Applied Sciences Research Periodicals
January 2024, Vol. 2, No. 1, pp. 74-95

Quality Evaluation of Jam Produced from Fresh and Dried Roselle Calyces (*Hibiscus sabdariffa*)

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Abstract:
The quality evaluation of jam produced from fresh and dried roselle calyces was investigated. Jams were produced from fresh and dried roselle calyces. The jam samples were subjected to physico-chemical, and sensory analysis using standard methods. The result of the physico-chemical properties of jams produced from fresh and dried roselle calyces indicated no significant (P>0.05) differences in ash (0.77-0.71), moisture (32.71-29.26) and TTA (1.73-1.82) except for Vitamin C (27.79-14.49) where significant (P<0.05) difference was observed. The result of the sensory attributes of jam produced from fresh and dried roselle calyces showed no significant (P>0.05) differences in their level of preferences and acceptability. The appearance, aroma, taste, mouthfeel and overall acceptability ranged between 7.93-8.47, 7.53-773, 7.07-7.73, 7.73-7.80 and 7.60-8.07 for jam from fresh and dried roselle calyces, respectively. It was therefore deduced that roselle jams prepared from either fresh or dried calyces are acceptable for consumption. The study recommended that either fresh or dried roselle calyces could be used in the production of jam due to their nutritional values. Similarly, the study advised that roselle jam be processed from the fresh calyx so as to reduce the rate of Vitamin C loss.

INTRODUCTION

Background of the Study

Fruits and vegetables are important in human nutrition and commerce; however, they are seasonal and highly perishable and need to be processed into more stable forms such as jams, jellies and juice so as to derive their maximum benefits (Ashaye and Adeleke, 2019).

Jam is food that is cooked using the meat/juice of fruits or vegetables which are then converted into jelly-like form. In general, jam is made using only one type of fruit with the characteristics of a good jam is to have a soft and even texture, favorable color and good fruit taste (Berolzheimer, 2019). Jam production can use various types of fruit, but in general the fruit that is used contains pectin. Pectin is a sugar/polysaccharide compound that makes jam to have a soft but thick texture. Jam is an intermediate moisture (semi-solid) food product prepared by cooking of fruits with sugar (with/without added pectin and acid) to increase the total soluble solids (TSS) content to >65% (Codex Stan-79, 1981). Fruits have mostly enough acidity and pectin content (extracted during cooking), contributing to the texture development in jam. It tends to apprehend shape, but normally less firm compared to jelly. Jam has prolonged shelf life so that it can be available round the year. Production of jam requires ingredients (fruit pulp, acid, pectin and sugar) of correct quantities for having desired finished product. Raw material quality and process of manufacturing are the exponents to the quality of finished goods (Nindo *et al.*, 2015).

Roselle (*Hibiscus sabdariffa* L) is a member of the family Malvaceae to which okra, cotton and kenaf belong. Both the leaves and the fleshy base of the flower (the calyx) are employed in the preparation of soups and sauces. Roselle calyx is a cheap source of vegetable protein, fat and minerals therefore its consumption should be encouraged in order to avoid nutrition deficiency diseases such as night blindness, scurvy and rickets (Babalola *et al*., 2011).

High sugar content is adopted in Jam making in order to suppress microbial growth, sweeten the product, help set the pectin, and make the product glisten (Kataria *et al*., 2016), while the pectin precipitates and helps form a matrix gel with the fruit content and sugar to yield a mixture that has a shelf-life of over 6-12 months. The act and art of jam making is an interesting process that helps reduce post-harvest losses that are often associated with fresh fruits. This research work was therefore geared towards evaluating the quality of jam produced from fresh and dried roselle calyces.

Justification of the Study

In Nigeria, the utilization of fresh Roselle (*Hibiscus sabdariffa* L) is not popular except in the preparation of sorrel drink popularly known as 'zobo' drink. Production of jam using fresh and dried roselle would not only improve utilization of the unpopular plant but as well enhance the nutritional qualities at the same time providing tasty jam products.

Objectives of the Study

Broad Objective:

The broad objective of the study was to evaluate the quality of jam produced from fresh and dried roselle calyces.

Specific Objectives:

The specific objectives of the study were to;

1. Formulate jam from fresh and dry roselle calyces
2. Determine the physico-chemical properties of jam produced from fresh and dried roselle calyces.
3. Evaluate the sensory properties of jam produced from fresh and dried roselle calyces.

LITERATURE REVIEW

Jam

Jam is defined as an intermediate moisture food obtained upon boiling fruit pulp with sufficient quantity of sugar (sucrose), pectin, acid, and other ingredients such as preservatives, colouring agents and flavouring materials to a gel like consistency which is firm enough to hold the fruits tissues in position (Khan *et al*., 2015). As per FSSAI Standards (2012), Jam should contain more than 68.5% total soluble solid (TSS) content and fruit pulp content should be at least 45%. Usually, jams have been prepared with high amount of sugars, mainly sucrose (WHO/FAO, 2013). However, consumption of sucrose in large quantity has been associated with adverse effects on health, such as obesity, diabetes, cardiovascular diseases and hypertension (Mendonca *et al*., 2015). Therefore, the uses of low-calorie sweeteners for replacement now-a-days, natural sweeteners are trapping more attention as the replacer of sugar.

Fruits are high in sugar content and rich in vitamins A and C. It plays a critical role in human diet and nutrition. Due to the perishable nature and season availability, about 16 to 72 percent of fruits are gone to waste due to spoilage because of poor storage conditions and transportation conditions. Hence, preservation of fruit is required to reduce fruit wastage. Fruit jam is a food product made from whole fruit that is crushed or cut into pieces and then heated with sugar and water until it reaches the "setting" or "jelling" point, which is achieved through natural or added pectin. Lawrence and Franklin (2015) defined the Fruit Jams as a thick, sweet spread made by crushing/chopped fruits with sugar, pectin, water, and cooking. Bloomfield, in 1998, defined jam as a mixture of fruits and sweeting agents brought to a gelled consistency with or without a permitted ingredient.

The fruit jam should have good constancy to spread quickly and should be firm enough to not flow like fluid. The fruit jam should contribute at least 68.5% of total soluble solids, and the fruit should contribute at least 45%. The study shows that 27% of essential nutrients are found in the fruit jam during the analysis using the AOAC (Association of Official Analytical Chemists), (2003) method. The fruits jam provides a good source of carbohydrates and energy, and the sugar content lowers the water activity and increases shelf life. Fruit jams are deficient in fatty acid content (Sandrou and Arvanitoyannis, 2010).

There is a wide variety of fruits jams like strawberry jam, raspberry jam, wild plum jam, strawberry watermelon jam, mango jam, mixed fruit jam, among others. It is used to make different food products like pancakes, ice cream, toast, among other meals (Mishra *et al*., 2012).

Global Production of Food Spread

Food spreads had a global market volume of 46.6 million tonnes and a value of US$56 billion in 2016 (Euro monitor International, 2017). Margarine is the most popular product (5.2 million tonnes), followed by butter (3.2 million tonnes), spreadable process cheese (2.1 million tonnes), nut and seed spreads (688 million tonnes), and yeast extracts (16.2 K tonnes). However, the butter category has the highest retail value (US$17.5 billion), followed by processed cheese (US$15.2 billion), margarine and spreads (US$14.3 billion), nut and seed spreads (US$3.4 billion), and yeast extracts (US$0.2 billion). Since 2011, the overall volume and retail value have decreased by 8.9% and 9.7%, respectively, throughout the entire category (Johnson, 2019). The drop in total volume is attributable to the margarine and spreads (4.5 per cent) and yeast extract (6.6 per cent) categories. All categories are on the decline in retail value, except for nut and seed spreads (4.1 per cent). The US (642.9 million tonnes), Brazil (581.6 million tonnes), Germany (364.7 million tonnes), and the United Kingdom (364.7 million tonnes) have the most significant overall quantities of margarine and spreads (Beeren *et al*., 2019).

Food spreads cover a wide range of products, including sweet fruit-based, savory, and sweet fruit-based spreads. Nutbased, dairy-based, and savory yeast extract-based alternatives are also available. Natural sodium is present in many ingredients (for example, fruit, vegetables, nuts, and milk), but its contribution to the sodium concentration of the product as a whole is quite little. Take salt, for instance, each 100 g of strawberry, peanuts, and milk has 1, 18, and 49 mg of salt, respectively (United States Department of Agriculture, 2016). There miht be changes across crop years, as well as between species and types, because they are agricultural crops. Feeding methods, this might have a slight impact on the finished product's salt content. The other substances would provide the majority of the sodium, with salt being the most prevalent. Salt makes up the majority of the sodium components in the fruit-based and yeast groups. Other additives, such as stabilisers, could be used to keep the fat, fats, ground nuts, and water in an emulsion form in nut and dairy spreads and cream cheeses. All but butter could be found in the dairy-based kind (e.g., cream cheese).

Classification of Spreads

Different types of spreads are: Margarine, butter spreads, cream spreads, cheese spreads, paneer spreads, chakka spreads and yoghurt spreads. Fat spreads like margarine, blended fats and butter spreads are water–in-oil type emulsions whereas others are oil-in-water type emulsions. Different categories of spreads are presented in Table 2.

