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Assessment of the Suitability of Using Jakjak Fruits (*Azanza garcheana*) for Production of Lokum Candy

إمكانية استخدام ثمار الجقجق في صناعة حلوى الحلقوم

A Dissertation Submitted to Sudan University of Science and Technology in Partial Fulfillment for the Requirements of B.Sc. (Honours) Degree in Food Science and Technology

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الآية

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قال تعالى:

فَلْيَنظُرِ الْإِنسَانُ إِلَى طَعَامِهِ ﴿٢٤﴾ أَنَّا صَبَبْنَا الْمَاءَ صَبًّا ﴿٢٥﴾ ثُمَّ شَقَقْنَا الْأَرْضَ شَقًّا ﴿٢٦﴾ فَأَنبَتْنَا فِيهَا حَبًّا ﴿٢٧﴾ وَعِنَبًا وَقَضْبًا ﴿٢٨﴾ وَزَيْتُونًا وَنَخْلًا ﴿٢٩﴾ وَحَدَائِقَ غُلْبًا ﴿٣٠﴾ وَفَاكِهَةً وَأَبًّا ﴿٣١﴾ مَّتَاعًا لَّكُمْ وَلِأَنْعَامِكُمْ ﴿٣٢﴾

صدق الله العظيم

سورة عبس الآيات (24-32)

DEDICATION

To our Family,

Teachers

And Friends …

With respect.

ACKNOWLEDGEMENTS

Prayers and thanks to ALLAH who gave us good health and support to accomplish this study.

Grateful thanks to my supervisor **Dr. Salma Elghali Mustafa** who was too patient with us during this study, alsofor his unlimited assistance and guidance which made this study worth full.

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Abstract

The main goal of this research was to assess the suitability of utilization of Jakjak (*Azanzagarckeana*) fruits as raw material for production of lokum with high nutritional value in order to improve industrial uses and facilitate the domestic consumption of these fruits in Sudan. The results indicated that Jakjak fruits contain high percentages of dry matter (84.92%), total carbohydrates (87.56%), crude fiber (36.00%), total sugars (61.39%), and low percentages of protein (6.65%) and fat (1.81%), on dry matter basis. Also, the fruits was found to contain high percentages of calcium (29.3), sodium (05.2), magnesium (21.8), phosphorous (96.5), potassium (186.0), iron (04.0) and low percentages of manganese (0.43), and cupper (0.43) mg/100g dry matter (DM). Also, the study indicated that the fruits could be easily extracted after soaking overnight (16 hr) in distilled water (1:4,1:6 and 1:8) at room temperature. The extract (1:4) was found to contain appreciable amounts of total soluble solids (12.20%), while, the hydrogen ions concentration and the total yield of the extract were about 5.43and 41.55%, respectively. Jakjak Lokum was processed according to the chemical and physical characteristics of Jakjak fruits extract, and it was found to contain high energy value (308.2Kcal/100gm), and crude fibre (0.64%). The results for hydrogen ions concentration and titreable acidity of Jakjak lokum was 4.95 and (0.46%) respectively . Finally, the sensory evaluation results verified the quality of Jakjak lokum samples especially those produced with Jakjak juice with the ratio 1:4.

ملخص الدراسة

الهدف الأساسي لهذا البحث هو معرفة مدي امكانية استخدام ثمار الجقجق كمادة خام لإنتاج حلوى حلقوم ذات قيمة غذائية عالية لتطوير الاستغلال الصناعي وتسهيل طريقة الإستهلاك الغذائي لهذه الثمار في السودان.

ولقد أوضحت نتائج الدراسة أن ثمار الجقجق تحتوي على نسب عالية من المادة الجافة (84.92%)، الكربوهيدرات الكلية (% 87.56)، الألياف الخام (% 36.00)، السكريات الكلية (% 61.39) ونسب قليلة من البروتين (% 6.65) و الدهون (1.81%) على أساس الوزن الجاف. كما تحتوى الثمرة أيضا على نسب عالية من الكالسيوم (2.93) الصوديوم (5.2)، المغنزيوم (21.8)، البوتاسيوم (186.0) والحديد (0.40) ونسب اقل من عنصري المنجنيز (0.43) والنحاس (0.43)، ملجم لكل 100 جرام من المادة الجافة.

كذلك أظهرت الدراسة سهولة إستخلاص ثمار الجقجق بعد غمرها في ماء مقطر(1:4و1:6 و 1:8) لمدة 16ساعة في درجة حرارة الغرفة. ولقد إحتوى المستخلص (1:4) على نسبة عالية من المواد الصلبة الذائبة (12.20٪)، بينما كان تركيز أيون الهيدروجين والعائد الكلي للمستخلص الي 5.43 و41.55%، على التوالي .

وبعد ذلك تم تصنيع حلوى حلقوم الجقجق بناءً على الخواص الكيميائية والفيزيائية لمستخلص الثمار، حيث تميزت بإرتفاع قيمة الطاقة (308.2 كيلوكالوري/100جم) والألياف الخام (0.64%).

كما كانت نتائج التحليل من حيث تركيز ايون الهيدروجين ونسبة الحموضة التنقيطية لحلوي حلقوم الجقجق 4.95 و0.46% علي التوالي .وأخيرا أكدت نتائج التقييم الحسي الجودة العالية لحلوي حلقوم المصنعة من التركيز 1:4 لعصير ثمار الجقجق .

CHAPTER ONE

1-INTRODUCTION

Jakjak tree is one of the valuable plant species that grows naturally in Sudan, its scientific name is *Azanza garckenea*. It is largely spread in arid area such as sand and near mountain, especially in savanna plantation area at the Southern Darfur and Kordofan (Salih *et al.,* 2012). In Africa, Jakjak tree (*A.garckenea*) dry fruit may be cooked and eaten in large quantities during famine and peak farming periods. The ripe fruit carples are edible and have an energy value of 8-10 kj/g (Ruffo, 2002; Oraw, 2009).

Sweet mucilage comes out when chewed. The leaves make a relish or can be burned to produce salts. Also in Sudan Jakjak fruit may be eaten ripe (Chewing), fresh or is kept for large usage, because it consists of great proportion of sugar, vitamins and minerals. Also it is used as sauce before ripe, porridge (medida) juice preparation (Ruffo, 2002; Oraw, 2009; Salih*et al.,* 2012). Roots of Jakjak tree *(A. garckenea*) alone are boiled and drank to treat infertility and constipation, coughs and Chest pains (FAO, 1983). In Sudan, the fruit of Jakjak is used traditionally in Sudanese folk medicine for treatment of anemia (Ali, 2009).Therefore, efforts should be directed towards the industrial uses of Jakjak fruits in food processing in Sudan as the fruit is considered very rich in carbohydrates, crude fiber, minerals, and vitamins. The development of Jakjak candy with high caloric value will add nutritional value to the product and facilitate their consumption.

