sweeteners as Substitutes for Sucrose in Strawberry Jam. Product Development. *Journal of Food Science*; 48:183 -185,**1983**.