Table 1: Volume of spread used by different countries

S/No	Country	Volume (Million tonnes)
1	United States	642.9
2	Brazil	581. 6
3	Germany	364.7
4	United Kingdom	303. 3

Source: Beeren *et al*. (2019)

Table 2: Types and classification of food spreads

<table>
<tr><td colspan="3">Based on source of ingredients</td><td colspan="2">Based on functional attributes</td></tr>
<tr><td colspan="3">Dairy spreads: Only milk fat is used</td><td colspan="2">Fortified (fatty acids, vitamins, antioxidants etc.)</td></tr>
<tr><td colspan="3">Non-dairy spreads: Vegetable fat with or without milk fat used as a source of fat</td><td colspan="2"></td></tr>
<tr><td colspan="3">Composite spreads: Dairy ingredients + Nondairy ingredients</td><td colspan="2">Probiotic</td></tr>
<tr><td colspan="2">World Health Organization & International Diabetes Federation (WHO/IDF)</td><td colspan="2">Food Safety and Standards Authority of India (FSSAI)</td><td>Food and Agriculture Organization (FAO)</td></tr>
<tr><td>Dairy spread</td><td rowspan="3">Normal: 62 – 80% fat; Reduced fat: 41–61% fat; Low fat: < 41% fat</td><td rowspan="3">Not more than 80% fat and not less than 40% fat by weight</td><td>Milk fat spread</td><td>Dairy spread: not less than 60% fat</td></tr>
<tr><td>Blended spread</td><td>Mixed fat spread</td><td>Reduced fat spread: 60–70% fat</td></tr>
<tr><td>Fat spread</td><td>Vegetable fat spread</td><td>Low fat spread: 40- 60% fat</td></tr>
</table>

Source: Supit *et al*. (2018)

Different types of fruit-based spread:

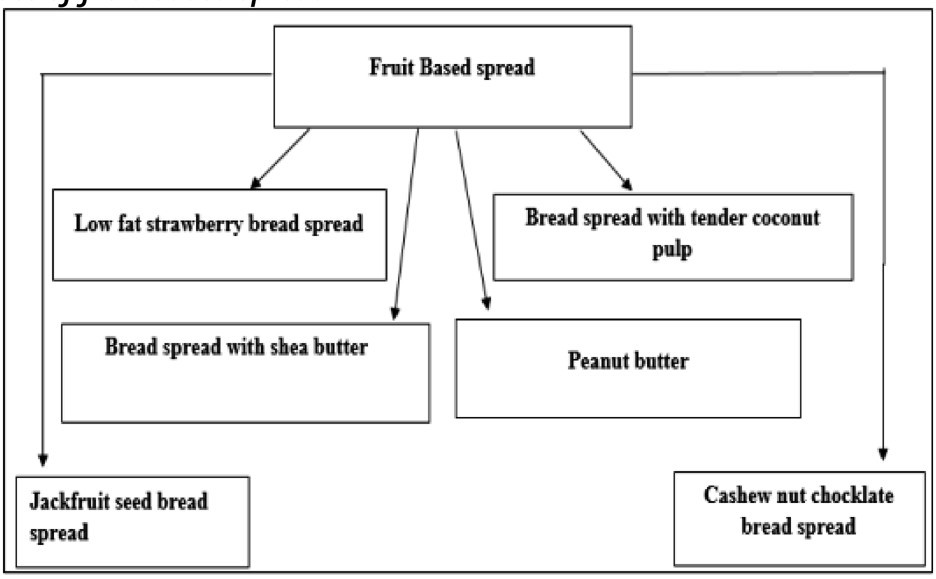

Figure 1: Different type of spread

Source: Supit *et al*. (2018)

Manufacturing Process of Fruits and Vegetable Spread

In general, production of spreads involves preparation of the water phase and fat phase, emulsion preparation, pasteurization, crystallization, filling and packaging, flow chart of which is shown in Figure 2.

General process of manufacture is: The aqueous phase consisting of water, salt, gums, thickeners, preservatives and water soluble colours is mixed thoroughly with fat phase consisting of oils, emulsifiers and fat soluble colours and the mix is pasteurized at 95°C for no hold. In the next holding tank, flavours are added, mixed and cooled using air blast coolers and finally packaged.
The speed of agitation and time is very important in obtaining desirable consistency in *processed cheese spread* (PCS) (Cerníková *et al.*, 2018). Samples produced using 3000 rpm were having significantly higher consistency in comparison with the *processed cheese spread* produced using lower agitation speeds (1000 and 1500 rpm). However, the firmness of the product increased during storage at about 6°C.

Manufacture of low-fat spread is a technological challenge. A good quality low fat spread can, however, be prepared if suitable emulsifiers and ingredients are used. Since higher levels of water content are available in low fat spreads, an appropriate stabilizer system is needed to impart the necessary stability in the crystallized product. Alginates, pectin and carrageenans have good water binding effect and give stable emulsions. Water-soluble flavours and colours are generally added. To prepare low fat spreads, the water phase and oil phase having the same temperature are to be mixed slowly to form a proper emulsion and avoid formation of high viscosity. Intensive mechanical treatment tends to build up a higher emulsion viscosity in very

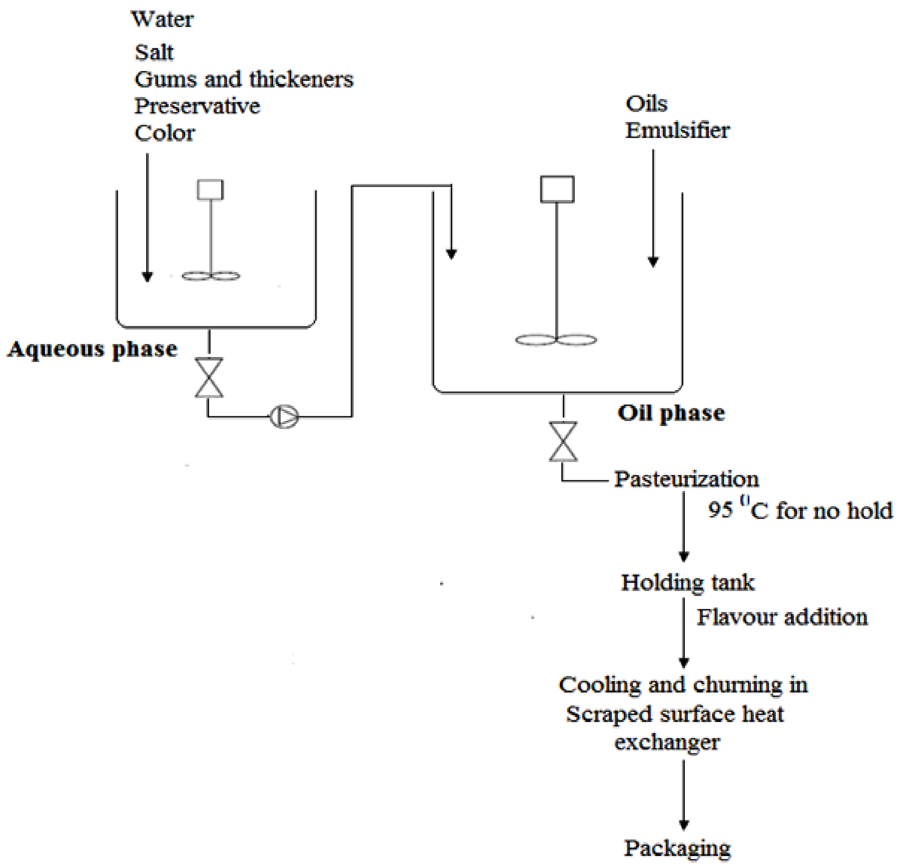

Figure 2: Schematic diagram of manufacture of vegetable fat spread

Source: Rao and Devaraja (2021)

low fat spreads, necessitating use of suitably designed stirrers to handle highly viscous emulsions. Anker stirrers function very well in the relatively high viscous emulsions. Storage of spread at a high temperature may render the product soft after cooling, while fast cooling may produce a brittle and more unstable low-fat spread. Low fat spreads should be stored at 15°C for 3-5 days before cooling to 5°C. Using storage (G′,) and loss (G′) moduli within the frequency of 01- 100 Hz in a rheometer, the effect of different agitation speeds and various holding times of the melt on the consistency of PCS having 35% dry matter and 40% fat in the dry matter, was examined by Cernikova *et al*. (2017). There was a continuous decrease in firmness of the samples in the first three minutes during holding. Thereafter, the firmness of the samples steadily increased from the third to the twentieth minute of holding time regardless of the speed of agitation tested. All the processed cheese samples showed an increase in firmness over 60 days of storage. To ensure homogeneity, the emulsion needs to be properly blended avoiding incorporation of air during emulsification. It is normally difficult to decrease the fat content to less than about 25% in a spread, if the water droplets have exactly the same size in a water-in-oil emulsion. By utilizing the combined benefits of different emulsifiers, it is, however, possible to create water droplets having different sizes and make the emulsion more closely packed. This also enables to produce 20 - 15% or even 10% fat spreads. Since the oil phase needs to cover a large number of water droplets, it is necessary to have more liquid oil in the fat composition of a low-fat spread than similar high fat spreads to preserve the smoothness. Presence of too much palm stearin may render a low-fat spread (10% fat) more unstable compared to palm oil probably due to more brittleness during and after production.

Bascuas *et al*. (2021) claimed that oleogels are viable and healthy alternatives to replace the saturated fat present in chocolate spreads and can be used to replace upto 50% coconut butter in the formulation. The authors designed chocolate spreads using oleogels with two oils (olive and sunflower), hydroxyl propyl methyl cellulose (HPMC) and xanthan gum (XG), as structuring agents. The oleogels conferred consistency to the spreads due to the network formed by HPMC and XG. This concept can have a potential application in dairy spreads. Corn milk, maltodextrin, citric acid and papain were used by Aini *et al*. (2019) to prepare an analogue of low-fat cheese spread containing about 7% fat.