Objectives

The objectives of this research can be summarized under the following:

1. To study the nutritional value of Jakjak fruits.
2. To study the suitability of Jakjak fruits for candy production.
3. To find out the maximum processing conditions for Jakjak candy production.
4. To evaluate the chemical, physico-chemical and organoleptic characteristics of the end product.

CHAPTER TWO

LITERATURE REVIEW

2.1 Jakjak Tree

2.1.1 Taxonomy and Nomenclature

Jakjak tree is taxonomically belongs to the genus (Thespeia) which belong to family Malavaceae and kingdom Planate. Also, the species has been classified under different synonymous. The species*garckenea _Shantziagarckenea.* Also it has different local names in different languages and countries. For example the name of the tree in Arabic “Jakjak" while in English "Azanza" tree hibiscus, snot apple quarters and wild hibiscus African chewing gum (Elamin,1990 and Krog, 2003).

2.1.2 Botanical description

Jakjak tree is deciduous shrub or tree reaching about 2-20 meter in height with spreading tree and irregular crown. It sbark is rough and dark grey, with longitudinally fissured. While, the branches covered with dense stellate tementose hairs, later glbrous. While the leaves contain 3-5 lobed sometimes 7 lobes about 15 cm cross, apex of entire, rough usually (Elamin, 1990). The flowers are solitary on the axils of the single, yellow, turning red or organ, peralsover lap do not open (Ruffo *et al*, 2002). The seeds are obovoid, compressed, covered with shorb rusty- brown hairs. The fruit are spherical and woody, 2-5 cm to 4 cm in diameter long with short hairs. The fruit are divided into 4-5 sections. They are yellowish to brownish green and hairy when mature and tardily. (Elamin, 1990; Ruffo *et al*, 2002; Tshwenyane and Mojeremane, 2004)

2.1.3 Phenology and reproductive biology

White (1962) observed that in Zambia, A. garckenea flowers between November and January, whit fruit ripening occurs in April and August (Lingaipe) observed that in Zambia fruit ripening takes place between July and September. However, the species occasionally are flowering in August in western Tanzania (FAO, 1983). In Sudan, the flowering time beings in October and January while the fruiting starts in April to August (Elamin, 1990).

2.1.4 Ecology and distribution

Jakjak trees are found in Bostwana, Kenya, Malawi, Mozambique, Namibia, South Africa, Sudan, Tanzania, Zombia, Zimbabwe (Orwa *et al*., 2009). In Sudan Jakjak tree (*Azanzagarckenea* is distributed throughout the different vegetation zones from arid-semiarid region to the savanna and mountainous areas. The species occurs on the south Darfur (Jabl Mara Gola) mountain area, Kordofan (Nub amts, JablDaier), Bahr Elchazal and upper Nile (Elamin, 1990 and Salih *et al*., 2012). In general Jakjak tree grows naturally in wooded grasslands, open woodlands and thickets on high rainfall savavna, sometimes associated with hilly ground and near water (Elamin, 1990 ;Orwa *et al*., 2009).

2.1.5 Biophysical limits

Jakjak species can easily grow in the Altitude ranging from 0-1900 m, mean annual rainfall 250-500 mm. in hight yellow- brown to reddish- yellow gritty, sandy clay loams soil and often grows on black to dark grey and brown clay soil (Orwa *et al*., 2009).

2.1.6 Propagation and management

A. garckenea regenerates naturally from seed coppice and suckers filed observation have showed that on ripening the fruit splits releasing the seed germinates readily, especially when condition and favorable coppice shoots are produced on felling of tree. The root suckers are produced after wounding of the root e.g cultivation, fire, and trampling by animals etc. The stocking of *A. garckenea* in its natural habitat is being limited by of the young seed lings and saplings. The artificial regeneration there have been no efforts to regenerate the species artificially, however because of the good germination of seed potted seeding could b raised in the nursery and planted out in filed. Alternatively, direct sowing could be a feasible technique. The species is a light demander, thus the planting site should be subjected to partial cleaning before planting out. Moreover, intensive weeding would be necessary during the first few years after planting out (FAO, 1983). The seed storage behavior is orthodox there is loss viability within 6 months. Natural regeneration is better than raising seedlings fairly fast growing light demanding, coppicing (Ruffo *et al.*, 2002).

2.1.7 Diseases and pester

The tree gets infested with leaf hoppers (Cicadollidae family) in both nursery and field control measures include use of matathion and dichlorophos. The tree is host to the cotton stainer (Dydereusnigro fascinates) and should therefore not be planted in cotton producing areas (Orwa *et al.*, 2009) also, the tree is susceptible to leaf defoliation insects (Empoasca) and fungi (phakopsora) (Orwa *et al.*, 2009 ; Von Carlowitz, 1991).

2.1.8 Utilization

2.1.8.1 As agro forestry

Jakjak is an incidental component of many farming system. Traditionally many crops (Maize, Millet, Sorghum etc) are grown under the canopy of Jakjak. The advantages of inter cropping these crops with Jakjak have not been scientifically studied. However, causal observations indicate that crops grow better canopy. There is no information available on the species contribution to crop production and soil fertility, most recently it has been planted intentionally as an agro forestry tree in trials in Botswana and other countries but conclusive result of the trials are not yet available (Tshwenyane and Mojeremane, 2004).

2.1.8.2 As food

In Africa, Jakjak tree (*A. garckenea*) dry fruit may be cooked and eaten in large quantities during famine and peak farming periods. The ripe fruit carples are edible and have an energy of 8-10 kj/g. a sweet mucilage comes out when chewed. Also the fruit may be eaten raw if gathered green and juicy and the rinds is peeled off. Boiled, it is widely used as relish or made into porridge .The leaves make arelish or can be burned to produce salts (Ruffo *et al*, 2002 and Oraw *et al*, 2009). In Sudan (Darfur States) Jakjak fruit may be eaten ripe (chewing), fresh or is kept for later usage, because it consists of great proportion of sugar, vitamins and minerals. Also it is used as sauce before ripe, porridge (Madeda) juice preparation and for school boys chewing (Salih *et al*., 2012).

2.1.8.3 As folk medicine

In Tanzania, the roots are boiled and drunk to treat in fertility and constipation. Adecotions is made from the roots and taken orally for painful menstruation and to treat coughs and chest pains. An infusion made from the roots and leaves is dropped into the ear to treat earache or taken orally as an antiemetic. In Sudan, the fruit of Jakjak is used traditionally in Sudanese folk medicine for treatment of animea, has a potential effect in increasing iron absorption rather being a rich source of iron and different doses of the extract used to establish its stability in inducing favorable eryrhropotetic properties (Ahmed, 2016).