Fruit Spread

Low Fat Strawberry Spread:

Strawberry is a popular fruit of the Rosaceae family. It is planted all across the world and holds a prominent position among little fruit plants. The very perishable fruit has a good flavor and is deep crimson in color with a distinctive form. It's high in vitamin C, sugar, organic acids like anthocyanin, phosphorus, iron, and other minerals and vitamins, and it has a fruity, sweet, and tangy flavor. Purees, juice concentrate, juice, jams, preserves, and rose red wine are all made using it. (Sharma *et al*., 2009) Strawberries (*Fragariax ananassa*) are one of the most popular fruits in the world, having a distinct and appealing flavor. The texture and presence of volatile chemicals are the two most important properties of ripe strawberries (Jiawei *et al*., 2019) Strawberry's high fiber, potassium, vitamin C, and folate levels are well known for their potential health advantages. Strawberries are also high in blood sugar-regulating dietary fibers (pectins, celluloses, among others.) as well as thyroid-supporting iodine. Strawberry fruits are high in sugars (mostly glucose and fructose, with little sucrose) and acids. Strawberry is an excellent source of vitamin C. Vitamin C and phenolic compounds have been shown to contribute to the antioxidant capacity of fruits by acting as oxygen radical scavengers and may have health benefits (Yildiz *et al*., 2014). Potassium (the most prevalent mineral), calcium, and magnesium are all abundant in strawberries. They're also high in folate, omega-3 fatty acids, vitamin B6, vitamin K, and the energy-boosting vitamins B2 and B5 (Milivojevic *et al*., 2010) Ripe strawberries, on the other hand, are very perishable due to their smooth texture, rapid softening and respiration, and resistance to fungal infections and off-flavor development (Lara *et al*. 2014). For pulp processing, uniform red-colored, medium-sized, healthy fruits were chosen. The fruit sepals were manually removed and crushed using a Pulp-Homogenizer combination. After that, the pulp was put into sterilized glass bottles and pasteurized for 15 minutes at 100 °C. The homogenized pulp was then sieved at 1 mm in stainless steel. According to the approach described by, the pulp was treated and held for a longer amount of time (Bishnoi *et al*., 2016).

Powder Preparation:

Strawberry was purchased at a local market in Kolhapur and transported to the Department of Animal Sciences' laboratory. RCSM College of Agriculture, Kolhapur, Department of Animal Husbandry and Dairy Science the strawberries were cleaned under running water from a tap. The fruits were then blanched for 3 to 5 minutes in hot water. After blanching, the fruits were sliced into four pieces and dried for 18 hours at 55°C (Olubunmi *et al*., 2013) Using a kitchen mixer blender, the dried strawberry fruit pieces were ground into powder. A 1mm stainless steel sieve was used to filter the powder. For later usage, the sieved strawberry powder was wrapped in plastic bags and stored at room temperature. Except for boiling into the water for 3-5 minutes, the same procedure was followed for strawberries that had not been blanched.

Making A Low-Fat Spread with Cow Milk Ghee and Strawberry Jam:

In a planetary mixer, low-fat spread made from cow milk ghee was made according to a procedure described by Patange (2016). Before combining and emulsifying the fat and serum stages, they must be separately prepared and tempered. Ghee was heated to 50 °C before being combined with the emulsifier to make the fat phase. It was then rapidly cooled to 20 °C (rate of cooling, 12 °C/min) with continuous agitation in a cold water-bath (2.5 - 1 °C) and finally to 5 °C by quiescent holding in a refrigerator for an overnight duration. The chilled fat phase was then tempered at room temperature for 6 hours before usage to the blending temperature of 25 °C 1 °C.

The final product was tested for sensory factors such as colour and appearance, flavour, body and texture, spread ability, and general acceptability, according to the findings. It was concluded from this investigation that a reduced fat spread made with blanched powdered strawberry was the most acceptable.

Bread Spread with Tender Coconut Pulp:

The coconut palm (*Cocos nucifera* L), a palmaceae family member, is one of the world's most economically important trees. The various possible uses of this multi-purpose tree crop have earned it the nickname "tree of life." Coconut holds a unique place among the different horticulture crops grown throughout the universe due to its contributions to both the food and edible oil economies. Only about 50-55 percent of India's matured nuts are used for domestic culinary purposes as well as social and religious occasions, leaving the rest for processing into oil and various food products. Around 15% of the collected nuts are used at the tender nut stage for direct consumption as well as conversion into bottled beverages (Afrin *et al*., 2016). The raw materials that needed for this is tender coconuts aged 7-8 months were purchased from local stores, while fully ripened fruits were obtained from Thrissur, Kerala neighbourhoods. The flesh of the young coconut is a white albuminous endosperm that was chosen for the study because it is edible and tender. Tender coconut pulp was used as the substrate for the spread, which was then combined with fruit extracts in three different quantities. Guava extracts in 75:25, 50:50, and 25:75 ratios from tender coconut pulp. Tender coconut pulp: 75:25, 50:50, and 25:75 extracts of jackfruit rind. Plantain extracts in 75:25, 50:50, and 25:75 ratios from tender coconut pulp (TCP). Three replications of the experiment were carried out in CRD. In an open pan, delicate coconut pulp and fruit extracts were combined in the desired ratio and heated continuously with the other ingredients. When the TSS reached 68-690 Brix, the heating was turned off and the liquid was poured into clean, sterilized, and dry glass bottles with a volume of 200 mL and sealed airtight. The bottles were then kept at room temperature for storage testing. For a period of six months, quality evaluations of the products were conducted at monthly intervals. A panel of ten judges conducted an organoleptic examination of the spread using a score card, and quality criteria such as appearance, color, flavor, texture, taste, and overall acceptability were scored using a nine-point hedonic scale. The findings of Afrin *et al*. (2016) demonstrate that various fruit extracts such as guava, plantain, and completely wasted jackfruit rind, as well as residual coconut pulp left in tender coconuts after intake of coconut water, can be used to make spread. The spread's physicochemical and organoleptic examination revealed that the items had a six-month shelf life when stored at ambient temperatures. When different textural characteristics such gel strength, adhesiveness, brittleness, and rupture strength were investigated, the generated spread was shown to have good textural features. At the conclusion of six months of storage, microorganisms were found, although these were within acceptable limits of above 6.5 on 9-point hedonic scale. The goods were ranked based on the scores they received for several organoleptic qualities. ST8 (50 percent TCP + 50 percent PE) received the greatest ranking in terms of spread, followed by ST3 (25 percent TCP+ 75 percent GE).

Bread Spread with Shea Butter:

Shea tree fruit is green in color and contains a fleshy edible pulp that is high in vitamins and minerals. It is highly sweet and includes 0.7-1.3 g of protein and 41.2 g of carbohydrates. In comparison to oranges, which have 50mg/100g of ascorbic acid, the fruit pulp has 196.1mg/100g. The iron and calcium content are comparable to that of raspberries (FAO, 1998). Sugar concentration ranges from 3-6 percent, with glucose, fructose, and sucrose being divided evenly. Shea butter is made in one of two ways. Traditional and chemical processes include hexane extraction, clay filtering, and refined shea butter as the final product (Davrieux *et al*., 2010). Shea butter is used as a foundation for therapeutic ointments, and its anti-inflammatory, emollient, and humectant effects have been reported. Shea butter is also used as a water proofing wax, in hair styling, and in candle production. It's also used to treat colds and the flu. It's also used by traditional African percussion instrument makers to help wood and leather ties last longer (Alander, 2004). Shea butter is used as a cooking oil in West Africa, particularly Ghana, Nigeria, and Togo (Olajide *et al*., 2010). It is edible and can be used in cooking, and the chocolate industry occasionally substitutes shea butter for cocoa butter, but the taste is different. Shea butter has found a market in Europe and Asia as a baking fat, margarine and other fatty spreads, confectionery and chocolate sector due to its high nutritional value (Akhter *et al*., 2018). Shea butter could be a creamy solid at room temperature, easily spreading on bread like dairy butter. It is extremely high in vitamins A and E, and it offers the skin with all of the necessary nutrients for balance and flexibility. Spices such as ginger, garlic, and fragrance leaves are widely used in Nigeria. They are a collection of esoteric food additives that have been used to improve the sensory quality of foods for thousands of years. These spice ingredients provide dishes a distinct flavor, aroma, or piquancy, as well as color (Ifesan, 2020). Several studies have shown that plant extracts or essential oils can be used as food additives and have antioxidant qualities (Banon *et al*., 2007; Capenter *et al*., 2007; Ifesan *et al*., 2009; Ifesan, 2020).

A local factory in Ilorin, Kwara State, provided processed shea butter. Suya spice was obtained in Wuse, Abuja, Nigeria, while ginger, garlic, and fragrance leaf were purchased at a local market in Akure, Ondo State. Sorted ginger, garlic, and fragrance leaves were rinsed in water. They were dried in an air oven at temperatures ranging from 50 to 550 degrees Celsius (^{o}C). The spices were processed into powder form after drying. Shea butter and spice blends were made in two ratios: 70:30 (shea butter: spice) and 85:15 (shea butter: spice) (shea butter: spice). Shea butter and spice were weighed into a blender and properly combined to achieve a homogeneous product, which was then packaged in a transparent rubber plastic and stored at room temperature for 4 weeks. The following labels were applied to the samples: SGG (70:30) SGG Shea butter + Ginger (85:15) SSS Shea butter + Ginger (70:30) - Suya spice + shea butter, SSS (85:15) -SGL, Shea butter + Suya spice (70:30) -SGL Shea butter + Garlic (85:15) SSL -Shea butter + garlic (70:30) -. The saponification value in shea butter-spice samples was reduced when the quality of the butter was improved by adding different spices to make bread spread. The addition of spices to shea butter improved the blends' ability to scavenge free radicals, potentially extending the shelf life of the items. In addition, sensory scores suggested that the shea butter + suya spice blend was the most preferred in terms of taste and color.