2.1.8.4 Other uses

Jakjak tree (*A. garckenea* timber the deep brown mottled wood is often used for making bows, tools handles and small pieces of furniture, implement handles and knife sheaths (Orwa *et al*., 2009).The woods resource of charcoal fire wood, spoons, poles, carving, combs (Ruffo *et al*., 2002). Jakjak suckers freely and has been used in soil conversation projects (Tshwenyane and Mojeremane, 2004). And leaves have been used for mulching and as green manure (Tshwenyane and Mojeremane, 2004). The Jakjak tree fiber is good quality tope can be made from fibers of the inner bark and the fire wood use it as fuel (Orwa *et al*., 2009).

Jakjak tree (*A. garckenea*) leaves contain high level of crude protein. It is browsed by game and in the season by cattle (Orwa *et al*., 2009).

2.1.9 Fruit nutritive value

As reported by Saka *et al*., (1994) and Orwa *et al*., (2009) the dry matter, Ash, Crude protein, Crude lipid, Crude fiber and available Carbohydrate content in Jakjak fruit were 52.8 %, 7.0, 12.0%, 1.1%, 45.3% and 35.2%, respectively on dry basis. While, the concentrations as fruit pulp of Calcium, Iron, Sodium and Potassium were 56.00, 6.00, 13.00 and 60.00 mg/100 g respectively. *Salih et al*., (2012) reported the dry matter moisture, ash, fat, crude fiber, crude protein and available carbohydrate content in Jakjak pulp were as 7.300, 1.040, 45.52, 10.05, 22.44 %, respectively on dry basis. The energy value was estimated to be 2313.08 k cal/100g pulps. While, the concentrations of iron, calcium, sodium, potassium as mg/100g fruit pulp were found to be 6.000±0.1, 56.000±0.3, 60.000±0.5, 1360±1.3, respectively.

2.1.10 Fruit processing

Jakjak fruit is split open by hand to release the seeds. After cleaning, the seeds are dried under sun. 10 kg of fruits produce 1 kg of seeds or about 4000 seeds (Krog, 2003). Then, the seeds were removed from the pulps and pulp sun dried. The dried pulp was pounded into powder and sieved using BS 0.8 mm mesh sieve, packed in nylon bag and store in refrigerator until use (Onyia *et al*., 2015).

2.2 Candy

2.2.1 Definition

Candy, also called sweets or lollies, is a confection that features sugar as a principal ingredient. The category, called sugar confectionery, encompasses any sweet confection, including chocolate, chewing gum, and sugar candy. Vegetables, fruit, or nuts which have been glazed and coated with sugar are said to be candied (Richardson, 2002).

2-2-2 Types of candy

2-2-2-1 Caramel

Caramel is a medium to dark-brown confectioner product made by heating a variety of sugar. It can be used as a flavoring in puddings and desserts, as a filling in bonbons, or as a topping for ice cream and custard (Oxford University Press, 2010).

2-2-2-2 Chocolate

Chocolate is a typically sweet, usually brown food preparation of the obroma cacao seeds, roasted and ground. It is made in the form of a liquid, paste, or in a block, or used as a flavoring ingredient in other foods. Cacao has been cultivated by many cultures for at least three millennia in Mesoamerica. The earliest evidence of use traces to the Mokaya (Mexico and Guatemala), with evidence of chocolate beverages dating back to 1900 BCE (Watson, 2013). In fact, the majority of Meso American people made chocolate beverages, including the Maya and Aztecs, who made it into a beverage known as xocolātlNahuatl pronunciation: , a Nahuatl word meaning "bitter water". The seeds of the cacao tree have an intense bitter taste and must be fermented to develop the flavor (Waston, 2013).

2-2-2-3 Divinity

Divinity is a nougat-like confection made with egg white, corn syrup, and sugar. Optional ingredients such as flavors, chopped dried fruit and chopped nuts are frequently added. Replacing the sugar with brown sugar results in a related confection called "sea foam" (Labau, 2015).

2-2-2-4 Fondant

Fondant icing, also commonly referred to simply as fondant is an edible icing used to decorate or sculpt cakes and pastries. It is made from sugar, water, gelatin, and glycerol. It does not have the texture of most icings; rolled fondant is akin to stiff clay, while poured fondant is a thick liquid. The word , in French, means "melting", coming from the same root as fondue and foundry (Labau, 2015).

2-2-2-5 Fudge

Fudge is a type of confectionery which is made by mixing sugar, butter and milk, heating it to the soft-ball stage at 240 °F (116 °C), and then beating the mixture while it cools so that it acquires a smooth, creamy consistency. Fruits, nuts, chocolate, caramel, candies, and other flavors are sometimes added either inside or on top. It is often bought as a gift from a gift shop in tourist areas and attractions (Jones and Charlotte,1991).

2-2-2-6 Halva

Halva is any of various dense, sweet confections served across the Middle East, South Asia, Central Asia, West Asia, the Caucasus, North Africa, the Horn of Africa, the Balkans, Central Europe, Eastern Europe, Malta and the Jewish diasporas. Identical sweets exist in other countries, such as China, though these are not generally referred to as "halva".

In global, popular usage it means "desserts" or "sweet", and describes two types of desserts:

a) Flour-based:

This type of halva is slightly gelatinous and made from grain flour, typically semolina (suji- India). The primary ingredients are clarified butter (ghee), flour, and sugar.

b) Nut-butter-based:

This type of halva is crumbly and usually made from tahini (sesame paste) or other nut butters, such as sunflower seed butter. The primary ingredients are nut butter and sugar. Halva may also be based on various other ingredients, including beans, lentils, and vegetables such as carrots, pumpkins, yams and squashes (Davidson,1999).Halva can be kept at room temperature with little risk of spoilage. However, during hot summer months, it is better kept refrigerated, as it can turn runny after several days (Amsden, 2006).

2-2-2-7 A hard candy

A hard candy, or boiled sweet, is a sugar candy prepared from one or more sugar-based syrups that is boiled to a temperature of 160 °C (320 °F) to make candy. Among the many hard candy varieties are stick candy (such as the candy cane), lollipops, aniseed twists, and bêtises de Cambrai. Hard candy is nearly 100% sugar by weight; Recipes for hard candy may use syrups of sucrose, glucose, fructose or other sugars. Sugar-free versions have also been created (Sherman, 2011).

2-2-2-8 Liquorice

Liquorice (British English) or licorice (American English) is a confection usually flavoured with the extract of the roots of the liquorice plant Glycyrrhizaglabra. A wide variety of liquorice sweets are produced around the world. In North America, black licorice is distinguished from similar confectionery varieties that are not flavored with liquorice extract but commonly manufactured in the form of chewy ropes or tubes. So called "black licorice" is also a widespread flavour in other forms of confectionery such as jellybeans. In addition to these, various other liquorice-based sweets are sold in the United Kingdom, such as liquorice allsorts. Dutch and Nordic liquorice characteristically contains ammonium chloride instead of sodium chloride, prominently so in salty liquorice (Manhem *et al*., 2001).

2-2-2-9 A marshmallow

A marshmallow is a sugar-based confection that, in its modern form, typically consists of sugar, water and gelatin which is whipped to a spongy consistency, molded into small cylindrical pieces, and coated with corn starch. Some marshmallow recipes call for eggs. This confection is the modern version of a medicinal confection made from Althaeaofficinalis, the marshmallow plant (Hartel , 2014 ; Greweling,2013).

2-2-2-10 Marzipan

Marzipan is a confection consisting primarily of sugar or honey and almond meal (ground almonds), sometimes augmented with almond oil or extract (Sinclair, 2011).

2-2-2-11Mithai

Mithai a generic term for confectionery in India typically made from dairy products and/or some form of flour. Sugar or molasses are used as sweeteners (Bruce and Colleen, 2013).

2-2-2-12 Tablet

Tablet (taiblet in Scots) is a medium-hard, sugary confection from Scotland. Tablet is usually made from sugar, condensed milk, and butter, which is boiled to a soft-ball stage and allowed to crystallise. It is often flavored with vanilla or whisky, and sometimes has nut pieces in it.

Tablet differs from fudge in that it has a brittle, grainy texture, where fudge is much softer. Well-made tablet is a medium-hard confection, not as soft as fudge, but not as hard as hard candy.

Commercially available tablet often uses fondant instead of the milk products. This produces a slightly less granular texture compared to the traditional home-made tablet, and is supposedly much easier to prepare on a commercial scale (David, 2011).

2-2-2-13 Taffy

Taffy (North American English) or chews (British English) are a type of candy similar to toffee. Taffy is made by stretching or pulling a sticky mass of boiled sugar, butter or vegetable oil, flavorings, and colorings until it becomes aerated (meaning that tiny air bubbles are produced, resulting in a light, fluffy and chewy candy) When this process is complete, the taffy is rolled, cut into small pastel-coloured pieces and wrapped in wax paper to keep it soft. It is usually fruit-flavored, but other flavors are common as well, including molasses and the "classic" (unflavored) taffy (Sharkey, 2001).

2-2-2-14 Toffee

Toffee is a confection made by caramelizing sugar or molasses (creating inverted sugar) along with butter, and occasionally flour. The mixture is heated until its temperature reaches the hard crack stage of 149 to 154 °C (300 to 310 °F). While being prepared, toffee is sometimes mixed with nuts or raisins (Hughes, 2010; Sharkey, 2001).

2-2-2-15 Jelly candies

Jelly candies including those based on sugar and starch, pectin, gum, or gelatin such as Turkish delight (Lokum), jelly beans, gumdrops, jujubes, gummies, etc (Williams and Margaret ,2006).

2-3 Turkish delight (Lokum)

2-3-1Defiition

Turkish delight is defined as a product which is prepared in accordance with its technique by adding, if required, flavoring agents, dry and/or dried fruits and such ingredients into the Turkish delight mass made from sugar, starch, drinking water and citric or tartaric acid or potassium bitartrate.

The flavoring agents include ingredients such as mastic, cocoa, chocolate, sesame, poppy seeds, grated coconut etc and crusty fruits such as hazelnut, pistachio, walnut, dried fruits, dry and fresh fruit candies and Turkish delight (lokoom) cream. Also being produced by adding leaves of some flowers, natural or synthetic essences, Turkish delight is coated with coconut or powdered sugar, Turkish delight has various types such as plain, fruit, chocolate, pistachio, rose etc (Özen,2008)

2-3-2 The raw materials in lokum production

Lokum is made from starch and sugar. A main ingredient is rosewater, although some are made with lemon. Some recipes include small nut pieces, usually pistachio, hazelnut or almonds. This dessert is highly valued by children. Either raw materials or ingredients used by manufacturers of Lokum are sugar, corn starch, natural flavors, cream of tartar, and natural or artificial colors. An ingredient for rose flavored Lokum is rosewater (Batu and Kirmaci, 2009).

2-3-1-1 Sugar

Sugar is the one of the most important raw material in Lokum production. Honey and pekmez were used as sweeteners, flour was used to hold water and make texture in candy production began at 16th in Turkey. After producing in European factories at the end of 18th, sugar was begun to use in Lokum Production (Batu and Kirmaci, 2006).

2-3-2-1-2 Starch

Starch is the major component of grains and a common ingredient used in the food industry. Understanding the relationship between the structure of starch and rheological properties will improve the ability to manipulate texture and could result in identification and development of lines and mutants of starch with abilities to resist breakdown and retro gradation. Starch used in Lokum production as a basic raw material has important quality criterions. Starch found by a German scientist in 1811, used in Lokum production instead of flour. And with appropriate sugar-starch mix Lokum production was done in today’s taste of it. When starch is mixed with water and heated, it gelatinizes (Saldamlı,1998).

2-3-2-1-3 Acid

Acid used in Lokum production during cooking to prevent crystallization by changing sucrose to invert sugar. Citric and tartaric acid are used in Lokum production in Turkey. Manufacturers often determine acid amount to be added by themselves. Researches were made on usage of tartaric and citric acid in Lokum production trials. At the end of the researches, using 5g tartaric acid results the best quality Lokum. Lokum made with 3g citric acid took place in second. Neither reducing tartaric acid amount to 3g nor increasing citric acid amount to 5g will arise the quality. Taking into consideration of acids used in Lokum production shows citric acid amount should always be lower than tartaric acid (Özbey,2002).

2-3-2-1-4 Water

In Lokum production, water is the one of the most important raw material effecting quality after sugar. Especially soft water increases quality, on the contrary water with high lime content destroys the structure of lokum. Some lokum manufacturers think that using more water will increase quality (Batu and Kirmaci ,2009) .

2-3-2-1-5 Color, odor and other additives

Many varieties of color and odor additives and dried fruits areused in Lokum production. When color and odor additives aregoing to be used, it is very important to be agreement with the‘‘Food Additives Regulation”. These types of food additives are used with respect to the consumer’s desires. Additionally, coconut, peanut, pistachio, and almond can also be used in Lokum production (Anonymous, 2006).