Peanut Butter Spread:

The peanut (*Arachis hypogaea*) is officially a pea and belongs to the bean/legume family (Fabaceae). Despite being a legume, it is usually classified as an oilseed due to its high oil content. Peanuts are a good source of protein, oil, and fibre (Lukaniuk *et al*., 2011). Sometimes known as “groundnuts” in some world areas, Peanuts are the edible seeds of a legume. India is the world’s second-largest producer of peanuts, with an annual production of 7.131 million metric tons. Peanuts are used to make peanut butter, confections, roasted peanuts, snack items, extenders in meat product formulations, soups, and desserts, in addition to oil. Peanuts are eaten in several ways worldwide, most of which are traditional dishes.

People on excursions to places like Antarctica, space, and hiking use peanuts as their sole source of nutrition. In recent years, it has notably been the source of eradicating malnutrition among the populace of several African countries (Guimon and Guimon, 2012). According to a recent study, cooking peanuts increases their antioxidant content. Boiling peanuts increases the amount of the isoflavone antioxidants biochanin A and genistein by two and four times, respectively (Craft *et al*. 2010). Peanuts and peanut butter are popular as a snack, meal items, and ingredients in various commercial products, and their consumption is linked to a lower incidence of cardiovascular disease, and they offer little harm to positive energy balance. However, concerns have been raised about whether product shape (e.g., whole nut vs butter) and processing characteristics (e.g., roasting and flavouring) may impair their beneficial health benefits. The effects of peanut shape and processing on two cardiovascular disease risk factors: fasting plasma lipids and body weight, were studied in this study. One hundred and eighteen persons (47 men and 71 females; age 292 (SD 84) years; BMI 300 (SD 45) kg/m2) were studied. For four weeks, participants from Brazil, Ghana, and the United States were randomly assigned to eat 56 g of raw unsalted (n 23), roasted unsalted (n 24), roasted salted (n 23), or honey-roasted (n 24) peanuts, or peanut butter (n 24). Peanut shape and processing did not affect body weight or fasting plasma lipid responses in the whole sample. However, when comparing high fasting plasma lipids candidates to those with normal fasting plasma lipids, HDL-cholesterol rose considerably at the group level, while total cholesterol, LDL cholesterol, and TAG concentrations fell significantly. These findings show that the processing characteristics investigated in this study do not impair the lipid-lowering benefits of peanuts or have a detrimental influence on body weight. In order to evaluate the impact of peanut shape and processing on additional health risk factors, more research is needed (Kiernan *et al*., 2010).

Jackfruit Seed Bread Spread:

The largest tree-borne tropical fruit globally, the jackfruit (*Artocarpus heterophyllus* Lam), belongs to the Moraceae family. It is a monoecious evergreen tree that's thought to be native to the Western Ghats rain forests in India's southwest (Baliga *et al*., 2011). Jackfruit is the national fruit of Bangladesh and Indonesia (Matin, 2015). The name jackfruit is taken from the Portuguese word jaca, which originates from the Malayalam word chakka. Jackfruit is a significant underutilised tropical fruit, frequently referred to as the poor man's fruit that has been used to add value to dishes in India since ancient times (Arora and Parley 2016). This section of the jackfruit is a good source of vital food components like carbohydrates, protein, and minerals (Ocloo *et al*., 2010). However, they are not used to their full potential due to the lack of knowledge about the seeds' nutritional and food production potential.

Jackfruit seeds are valuable by-products that account for more than 15% of the total weight of the fruit (Akter and Huque 2018). As a result, the goal of this study was to explore if the jackfruit seed could be used to make a bread spread that was healthy, inexpensive, and acceptable in terms of consistency, texture, scent, and flavour. Clean jackfruit seeds were cooked for 30 minutes before being blended with jackfruit rags, raw sugar, olive oil, lemon juice, lemon rind, turmeric powder, and salt until a paste-like consistency and smooth texture were reached. In order to eliminate the excess moisture, enhance shelf life, and achieve a spreadable consistency, the mixed ingredients were simmered for 15 minutes on low heat. The finished product was sealed in sterilised jars. The qualities of jackfruit seed spread include a canary yellow hue, a silky texture, a lemony scent, and a sweet acidulous flavour. Potassium (59mg), phosphorus (8mg), calcium (26mg), magnesium (4mg), thiamin (0.02mg), riboflavin (0.02mg), niacin (0.2mg), and vitamin C are all included in one meal (21g) (2mg). On a nine-point hedonic scale, 30 evaluators of both genders assessed the product as very highly liked. The jackfruit seed spread is inexpensive, with a jar of 200g net weight retailing for 58.00. In the refrigerator, the shelf life is 30 days. It was suggested that more research be done on manufacturing jackfruit seed dispersed on a big scale in areas where the fruit is commonly grown (Supit *et al*., 2018).

Cashew Nut Chocolate-Bread Spread:

Consumers nowadays seek products with more tremendous health advantages, which has resulted in significant growth in consumer knowledge and interest in the health-enhancing properties of certain foods or dietary components (Jnawali *et al*., 2016). Many families use margarine as a spread, although it is discouraged owing to concerns voiced by health providers about the trans-fats in margarine. On the other hand, cashew nuts are high in macro-and micronutrients, phytochemicals, tocopherols, and phenolic compounds. Furthermore, the nutritional profile of nuts revealed that they are high in unsaturated fatty acids, fibre, minerals, and proteins, making them healthful meals (Chen *et al*., 2006). They include essential fatty acids, which are required for the body's healthy functioning and play a vital role in controlling various metabolic, transport, and excretion activities (Soares *et al*., 2013). The creation of a nut spread can expand the culinary applications of cashew nuts & introduce customers to a healthier breakfast or snack option (Shakerardekani and Karim, 2012). As obesity, diabetes, and other lifestyle-related disorders threaten the world, health concerns take precedence in people's eating choices. As a result, manufacturing a plant-based spread will provide individuals with a healthier spread option ((Kulkurani and Soni, 2014). A spread is a type of food applied over bread, crackers, or other pastries. Cheese, butter/margarine, jam/jellies, and chocolate spread are frequently prepared from fruits, nuts, milk, fat, and chocolate. Nut spreads are spreadable nuts mashed into a paste (Shakerardekani, Karim, Ghazali, & Chin, 2013). The preparation method is that all other additional components (sugar, milk, vegetable oil, and flavour) were acquired at the Madina market in Accra, Ghana, and roasted cashew nuts from CRIG's (Cocoa Research Institute) Ghana, Tafo) substation in Koforidua. The roasted cashew nuts were ground into a slurry in a household blender. Cashew nut slurry (CNS) was substituted for cocoa powder (CP) in the preparation of chocolate spread at a rate of 95 per cent, 90 per cent, 85 per cent, 80 per cent, and 75 per cent, for a total of five samples. Thirty-five per cent cashew nut–CP composite, 29.4 per cent sugar, 20 per cent milk, 15 per cent vegetable oil, 0.1 per cent vanilla, and 0.5 per cent lecithin were found in the prepared spreads. A melanger was used to weigh and grind the components. A market-purchased chocolate spread was utilised as a control (Olaleye *et al.*, 2021). From the microbial findings, microorganisms such as bacteria, mould, and yeast proliferate with high water activity, but because most confectionery goods have a low water activity (less than 0.75), they are resistant to microbial deterioration and could be considered ambient-stable (Subramaniam, 2010). The mineral content of the cashew nut–chocolate spreads was more significant than the control sample (Mg, Na, and K) as reported by Olaleye *et al*. (2021).

Roselle (*Hibiscus sabdariffa* L.)

Roselle (*Hibiscus sabdariffa* L.) is native of Asia. It is grown commonly in India and Malaysia, and very probably was brought from there to Africa. Roselle has been widely distributed in the tropics and subtropics of both north and south hemispheres as well as in many areas of Jamaica, Trinidad and Tobago, and Central America (Morton, 2014). The Roselle plant is an annual or biannual semi-ligneous shrubby that belongs to the Malvaceae family that can reach between one and three meters of height. Its red-dark stems are abundant and highly branched; the alternated leaves have irregular serrated edges (Ortiz-Marquéz, 2018). The genus Hibiscus, of the Malvaceae family, has over 500 species worldwide. There are two types of *H. sabdariffa* of economic importance. One is *H. sabdariffa* var. altissima Wester, used for fiber production in India, Nigeria, and in some parts of the tropical America. The stems of this variety might be green or red and the leaves are green, sometimes with red veins. Its flowers are yellow with red or green calyces, not fleshy, fibrous, and thorny, therefore, they are not used as food. This type of flower is occasionally confused with kenaf (*H. cannabinus* L.), a source of fiber, similar to *H. sabdariffa*, but more widely exploited (Morton, 2014). The other type is *H. sabdariffa* var. sabdariffa which includes short and thick bushes; different subspecies have been described: bhagalpuriensis, intermedius, albus and rubber. The first one has non-edible red-veined green calyces, the second and third ones have edible greenish-yellow calyces and are also used for fiber production. The last one is an annual, erect, thick shrub of about 2.5 m in height with smooth stems, typically cylindrical and red. Its green with reddish veined leaves are alternated, from 7.6 to 12.7 cm long, and have long or short petioles. Calyces, stems and leaves have acid properties very similar to the cranberry taste (Morton, 2014). In Mexico, the main varieties grown are Creole (cv. long red), Chinese, Jerzy, and Sudan (Domínguez-Domínguez *et al*., 2017).