2-3-3 Lokum production process

2-3-3-1 Preparing of sugar syrup and starch milk

First of all, syrup is made from sugar with enough water to melt it. Then, starch is mixed with the remaining water. Practically, this mixture is called as starch milk. Starch milk is added to the boiling (Batu and Kirmaci ,2009) .

2-3-3-2 Cooking

Once the water has boiled the sugar is added and the solution is boiled for an hour, stirred continuously by an electric paddle. Next the starch is added, and the mixture brought back to the boil, for another five to six hours until it is smooth and shiny. The mixture is allowed to cool for a while, before the various flavors are added. There are twenty four to choose from including cherry, lemon, almond andchocolate, as well as the traditional rose flavor. The rose flavoring is made by the villagers at this time of year by boiling handfuls of fragrant rose petals and Collecting the condensed moisture. After the flavorings have been carefully added, the mixture is poured into large wooden trays to set. About five hours later it is ready to be cut into squares, liberally dusted with icing sugar and packed into small boxes lined with greaseproof paper ready for selling. Lokum production process is given (Batu,2006).

Lokum, which is the best example of Turkish palate and is a well-known product, is pr5oduced by open vessel or pressure cooking (Batu and Kirmaci ,2009) .

In open vessel cooking, cooking is done in 2-2,5 hours at 125 ºC. In pressure cooking, cooking time is reduced to 30-40 minutes. which may be accepted as economic. Moreover, in pressure cooking amount of water, acid and acid modified starch is lowered (Anonymous, 2006).

Cooking time changes 1,5 to 2,5 hr. with respect to vessel capacity. Cooking is checked by examining Lokum dough by hand after cooling it. Reducing cooking time is the one important problem of Lokum production. In practice, cooking time in open vessel is very long and depends on amount of Lokum dough. To achieve economic cooking, i.e. cooking in short time, this process should be done in pressure cooking (Batu and Kirmaci ,2009)

2-3-3-3 Pouring & Shaping

Cooked Lokum is poured to molds after adding required additives. Wooden and stainless steel molds are used to shape Lokum. Used molds change with respect to type of Lokum and cutting type. Lokum’s thickness should be 5 cm and 1,5-2,5 cm according to the cutting type; by hand and machine respectively. In one study, molds and metal pans are use for shaping. As result of study, pouring Lokum dough to greasy metal pan may prevent crust forming. On the other hand, humidity of natural starch used to shape Lokum in wooden pans, is determined as another factor affecting crusting (Batu and Kirmaci ,2009)

2-3-3-4 Cooling

Lokum is cooled in room conditions for 24hr after pouring cooling may be done in 3-4 hours with water cooling systems. In all companies do not use any special process to fasten cooling. Some Lokum experts believe that waiting for cooling in room temperature causes high quality products. On the contrary if any effect on cooling may lower quality (Anonymous, 2006).

2-3-3-5 Cutting

Cooled Lokum is put on cutting tables. In turkey , cutting of Lokum is done by hand or machine. Sugar powder or coconut is found on table. Different types of knives are used in hand cutting. There are three steps in hand cutting whether the knife's type. These steps are cutting to halve the lokum's length, width and thickness. In companies having high capacity, cutting is done by both hand and machine. Lokum manufacturers pay attention cutting of lokum which will be expected. Purchasing countries want lokum in standard sizes. Especially countries are very sensitive to this issue, in which lokum is sold one by one like France. On the other hand, selling lokum with packages certain package weight should be provided to countries in which lokum is sold in packages. Therefore development in cutting machines of lokum to standardize lokum sizes. To mechanize, automatic lokum cutting machines are invented and presented to lokum manufacturers (Batu and Kirmaci ,2009).

2-3-3-6 Packaging

Cut Lokum's are fitted in boxes in desired weight and transported to storage rooms to sell.Generally,Lokum which is sold in Turkey is packed in 5kg wooden boxes. To prevent stick Lokum to box polyethylene, greasy and waxy paper are used. Every row is separated from each other by packaging materials. Some companies packages Lokum in

¼ - 1 kg for both consumers in abroad and in Turkey. In these types of Lokums are sorted with only one row **(Anonymous, 2006).**

2-3-4 Quality of Turkish delights

Lokum manufacturers have different opinions on the quality Attributes such as color and texture of Lokum . But they agreed that appearance, structure and taste are the quality criteria for Lokum. Sugar powder should remain dry by itself. Retaining the dryness of sugar is an important quality aspect from the appearance point of view. Retaining its shape, not having crack formation on its surface, having a transparent appearance, and retaining the Lokum color are the subjective quality attributes. Lokum manufacturers have different opinions about the most convenient color for it. Softness and elasticity of Lokum are the most important attributes of texture. There is no certain measurement determined by lokum manufacturers. It is only explained that lokum should not be too hard and too soft. Moreover, Lokum should not get smeared or hard that causes difficulty in chewing. Lokum's softness should not cause it to lose its shape and form cracks on its surface. Taste and odor, other quality criteria, are evaluated by sensory analysis. Lokum without any additives is desired odorless and having taste of typical lokum. In lokums with food additives, such as odor-taste, is wished for having both taste of lokum and additives that used. Raw starch or burnt odor and taste result in the unwanted tastes in lokum (Anonymous, 2006). Stability is the another quality attribute in lokum. According to manufacturers, lokum should have one year shelf life protecting its quality. Also, manufacturers determined that the stability of lokum depends on cooking, packaging and storage conditions (Batu and Kirmaci ,2009).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials

Sample of ripe Jakjak fruits *(Azanaz garckenea)* was obtained from Nyala market in South Darfur State at the harvesting season (Novmber-2016). The sample was tightly kept in polyethylene bags at -18 °C until needed for the different investigations.

3.2 Methods

3.2.1 Chemical methods

3.2.1.1 Moisture content

The moisture content was determined according to the standard method of the Association of Official Analytical Chemists (AOAC, 2003).

Principle: The moisture in a weighed sample is removed by heating the sample in an oven (under atmospheric pressure) at 105 °C. Then, the difference in weight before and after drying is calculated as a percentage from the initial weight.

Procedure: A sample of 2 gm ±1 mg was weighed into a pre-dried and tarred dish. Then, the sample was placed into an oven (No.03-822, FN 400, Turkey) at 105 ± 1 °C until a constant weight was obtained. After drying, the covered sample was transferred to desiccators and cooled to room temperature before reweighing.

Triplicate results were obtained for each sample and the mean value was reported to two decimal points according to the following formula:

Calculation:

$$\text{Moisture content (\%)} = \frac{(W_s - W_d)}{\text{Sample weight (g)}} \times 100\%$$

[eq.1]

Where:

Ws = weight of sample before drying.