Roselle as Functional Food

Generally, roselle is considered as traditional medicine for the remedy of diuretic, mild laxative, cancer, cardiac and nerve diseases. Every fraction of roselle plants including leaves, fruits, roots, seeds are utilized in various foods. Among them, red fleshy calyces are employed for making fresh beverage tastes like Ribena, juice, jam, jelly, syrup, gelatin, pudding, wine, cakes, ice-cream and flavors and also dried and brewed into tea (Rao, 2016; Tsai *et al*., 2018). The bright red color coupled with exceptional flavor and other organoleptic attributes make them valuable food products (El-dawy and Khalil, 2014) such as wine, syrup, ice cream, pies, snakes, tarts and other desserts (Eslaminejad and Zakaria, 2011; Duke and Atchley, 2014).

The drink contains vitamin C and anthocyanins which act as an antioxidant. Anthocyanins present in roselle are dephinidin γsambubioside, cyanidin γ-sambubioside, delphinidin γglucoside and cyanidin γ-glucoside (Mgaya Kilima *et al*. 2014). Due to its commercial potential as a natural food and coloring agent roselle has drawn interest of manufacturers of food, beverage and pharmaceutical (Eslaminejad and Zakaria, 2011). Roselle seeds are used to produce biodiesel and also used as animal feed as the seeds contain 17.8 to 21% nonedible oil (Ahmed, 2010) and 20% protein (Ahmed and Nour, 2011).

Nutritional Value of Roselle

Roselle contains high amount of vitamin C and anthocyanins which makes it unique for nutritional characteristics. Nutritionists have reported that roselle calyces are high in Ca, K, Mg, Na, niacin, riboflavin and iron. Nutritional composition of 100 g fresh roselle calyces, leaves and seeds are shown in Table 1.

Table 1: Nutritional composition of 100 g fresh roselle calyces, leaves and seeds

Constituents	Fresh Calyces	Fresh Leaves	Seeds
Moisture	9.20 g	85.60 g	8.2 g
Protein	1.15 g	3.30 g	19.6 g
Fat	2.61 g	0.30 g	16.0 g
Fiber	12.00 g	10.00 g	11.0 g
Energy	44 kcal	43 kcal	411 kcal
Ash	6.90 g	1.00 g	7.00 g
Calcium	12.63 mg	213.00 mg	356 mg
Phosphorus	273.20 mg	93.00 mg	462 mg
Iron	8.98 mg	4.80 mg	4.2 mg
Carotene	0.03 mg	4135 µg	-
Thiamine	0.12 mg	0.2 mg	0.1 mg
Riboflavin	0.28 mg	0.45 mg	0.15 mg
Niacin	3.77 mg	1.2 mg	1.4 mg
Ascorbic Acid	6.70 mg	54 mg	Trace
Carbohydrates	10.00 g	9.20 g	51.3 g

Source: Islam *et al*. (2016)

MATERIALS AND METHODS

Materials Procurement

The fresh and dried roselle, sugar and salt for the production and formulation of jam were purchased from fruit market in Makurdi and were taken to the Department of Food Science and Technology, Joseph Sarwuan Tarka University, Makurdi for further processing.

Sample Preparation

The modified methods of Ghodke and Mane (2017) was used for the production of fresh and dried roselle jam. Freshly harvested roselle were washed with plenty of water. These were crushed using water through grinder to obtain pulp. Then, sugar was added to pulp and boiling was carried out till the end point was obtained which was judged when product obtained 68.5°Brix TSS. The finished product was immediately filled into sterilized glass bottle of 500 ml capacity. The product was allowed to cool and bottles were sealed air tight.

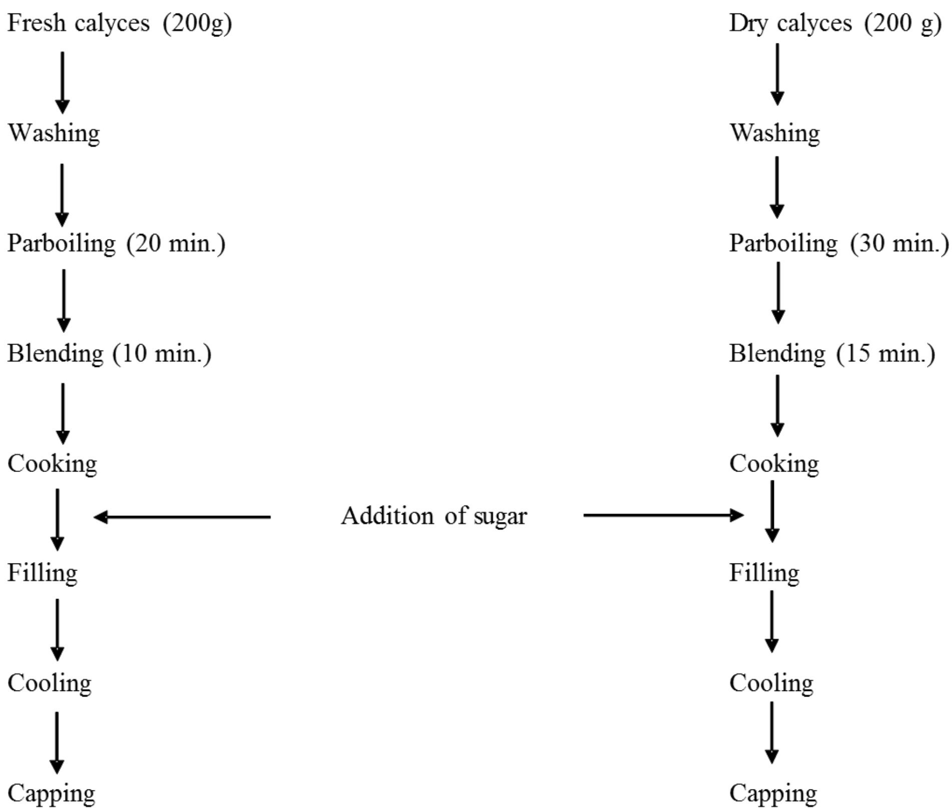

Figure 3: Preparation of Fresh and Dried Roselle Jam
Source: Ashaye and Adeleke (2009)

Physico-chemical Properties of Jam Produce from Fresh and Dried Roselle Calyces
Determination of Vitamins C (ascorbic acid) of Fresh and Dried Roselle Calyces:
Vitamins C (ascorbic acid) was determined using the AOAC method with slight modifications (2012). Approximately 10 g of each sample was weighed into a 250 mL flask, followed by 50 mL of acetone. The mix was left for 2 h with occasional shaking and then filtered. The filtrate was measured, and an equal volume of saturated NaCl was added to wash the filtrate. The resulting mixture was shaken and transferred into a separating funnel to remove the layer of the extract. The supernatant was washed again with an equal volume of 100% potassium trioxocarbonate (IV) (K_2 CO_3), which was separated and washed with 10–20 mL of distilled water. After separating water carotene and extracting carotenoid, the absorbance was defined by a spectrophotometer at 326 nm wavelength using 50:50 acetones and low boiling petroleum ether solution as the blank.

Determination of pH of Fresh and Dried Roselle Calyces:
The pH was determined using the AOAC method with slight modifications (2012). It required the use of a pH meter, calibrated using standard buffer solutions. The electrode was rinsed with distilled water and then dipped into 5 g of the sample, which was dissolved in 50 mL of water.

Determination of Total Titratable Acidity of Fresh and Dried Roselle Calyces:
The total titratable acid was determined using the AOAC (2012) method with slight modifications. Ten grams of the sample was dissolved in 100 mL of distilled water. Thereafter, 10 mL of the

supernatant was titrated with 0.1N NaOH and phenolphthalein as an indicator. The total titratable acidity (%) was defined based on citric acid according to the equation below:
Citric acid = volume of NaOH used × 0.1N × × mL equivalent of citric acid × 100

Determination of moisture Content of Fresh and Dried Roselle Calyces:
The moisture content was determined by hot air oven method as described by AOAC (2012). Empty crucible was weighed and 2g of the sample was transferred into the crucible. This was taken into the hot air oven and dried for 24 hours at 100°C. The loss in weight was regarded as moisture content and expressed as:

$$\% \, Moisture = \frac{W2 - W1}{W} \, X \, 100$$

Where:
W_2=Weight of the crucible and dry sample;
W_1=Weight of empty crucible
W=Weight of the sample

Determination of Ash Content of Fresh and Dried Roselle Calyces:
The ash content was determined by the method described by AOAC (2012). Two (2) grams of sample was weighed into an ashing dish which had been pre-heated, cooled in a desiccator and weighed soon after reaching room temperature. The crucible and content were then heated in a muffle furnace at 550°C for 6-7 h. The dish was cooled in a desiccator and weighed soon after reaching room temperature. The total ash was calculated as percentage of the original sample weight.

$$\% \, Ash = \frac{(W3 - W1)}{(W2 - W1)} \, x \, 10$$

Where: W1 = Weight of empty crucible, W_2 = Weight of crucible + sample before ashing,
W_3 = Weight of crucible + content after ashing.

Sensory Evaluation of Jam Formulated from Fresh and Dried Roselle Calyces
The jam samples formulated were subjected to sensory evaluation for the attributes of colour, flavour, taste, texture and overall acceptability. A semi-trained fifteen-member panel were used comprising of under graduate students, and scores were allocated by the panelists based on a 9-point Hedonic scale, ranging from 1 (dislike extremely) to 9 (like extremely). The data collected were subjected to statistical analysis to determine possible differences among samples.

Statistical Analysis
The data generated was subjected to T-test statistics and significance difference was tested at 5 % level of probability.

RESULTS AND DISCUSSION

Physico-chemical Properties of Jam Produced from Fresh and Dried Roselle Calyces
The result of the physiochemical properties of jam produced from fresh and dried roselle calyces is shown in Table 3. The ash contents were between 0.77 % and 0.71%, moisture content (32.71%

and 29.26%), TTA (1.73% and 1.82%), pH (2.87% and 3.67%), and Vitamin C content (27. 79% and 14.49%) for sample A and B respectively.

Sample A had the highest ash content of 0.77% while sample B had the least ash content of 0.71% respectively. All the results do not differ (p>0.05) significantly. The ash content of food material could be used as an index of mineral constituents of the food because ash is the inorganic residue remaining after water and organic matter have been removed by heating in the presence of an oxidizing agent (Sani *et al.,* 2008; Ukegbu and Anyika, 2012). Hence, the sample with high percentage ash content as noticed in the study is expected to have high concentrations of various mineral elements. Lower ash contents observed in this study may be due to increased activities of microorganism utilizing the minerals for growth (Ashaye *et al*., 2006).

The moisture content of the jams is presented in Table 3. Sample A recorded moisture content of 32.71% while sample B had moisture content of 29.26% and were not significantly (p>0.05) different from one another. The high moisture content of the samples could be attributed to the greater water holding capacity of the jams. This is similar to the findings reported by Babatunde and Bello (2016) in their study on the comparative assessment of some physicochemical properties of roselle jams sold within Kaduna Metropolis, Nigeria.

The results of the TTA value of jam produced from fresh and dried roselle calyces showed no significant (p>0.05) differences. Sample B had the highest value of 1.82 g/ml while sample A had lowest TTA value of 1.73 g/ml. The ranged of TTA obtained in this study is similar to report by Ashaye and Adeleke (2009); Ghodke and Mane (2017). The higher TTA value reported for sample B may be due to the presence of acidophiles in the jam sample (Ashaye and Adeleke, 2009).

The pH value for jam produced from fresh and dried roselle calyces differed (p>0.05) significantly. The pH value obtained for fresh calyces was higher compared to jam produced from dried calyces. The observed pH values for jams from both fresh and dried roselle calyces were however but lower compared to 5.20 that was reported by Abu (2012). The pH in the present study was slightly lower than that of jackfruit (Eke-Ejiofor and Owuno, 2013) and pineapple jam (Hanan *et al*., 2012) which ranged from 4.8 to 6.3 in low calorie baladi rose petals jam. The pH of jam is an important factor to obtain optimum gel condition.

Vitamin C (ascorbic acid) is one of the major nutrients that are obtained mainly from fruits and fruits products. Apart from the sweet sensation and flavour, the nutritional point of view of fruits and fruits products should also be of importance to consumers. The vitamin C content ranged from 14.49 mg/100 g to 27.79 mg/100 g, there were significant (P<0.05) differences across the samples in which the highest vitamin C content was noticed in jam produced from fresh roselle calyces (27.79 mg/100 g). This is an indication that fresh roselle caylces is richer in ascorbic acid compare to dried calyces. However, the result obtained was higher compared to what was reported (27.06 mg/100 g) by Ajenifujah-Solebo and Aina (2011).

Vitamin C are some of the major non-enzymatic antioxidants in the body that produce health beneficial effects by scavenging free radicals (Xu *et al*., 2008). The application of prolonged heat treatments on fruits, such as in the case of jams, can lead to important losses of the beneficial properties of these fruits (Igual *et al*., 2011). Vitamin C functions as a water-soluble antioxidant, and it is also an effective antioxidant that readily scavenges reactive oxygen species (ROS) and reactive nitrogen species (RNS).

Table 3: Physicochemical Properties of Jam Produce from Fresh and Dried Roselle Calyces

SAMPLE	A	B	P-value
Ash	0.77±0.02	0.71±0.02	0.59
Moisture	32.71±1.87	29.26±0.74	0.20
TTA	1.73±0.21	1.82±0.06	0.22
pH	3.67±0. 01	2.87±0.06	0.02
Vitamin C	27.79±1.46	14.49±0.47	0.03

Values are means ± standard deviations of duplicate determinations. Means in same row with p-value less than 0.05 are significantly different. Key: A = Jam produced from fresh roselle calyces, B = Jam produced from dried roselle calyces

Sensory Properties of Jam Produced from Fresh and Dried Roselle Calyces

Data on the sensory properties of jam produce from fresh and dried roselle calyces are presented in Table 4. The sensory score for the appearance of the jam samples ranged from 7.93 to 8.47 with sample A as least preferred and sample B as most preferred with no significant ($P<0.05$) difference as shown in Table 4. Aroma and taste of the jam samples ranged from 7.53 to 7.73 and 7.07 to 7.73. Mouthfeel of the jam samples ranged from 7.73 to 7.80 for samples A and B respectively. Overall acceptability of the jam samples ranged from 7.60 to 8.07 and sample B was rated most preferred while sample A was least preferred. The recorded sensory scores are an indication that both fresh and dried roselle calyces jam samples were highly acceptable by the consumers. Also, the fact that their overall acceptability is beyond 5.50 on a 9-point hedonic scales revealed that they were equally acceptable by the panelists. The high sensory values of these jams could be due to the color, flavor, and texture of these fruits which is transferred to the final products on processing. Ghodke and mane (2017) also reported the same trend for fresh calyces and guava jam blends in which fresh calyces jam recorded the best overall sensory acceptability due to the arrays of color and taste which this fruit supplies. Othman (2011) stated that fresh roselle calyces are an excellent source of vitamins and minerals and supply a range of sensory characteristics which enhances their eating attractiveness.

Table 4: Sensory Properties of Jam Produce from Fresh and Dried Roselle Calycess

SAMPLE	A	B	P-value
Appearance	7.93±0.88	8.47±0.83	0.10
Aroma	7.53±0.74	7.73±0.70	0.45
Taste	7.07±0.88	7.73±0.70	0.03
Mouthfeel	7.73±1.10	7.80±0.86	0.08
Overall acceptability	7.60±0.83	8.07±059	0.86

Values are means ± standard deviations of duplicate determinations. Means in same row with p-value greater than 0.05 are not significantly different. Key: A = Jam produced from fresh roselle calyces**,** B = Jam produced from dried roselle calyces

CONCLUSION AND RECOMMENDATIONS

Conclusions

1. Quality of jam produced from fresh and dried roselle calyces were evaluated. The result of the physicochemical properties of jams produced from fresh and dried roselle calyces indicated no significant ($P>0.05$) differences in ash, moisture and TTA except for Vitamin C where significant ($P<0.05$) difference was observed.
2. The result of the sensory attributes of jam produced from fresh and dried roselle calyces showed no significant ($P>0.05$) differences in their level of preferences and acceptability.

3. It was therefore deduced that Roselle jams prepared from either fresh or dried calyces are acceptable for consumption.

Recommendations

Based on the findings of this study, the following recommendations were made

1. that either fresh or dried roselle calyces can be used in the production jam due to their nutritional values.
2. it is however advised that roselle jam be processed from the fresh calyx so as to reduce the rate of Vitamin C loss.

REFERENCES

Adebawo, F. G., Naithani, V., Sadeghifar, H., Tilotta, D., Lucia, L. A., Jameel, H., & Ogunsanwo, O. Y. (201Morphological and interfacial properties of chemically-modified tropical hardwood. *RSC advances*, *6*(8), 6571-6576.

Adeyemi, L. C., & Ogazi, P. N. (2013). Utilisation of broken rice and cocoyam flour blends in the production of biscuits. *Nigerian Food Journal*, *33*(1), 8-11.

Afrin, S., Gasparrini, M., Forbes-Hernandez, T. Y., Reboredo-Rodriguez, P., Mezzetti, B., Varela-López, A., ... & Battino, M. (2016). Promising health benefits of the strawberry: a focus on clinical studies. *Journal of agricultural and food chemistry*, *64*(22), 4435-4449.

Agte, V. and Gite, S. (2014). Evaluation of hepatoprotective potential of functional food formulations using in vitro and in vivo models of CCl4 radical induced toxicity. *IJIMS*, *1*, 6-13.

Aini, N., Prihananto, V., Sustriawan, B., Romadhon, D. and Ramadhan, R.N. (2019). The formulation of cheese analogue from sweet corn extract. Int J Food Sci, 2019: 8624835, doi: 10.1155/2019/8624835

Ajenifujah-Solebo, S.O., and Aina, J.O. (2011). Physico-chemical properties and sensory evaluation of jam made from black-plum fruit (Vitex doniana). Afr. J. Food, Agriculture, Nutr. Dev. 11:3. doi: 10.4314/ajfand.v11i3.66629.

Akhtar, R., Sadiqa, M., Tipu, M. Y., Khan, M. R., Aslam, A., Ijaz, M. & Zahid, B. (2018). Use of molecular probes for presumptive diagnosis of tuberculosis associated with Mycobacterium tuberculosis and Mycobacterium bovis infection in antelopes in Pakistan. *Bovis*, *53*(52.6), 470.

Akintunde, B.O., Tunde, T.Y. and Adejumo, A.O. (2014). Development of a manual fruit juice extra to, NIFOL, 22, 178-182

Alander, J. (2004). Shea butter-a multifunctional ingredient for food and cosmetics. *Lipid technology*, *16*(9), 202-205.

Anderson, E. S., Winett, R. A., Wojcik, J. R., & Williams, D. M. (2010). Social cognitive mediators of change in a group randomized nutrition and physical activity intervention: social support, self-efficacy, outcome expectations and self-regulation in the guide-to-health trial. *Journal of health psychology*, *15*(1), 21-32.