W_d = weight of sample after drying.

3.2.1.2 Crude protein content

The protein content was determined in all samples by micro-Kjeldahlmethod using a copper sulphate-sodium sulphate catalyst according to the official method of the AOAC (2003).

Principle: The method consists of sample oxidation and conversion of its nitrogen to ammonia, which reacts with the excess amount of sulphuric acid forming ammonium sulphate. After that, the solution was made alkaline and the ammonia was distilled into a standard solution of boric acid (2%) to form the ammonia-boric acid complex which is titrated against a standard solution of HC1 (0.1N).The protein content is calculated by multiplying the total N % by 6.25 as a conversion factor for protein.

Procedure: A sample of two grams was accurately weighed and transferred together with, 4g $NaSo_4$ of Kjeldahl catalysts (No. 0665, Scharlauchemie, Spain) and 25 m1 of concentrated sulphuric acid (No.0548111, HDWIC, India) into a Kjeldahl digestion flask. After that, the flask was placed into a Kjeldahl digestion unit (No.4071477, type KI 26, Gerhardt, Germany) for about 2 hours until a colourless digest was obtained and the flask was left to cool to room temperature.

The distillation of ammonia was carried out into 25m1 boric acid (2%) by using 20 ml sodium hydroxide solution (45%). Finally, the distillate was titrated with standard solution of HC1 (0.1N) in the presence of 2-3 drops of bromocreasol green and methyl red as an indicator until a brown reddish colour was observed.

Calculation:

$$\text{Crude Protein (\%)} = \frac{(\text{ml HCl sample} - \text{ml HCl blank}) \times N \times 14.00 \times F}{\text{Sample weight (gm)} \times 1000} \times 100\% \qquad \text{[eq.2]}$$

Where:

N: normality of HCl.

F: protein conversion factor = 6.25

3.2.1.3 Fat content

Fat content was determined according to the official method of the AOAC (2003).

Principle: The method determines the substances which-are soluble in petroleum ether (65-70 $^{\circ}$C) and extractable under the specific conditions of Soxhlet extraction method. Then, the dried ether extract (fat content) is weighed and reported as a percentage based on the initial weight of the sample.

Procedure: A sample of 5gm ± lmg was weighed into an extraction thimble and covered with cotton that previously extracted with hexane (No.9-16-24/25-29-51, LOBA Cheme, India). Then, the sample and a pre-dried and weighed extraction flask containing about 100 ml hexanes were attached to the extraction unit (Electrothermal, England) and the extraction process was conducted for 6 hrs. At the end of the extraction period, the flask was disconnected from the unit and the solvent was redistilled. Later, the flask with the remaining crude ether extract was put in an oven at 105 °C for 3 hrs , cooled to room temperature in a desiccators, reweighed and the dried extract was registered as fat content according to the following formula;

Calculation:

$$\text{Fat content (\%)} = \frac{(W_2 - W_1)}{W_3} \times 100\ \% \qquad \text{[eq.3]}$$

Where;

W_2 =Weight of the flask and ether extract

W_1 =Weight of the empty flask

W_3=initial weight of the sample

3.2.1.4 Total carbohydrates

Total carbohydrates were calculated by difference according to the following equation:

Total carbohydrates = 100% - (Moisture + Protein + Fat + Ash).

[eq.4]

3.2.1.5 Crude fiber content

The crude fiber was determined according to the official method of the AOAC (2003).

Principle: The crude fiber is determined gravimetrically after the sample is being chemically digested in chemical solutions. The weight of the residue after ignition is then corrected for ash content and is considered as a crude fiber.

Procedure: About 2gm ± 1 mg of a defatted sample was placed into a conical flask containing 200 m1 of H_2SO_4 (0.26 N). The flask was then fitted to a condenser and allowed to boil for 30 minutes. At the end of the digestion period, the flask was removed and the digest was filtered (under vacuum) through a porclain filter crucible (No.3). After that, the precipitate was repeatedly rinsed with distilled boiled water followed by boiling in 200 ml Na OH (0.23 N) solution for 30 minutes under reflux condenser and the precipitate was filtered, rinsed with hot distilled water, 20m1 ethyl alcohol (96%) and 20 ml diethyl ether.

Finally, the crucible was dried at 105 °C (overnight) to a constant weight, cooled, weighed, ashed in a Muffle furnace (No.20. 301870, Carbolite, England) at 550-600 °C until a constant weight was obtained and the difference in weight was considered as crude fiber.

Calculation:

$$\text{Crude fiber}(\%) = \frac{(W_1 - W_2)}{\text{Sample weight(gm)}} \times 100\%$$

[eq.5]

Where:

W_1 = weight of sample before ignition (gm).

W_2 = weight of sample after ignition (gm).

3.2.1.6Available carbohydrates

Available carbohydrates were calculated by difference according to the following equation:

Available carbohydrates = Total carbohydrates – Crude fibre.

[eq.6]

3.2.1.7Total, reducing and non-reducing sugars

The total sugars as well as reducing and non-reducing sugars were determined according to Lane and Eynontitrometric method as described by the Association of Official Analytical Chemists (AOAC, 1984).

Principle: Reducing sugars in pure solution in plant materials after suitable pre-treatment (to remove interference substances) may be estimated by using copper sulphate as oxidizing agent in a standard Fehling's solution.

Sample preparation:

(A) Reducing sugars

A sample of 10 gm + 1 mg was weighted and transferred to 250 ml volumetric flask. 100 ml of distilled water was carefully added and then neutralized with 1.0 N Na OH to a pH 7.5 – 8.0. Then, about 2 ml of standard lead acetate (NO. 23500, BDH, England) was added and the flask was shaken and left to stand for 10 min. After that, 2 ml of sodium oxalate were added to remove the excess amount of lead acetate and the solution was made up to volume (250 ml) with distilled water and filtered.

(B) Total sugars

From the previous clear sample solution, 50 ml was pipetted into a 250 ml conical flask and 5gm citric acid and 50 ml distilled water were added slowly. Then, the mixture was gently boiled for 10 min to complete the inversion of sucrose and left to cool at room temperature. After that, the solution was transferred to 250 ml volumetric flask, neutralized with 20% NaOH solution in the presence of few drops of phenolphthalein (NO. 6606 J. T Baker, Holland) until the color of the mixture disappeared and the sample was made up to volume before titration.