Annema, N., Heyworth, J. S., McNaughton, S. A., Iacopetta, B., & Fritschi, L. (2011). Fruit and vegetable consumption and the risk of proximal colon, distal colon, and rectal cancers in a case-control study in Western Australia. *Journal of the American dietetic association*, *111*(10), 1479-1490.

Anwar, F. Tasnim, Jr. Hossain, M. Kamal, M. Hossain, D. Lopa and Formuzul, K. Haque. (2010). Quality Assessment of Industrially Processed Fruit Juices Available in Dhaka City, Bandladesh Council of Scientific and Industrial Research, Dhanmondi, Dhaka, Bangladesh, 1205, pp 431- 438.

AOAC. Official Methods of Analysis (20thed.) (2012). Association of Official Analytical Chemists, Washington DC, USA

Ashaye, A. & Adeleke, J. (2019). Functional foods and lifestyle approaches for diabetes prevention and management. *Nutrients*, *9*(12), 1310.

Asoegwu, C. R. (2019). A review on the role of biofertilizers in reducing soil pollution and increasing soil nutrients. *Himalayan Journal of Agriculture*, *1*, 34-38.

Babalola, O. O., Mamphogoro, T. P. & Aiyegoro, O. A. (2011). Sustainable management strategies for bacterial wilt of sweet peppers (Capsicum annuum) and other Solanaceous crops. *Journal of Applied Microbiology*, *129*(3), 496-508.

Bascuas S, Espert M, Llorca E, Quiles A, Salvador A et al., 2021. Structural and sensory studies on chocolate spreads with hydrocolloid-based oleogels as a fat alternative. LWT, 135:110-228, doi: 10.1016/j.lwt.2020.110228

Beeren, I., Goeij, L. D., Dandis, R., Vidra, N., Zutphen, M. V., Witjes, J. A. & Vrieling, A. (2019). Limited Changes in Lifestyle Behaviours after Non-Muscle Invasive Bladder Cancer Diagnosis. *Cancers*, *14*(4), 960.

Berolzheimer, M. K. (2019). *Nutritional composition, phytochemical and antioxidant activity of two variety (light red and dark red) roselle (Hibiscus sabdariffa L.) JAM* (Doctoral dissertation, Chattogram Veterinary & Animal Sciences University, Khulshi-Chattogram).

Bishnoi, M., Jain, A., Hurkat, P., & Jain, S. K. (2016). Chondroitin sulphate: a focus on osteoarthritis. *Glycoconjugate journal*, *33*(5), 693-705.

Biswas, A. (2021). A Review paper on Fruit Jam products. Agricultural and Food Processing Department, Indian Institute of Technology, Kharagpur, IJARIIE- Vol-7 Issue-5: 2395-4396,

Bloomfield, D., (1998). With Brooke We Did Chemistry…. *Political Dialogue in Northern Ireland: The Brooke Initiative, 1989–92*, 166-200.

Carvalho, P. G. B., Machado, C. M. M., Moretti, C. L., & Fonseca, M. E. N. (2016). Vegetable crops as functional food. Horticultura Brasileira, 24, 397-404. http://dx.doi.org/10.1590/S0102-05362006000400001.

Celik, F., & Topcu, F. (2006). Nutritional risk factors for the development of chronic obstructive pulmonary disease (COPD) in male smokers. *Clinical Nutrition*, *25*(6), 955-961.

Cerníková, M., Salek, R.N., Kozáèková, D. and Buòka, F, (2018). The effect of different agitations and temperature maintaining on viscoelastic properties of full-fat processed cheese spreads. LWT, 89: 244-247, doi: 10.1016/j.lwt.2017.10.054

Chaudhary, R., Yadav, M. and Singh, D.B. (2017). Changes in physicochemical characteristics of karonda jelly during the storage period. Plant archives; 792): 885-887.

Davrieux, F., Allal, F., Piombo, G., Kelly, B., Okulo, J. B., Thiam, M., ... & Bouvet, J. M. (2010). Near infrared spectroscopy for high-throughput characterization of shea tree (Vitellaria paradoxa) nut fat profiles. *Journal of Agricultural and food Chemistry*, *58*(13), 7811-7819.

Dosil-Díaz, C., Facal, D., & Mouriz-Corbelle, R. (2018). Behavioral interventions in long-term care facilities during the COVID-19 pandemic: A case study. *Geriatrics*, *7*(1), 1.

Dostalova, J. (2013). Low fat spread in encyclopaedia of food science and nutrition.

Eke-Ejiofor, J., & Owuno, F. (2013). The physico-chemical and sensory properties of jackfruit (Artocarpus heterophilus) jam. *International Journal of Nutrition and Food Sciences*, *2*(3), 149-152.

Elsayaid, E. E. (2008). Using Roselle as Natural Colorant in Jam Making. M.Sc. in Food Scince and Technology, Dept. of Food Technology, Khartoum University, Khartoum, Sudan.

Erinle, K. O. (2019). Soil water availability influences P pools in the detritusphere of crop residues with different C/P ratios. *Journal of Soil Science and Plant Nutrition*, *19*, 771-779.

Food and Agriculture Organization of the United Nations – FAO. (2020). Transforming food systems for affordable healthy diets food security and nutrition in the world. Rome: FAO.

FSSAI (2012). Manual of methods of analysis of foods- Fruit and vegetable products. Food Safety and Standard Authority of India, ministry of Health and Family Welfare, New Delhi, India.

Gakowska, D., Fortuna, T., Zago´rska, W.P., (2010). Physicochemical quality of selected strawberry jams with fructose. Potravinarstvo 4.

Ghodke, S., & Mane, K. (2017). Processing of roselle (Hibiscus sabdariffa) calyces for value addition. *Food Science*, *8*(2), 303-309.

Girdhari-Lal; Siddappa, G. S. and Tandon, G. L. (1986). Preservation of Fruits and Vegetable. Published by Indian Council of Agricultural Research, India.

Habauzit, V., Milenkovic, D., & Morand, C. (2013). Vascular protective effects of fruit polyphenols. In *Polyphenols in human health and disease* (pp. 875-893). Academic Press.

Hanan, F., Jawaid, M., Paridah, M. T., & Naveen, J. (2012). Characterization of hybrid oil palm empty fruit bunch/woven Kenaf fabric-reinforced epoxy composites. *Polymers*, *12*(9), 2052.

Hui, Y. (2006). Hand Book of Fruits and Fruit Processing. Published by Black Well. USA.

Ifesan, B. O. (2020). Quality assessment and consumer acceptability of cookies from blends of wheat flour and pumpkin (Cucurbita spp.) seed flour. *Himalayan Journal of Applied Medical Sciences and Research*, *1*(1).

Igual, M., Contreras, C., Martı´nez-Navarrete, N. (2011). Non-conventional techniques to obtain grapefruit jam. Innov. Food Sci. Emerg. Technol. 11, 335–341.

Igual, M., Garcı´a–Martı´nez, E., Camacho, M.M., Martı´nezNavarrete, N., (2013). Jam processing and storage effects on bcarotene and flavonoids content in grapefruit. J. Funct. Foods 5, 736–744.

Jawaheer, B., Goburdhun, D., Ruggoo, A., (2013). Effect of processing and storage of guava into jam and juice on the ascorbic acid content. Plant Food Hum. Nutr. 58, 1–12.

Johnson, G. (2019). An apple a day, and other myths. The New York Times. Retrieved from http://www.nytimes.com/2014/04/22/science/an-apple-a-day-and-other-myths.html?_r=0.

Kabat, G. C., Jones, J. G., Olson, N., Negassa, A., Duggan, C., Ginsberg, M. & Rohan, T. E. (2010). A multi-center prospective cohort study of benign breast disease and risk of subsequent breast cancer. *Cancer Causes & Control*, *21*, 821-828.

Kataria, S.H., Shah, A.S., Bilal, M., Khan, A., Ali, M.U., Ran,i S. (2016). Comparative studies on the shelf stability of different types of apple jams. Pak J Food Sci 2015; 25: 37-42.

Kaur, S. and Kapoor, V. (2011). Monitoring of incidence, severity, and causality of adverse drug reactions in hospitalized patients with cardiovascular disease. *Indian journal of pharmacology*, *43*(1).

Khan, S.H., Shah, A.S., Bilal, M., Khan, A., Ali, M.U., Ran,i S. (2015). Comparative studies on the shelf stability of different types of apple jams. Pak J Food Sci 2015; 25: 37-42.

Kopjar, M. and Sajple, M. (2009). Strawberry Jams: influence of different pectins on colour and textural proprieties. Journal of Food Science. (27): 20- 28.

Kumar, A., Deen, B. (2017). Studies on preparation and storage of jelly from wood apple (Limonia acidissima L.) fruits, Journal of Pharmacognosy and Phytochemistry 2017; 6(6): 224-229.

Lara, D., Weiner, A., Lorenzo-Vivas, E., Zaretsky, I., Jaitin, D. A., David, E. & Amit, I. (2014). Chromatin state dynamics during blood formation. *science*, *345*(6199), 943-949.

Lattimer, J. M., & Haub, M. D. (2010). Effects of dietary fiber and its components on metabolic health. *Nutrients*, *2*(12), 1266-1289.

Lawrence, B. D. and Franklin, J. D. (2015). Challenging the norm: further psychometric investigation of the neck disability index. *The Spine Journal*, *15*(11), 2440-2445.

Madhav, A. and Pushpalatha, P.B. (2012). Quality degradation of jellies prepared using pectin extracted from fruit wastes. J. Trop. Agric. 40, 31–34.

Marın, S., Sanchis, V. Ramos, A. J. Vinas, I. and Magan, N. (2018). "Environmental factors, in vitro interactions, and niche overlap between Fusarium monoliforme, F. proliferatum, and F. graminearum, Aspergillus and Penicillium species from maize grain," Mycological Research, vol. 102, no. 7, pp. 831–837.

Martin, M. C., Dabat-Blondeau, C., Unger, M., Sedlmair, J., Parkinson, D. Y., Bechtel, H. A., ... & Hirschmugl, C. J. (2013). 3D spectral imaging with synchrotron Fourier transforms infrared spectro-microtomography. *nature methods*, *10*(9), 861-864.

Mendonca, C.R., Zambiazi, R.C., Gularte, M.A. and Granada, G.G. (2015). Caracterısticassensoriais de compotas de pessego light elaboradas com sucralose e acesulfame-k. Ciencia e Tecnologia de Alimentos; 25: 401–407.

Milivojevic, N., Stamenkovic, I., & Schofield, N. (2010, March). Power and energy analysis of commercial small wind turbine systems. In *2010 IEEE International Conference on Industrial Technology* (pp. 1739-1744). IEEE.

Mishra, K., Ojha, H. and Chaudhury, N.B. (2012). Estimation of antiradical properties of antioxidants using DPPH assay: A critical review and results. Food Chemistry. 130: 1036-1043.

Miyamoto, S., Yoshimoto, T., Hashimoto, N., Okada, Y., Tsuji, I., Tominaga, T.& Tsutsumi, Y. (2014). Effects of extracranial–intracranial bypass for patients with hemorrhagic moyamoya disease: results of the Japan Adult Moyamoya Trial. *Stroke*, *45*(5), 1415-1421.

New, M. (2011). Four degrees and beyond: the potential for a global temperature increase of four degrees and its implications. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *369*(1934), 6-19.

Nindo, C.I., Tang. J., Powers, J.R. and Singh, P. (2015). Viscosity of blueberry and raspberry juices for processing applications. Journal of Food Engineering, 69(3), 343-350. https:// doi.org/10.1016/j.jfoodeng.2004.08.025

Nindo, C.I., Tang. J., Powers, J.R. and Singh, P. (2015). Viscosity of blueberry and raspberry juices for processing applications. Journal of Food Engineering, 69(3), 343-350. https:// doi.org/10.1016/j.jfoodeng.2004.08.025

Olajide, O., Aminu, M., Randawa, A. J., & Adejo, D. S. (2014). Sero-prevalence of IgM antibody to Rubella Virus in pregnant women in Zaria, Nigeria. *Archives of Medical and Biomedical Research*, *1*(4), 129-138.

Olubunmi, I. P., Olajumoke, A. A., Bamidele, J. A., & Omolara, O. F. (2013). Phytochemical composition and in vitro antioxidant activity of golden melon (Cucumis melo L.) seeds for functional food application. *Int. J. Biochem. Res. & Rev*, *25*(2), 1-13.

Orrego, C. E., Salgado, N., & Botero, C. A. (2014). Developments and trends in fruit bar production and characterization. Critical Reviews in Food Science and Nutrition, 54(1), 84-97. http://dx.doi.org/10.10 80/10408398.2011.571798. PMid:24188234.

Othman, Z. (2011). Influence of the Settleability Parameters for Palm Oil Mill Effluent (POME) Pretreatment by Using *Moringa Oleifera* Seeds as an Environmentally Friendly Coagulant. *Journal of Materials Science and Engineering*, *5*(3), 332-340.

Oyeniran, O. H., Ademiluyi, A. O., & Oboh, G. (2018). African mistletoe (Tapinanthus bangwensis Lor.) infestation improves the phenolic constituents, antioxidative and antidiabetic effects of almond (Terminalia catappa Linn.) host leaf in sucrose-rich diet-induced diabetic-like phenotypes in fruit fly (Drosophila melanogaster Meigen). *Food Frontiers*, *2*(1), 77-90.

Park, S. Y., Ollberding, N. J., Woolcott, C. G., Wilkens, L. R., Henderson, B. E., & Kolonel, L. N. (2013). Fruit and vegetable intakes are associated with lower risk of bladder cancer among women in the Multiethnic Cohort Study. *The Journal of nutrition*, *143*(8), 1283-1292.

Patange, G. (2016). Energy efficiency in small and medium scale foundry industry. *Metalurgija*, *55*(2), 257-259.

Payne, K. F. B., Wharrad, H., & Watts, K. (2012). Smartphone and medical related App use among medical students and junior doctors in the United Kingdom (UK): a regional survey. *BMC medical informatics and decision making*, *12*, 1-11.

Rao, K. J., & Devaraja, H. C. (2021). Recent developments in safe production of dairy spreads. *Indian J Anim Health*, *60*(2), 52-63.

Ros, M. A., García-Arellano, A., Toledo, E., Salas-Salvado, J., Buil-Cosiales, P., Corella, D., ... & PREDIMED Study Investigators. (2012). A 14-item Mediterranean diet assessment tool and obesity indexes among high-risk subjects: the PREDIMED trial.

S. Basu and U. S. Shivhare, (2010). "Rheological, textural, microstructural and sensory properties of mango jam," Journal of Food Engineering, vol. 100, no. 2, pp. 357–365.

Salehi, F. (2020). Recent applications of powdered fruits and vegetables as novel ingredients in biscuits: a review. Nutrire, 45(1), 1. http:// dx.doi.org/10.1186/s41110-019-0103-8.

Sandrou, D. K. and Arvanitoyannis, I. S. (2010). "Low-fat/calorie foods: current state and perspectives," Critical Reviews in Food Science and Nutrition, vol. 40, no. 5, pp. 427–447.

Sharma, V. K., Yngard, R. A., & Lin, Y. (2009). Silver nanoparticles: green synthesis and their antimicrobial activities. *Advances in colloid and interface science*, *145*(1-2), 83-96.

Shen, D. W., Pouliot, L. M., Hall, M. D., & Gottesman, M. M. (2012). Cisplatin resistance: a cellular self-defense mechanism resulting from multiple epigenetic and genetic changes. *Pharmacological reviews*, *64*(3), 706-721.

Sindumathi, G. and Amutha S., (2014). Processing and quality evaluation of coconut-based jam. IOSR J. Environ. Sci. Toxicol. Food Technol., 8(1), 10-14.

Slavin, J. L., & Lloyd, B. (2012). Health benefits of fruits and vegetables. Advances in Nutrition, 3(4), 506-516. http://dx.doi.org/10.3945/ an.112.002154. PMid:22797986.

Southon, W. (2010). Metal–organic frameworks with exceptionally high methane uptake: where and how is methane stored? *Chemistry–A European Journal*, *16*(17), 5205-5214.

Sun-Waterhouse, D., Nair, S., Wibisono, R., Wadhwa, S., Massarotto, C., Hedderley, D., Zhou, J., Jaeger, S. R., & Corrigan, V. (2010). Insights into smoothies with high levels of fiber and polyphenols: factors influencing chemical, rheological, and sensory properties. World Academy of Science, Engineering and Technology, 65, 276-285.

Supit, B., Jones, J. & Pattama, P. (2018). Components of national stability expectation in responding public management, a structural equation analysis. *Polish Journal of Management Studies*, *19*(1), 421-432.

Von Braun, K., Boyajian, T. S., van Belle, G. T., Kane, S. R., Jones, J., Farrington, C., ... & Sturmann, L. (2014). Stellar diameters and temperatures–V. 11 newly characterized exoplanet host stars. *Monthly Notices of the Royal Astronomical Society*, *438*(3), 2413-2425.

Wallace, T. C., Bailey, R. L., Blumberg, J. D., Burton-Freeman, B., Chen, C.-Y., Crowe-White, K. M., Drewnowski, A., Hooshmand, S., Johnson, E., Lewis, R., Murray, R., Shapses, S. A., & Wang, D. D. (2020). Fruits, vegetables, and health: a comprehensive narrative, umbrella review of the science and recommendations for enhanced public policy to improve intake. Critical Reviews in Food Science and Nutrition, 60(13), 2174-2211

Ward, K. A. (2000). Canning and Preserving for Dummies. 2nd ed., Published by John Willey and Sons, New York, USA.

WHO/FAO. (2013). Diet, nutrition and the prevention of chronic diseases. Report of a Joint WHO/FAO Expert Consultation, World Health Organization, Geneva, Switzerland

Wiley, C. (2019). Consumers say they want to eat healthy. Food Industry Executive. Retrieved from https://foodindustryexecutive.com/2019/03/ consumers-say-they-want-to-eat-healthy/.

Williamson, G. (2016). The role of polyphenols in modern nutrition. *Nutrition bulletin*, *42*(3), 226-235.

Xu, X., Gammon, M. D., Wetmur, J. G., Bradshaw, P. T., Teitelbaum, S. L., Neugut, A. I., ... & Chen, J. (2008). B-vitamin intake, one-carbon metabolism, and survival in a population-based study of women with breast cancer. *Cancer Epidemiology Biomarkers & Prevention*, *17*(8), 2109-2116.

Yahia, E. M., García-Solís, P., & Celis, M. E. M. (2019). Contribution of fruits and vegetables to human nutrition and health. In E. M. Yahia (Ed.), Postharvest physiology and biochemistry of fruits and vegetables (Chap. 2, pp. 19-45). Duxford: Woodhead Publishing. http://dx.doi.org/10.1016/B978-0-12-813278-4.00002-6

Yıldız, S., Baştürk, F., & Boz, İ. T. (2014). The effect of leadership and innovativeness on business performance. *Procedia-Social and Behavioral Sciences*, *150*, 785-793.