Procedure:

A volume of 10 ml from the mixture of Fehling's (A) and (B) solutions was pipetted into 250 ml conical flask. Then, sufficient amount of the clarified sugars solution was added from burette to reduce Fehling's solution in the conical flask. After that, the solution was boiled until a faint blue color is obtained. Then, few drops of methylene blue indicator (S-d-FINE-CHEM LIMITED) were added to Fehling's solution and titrated under boiling with sugars solution until brick-red color of precipitate cuprous oxide was observed. Finally, the titer volume was recorded and the amount of inverted sugars was obtained from Lane and Eynon Table. The total sugars, reducing and non-reducing sugars were calculated by using the following formulas:

Calculation:

$$\text{Total sugars \{\% DM\}} = \frac{\{\text{invert sugar (mg)} \times \text{dilution factor}\} \times 100}{\text{Titre} \times \text{sample weight (g)} \times (100\% - \text{moisture \%}) \times 1000}$$

[eq.7]

$$\text{Reducing sugars \{\% DM\}} = \frac{\{\text{invert sugar (mg)} \times \text{dilution factor}\} \times 100}{\text{Titre} \times \text{sample weight (g)} \times (100\% - \text{moisture \%}) \times 1000}$$

[eq.8]

Non-reducing sugars {% DM} ={Total sugars (%) – reducing sugars (%)}

Where: Titre = (Sample – blank)

[eq.9]

3.2.1.8 Ash content

The ash content was determined according to the method described by the AOAC (2003).

Principle: The inorganic materials which are varying in concentration and composition are customary determined as a residue after being ignited at a specified heat degree.

Procedure: A sample of 5g±1 mg was weighed into a pre-heated, cooled, weighed and tarred porcelain crucible and placed into a Muffle furnace (No.20. 301870, Carbolite, England) at 550 to 600 °C until a white gray ash was obtained. The crucible was transferred to a desiccator, allowed to cool to room temperature and weighed. After that, the ash content was calculated as a percentage based on the initial weight of the sample.

Calculation:

$$\text{Ash (\%)} = \frac{\text{[(Wt of crucible +Ash) - (Wt of empty crucible)]}}{\text{Initial weight (Wt)}} \times 100\ \%$$

[eq.10]

3.2.1.9 Minerals content

Ten milliliters (10 ml) of HCL (2N) were added to the remaining ash sample and placed in a hot sand path for about 10-15 min. After that, the sample was diluted to 100 ml in a volumetric flask and filtered. The trace elements ferrous (Fe^{++}) and manganese (Mn^{++}) were determined according to Perkin Elmer (1994) by using Atomic Absorbance Spectroscopy (JENWAY 3110, UK). Sodium (Na) and potassium (K) were determined by using Flame Photometer (Model PEP7 JENWAY), while, calcium (Ca), magnesium (Mg), and phosphorus (P) were determined as described by Chapmanandparratt (1961).

3.2.1.10Titrable acidity

The titrable acidity of Jakjak Lokum was determined according to Ranganna (1979).

Procedure:

50 gm ± 1g sample was diluted to 100 ml, and boiled in water for 30 min. Then 20ml of the diluted solution was titrated against (0.1N) sodium hydroxide using phenolphthalein solution (1%) as an indicator. The titrable acidity was calculated as percent citric acid according to the following equation:

Titrable acidity (%) =

$$\frac{[(\text{Titre} \times \text{N (NaOH)} \times \text{equivelent wt of cetric acid} \times 100)] \times 100\%}{\text{sample volume (ml)} \times \text{initial wt. of sample(g)} \times 1000}$$

[eq.11]

3.2.1.11 Food energy value

The energy value of Jakjak Lokum product was calculated based on Atwater factors as indicated by Leung (1968).

Protein = 3.87 K. cal/g

Fat = 8.37 K. cal/g

Carbohydrate = 4.12 K. cal/g

3.2.2 Physico-chemical methods

3.2.2.1 Total soluble solids

The total soluble solids as percent (T.S.S %) in the different samples were measured as described by Ranganna (2001).

Principle: The index of refraction of a substance is a ratio of light velocity under vacuum to its velocity in the substance which is largely dependent on the composition, concentration and temperature of the sample solution.

Procedure: After the adjustment of the Hand-Refractometer (No.002603, BS-eclipse, UK) with distilled water, the sample was placed on the surface of the refractometer prism, the prism was closed and the reading was recorded to the nearest 0.01 as T.S.S %.

3.2.2.2 Hydrogen ions concentration

The Hydrogen ions concentration (pH) of the different samples was determined as described by Ranganna (2001).

Principle: The pH value of the different samples was measured with a pH-meter. After standardization of the pH-meter electrodes with buffer solutions, the reading of the sample is recorded as pH value.

Procedure: After standardization of the pH-meter (N0.478530, Hanna, India) with buffer solutions (pH 4.01 and 7.01), the electrode of the pH-meter was rinsed with distilled water, immersed in the sample and left to stand until a staple reading was achieved.

All the readings were expressed as pH to the nearest 0.01-pH units.

3.2.3 Experimental processing methods

3.2.3.1 Jakjak juice extraction methods

For determination of optimum conditions that should be followed for production of Jakjak juice extract, two different extraction methods were used:

Cold extraction method: In this method, a sample of cleaned jakjak fruits (50 gm) was soaked overnight (16 hours) at room temperature in distilled water at different fruit: water ratio (1:4, 1:6, 1:8). Then, the mixtures were stirred by using a magnetic stirrer (No.505010E, Gallenhamp, England) for 5 min, immediately filtered with a coarse silk sieve, and weighed. After that, the filtrates were checked for their pH, total soluble solids (T.S.S), volume, weight and the yield (%) of each extract was calculated, as follows:

Calculation:

$$\text{Yield [\%]} = \frac{[\text{Weight of extract (gm)} \times \text{T.S.S \%}]}{\text{Initial weight of sample (gm)}} \times 100\%$$

[eq.12]

3.2.3.2 Jakjak Lokum processing method and recipe

After the removing the seeds from Jakjak fruits, the fruits then were then cleaned and washed. Fifty grams from the fruits were soaked in 200 ml distilled water for overnight 16 hrs. After that, the mixture was blended for 5 min with an electric mixer and filtered with a coarse silk filter. Then, the pH and the total soluble solids of the extract were being checked, the required amounts of citric acid, starch and sugar were calculated according to the methods adopted by Batu and Kirmaci (2008). Then, Jakjak extract (170g) with the proper amount of sugar (200g) were placed in an open kettle and, the mixture was pre-cooked until temperature of the mixture reached (100 ºC) with addition of citric acid (1 g). After that, starch was mixed with the water (Starch milk) and immediately added to the mixture with cooking and stirring continuously, until the mixture reached the appropriate texture. Finally, the kettle was put down and Jakjak Lokum was poured into large trays to set. After that Lokum left cool at room temperature and cutted in suitable shape. Then, it was stored until needed for chemical, physico-chemical and organoleptic evaluations. Jakjak lokum recipe and processing method are shown in Table (1) and Fig (1), respectively.

3.2.4 Lokum organoleptic evaluation method

Jakjak Lokum products were sensory evaluated as described by Ranganna (2001). In this method, 25 trained panelists from the Food Science and Technology Dept, College of Agricultural Studies, Sudan University of Science and Technology, were asked to evaluate the products with regard to their colour, flavour, taste, texture and overall acceptability using the following quality scales:

1= excellent, 2= very good, 3= good, 4= acceptable, 5= unacceptable.

3.2.5 Statistical analysis method

The results were subjected to Statistical Analysis System (SAS) by using One-Factor Analysis of Variance (ANOVA). The Mean values were also tested and separated by using Duncan's Multiple Range Test (DMRT) as described by Steel, *et a1*. (1997).

Table 1: Jakjak Lokum recipe and yield

Ingredients	(g)	(%)
Jakjak extract	170	33.6
Sugar	200	39.5
Starch	50	9.8
Citric acid	1	0.2
Water	85	16.8
Total weight	506	100

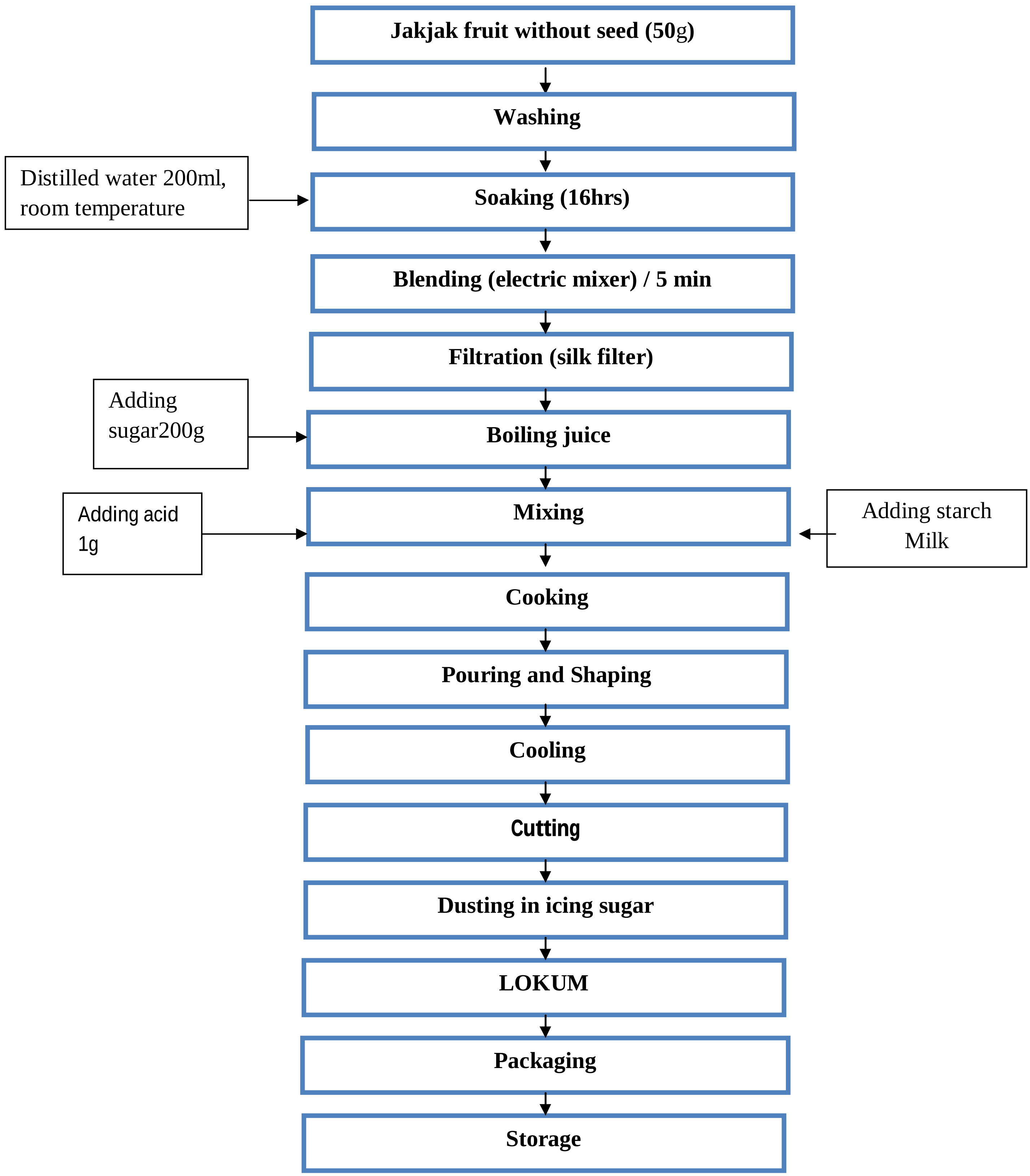

Figure 1: Jakjak Lokum processing method

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Nutritional value of Jakjak fruits

4.1.1 Chemical composition of Jakjak fruit

Table (2) shows the chemical composition of Jakjak fruits on wet and dry basis. The dry matter, Ash, Crude protein, Crude lipid, Crude fiber and available Carbohydrates were found to be 84.92,4.04, 6.65,1.81, 36.0,and 51.64%, respectively on dry basis. The results obtained in this study are agreed with those reported by Saka *et al*., (1994) and Salih *et al*., (2012).

4.1.2 Minerals content (mg/100g) of Jakjak fruits

Table (3) shows the minerals content of Jakjak fruits on wet and dry basis as mg/l00g. From the results, the fruits was found to be very rich in calcium (29.3 mg/100g), sodium (5.2 mg/100g), potassium (186.0 mg/100g) and iron (4.0 mg/100g), on dry weight basis. In general, the results of this study are in agreement with those reported earlier by Saka *et al*., (1994) and Salih *et al*., (2012).

4.2 Suitability of Jakjak fruits for Lokum production

4.2.1 Extraction of Jakjak fruit

Table (4) shows the results for yield and physicochemical analysis of cold extracted jakjak fruit juice The results showed that, the yield % of Jakjak was found to increase significantly (P< 0.05) with increasing fruit: water ratio . In contrast, the T.S.S % of Jakjak fruit juice was found to decrease significantly (P< 0.05) with increasing fruit:

water ratio. However, no significant differences were found in the pH of the different fruit pulp extracts. Among the different fruit: water ratios used in this experiment, the ratio of (1:4) was found to be more suitable for production of Jakjak fruits extract with suitable pH (5.43), T.S.S (12.20 %) and yield (41.55 %).

Table 2: Chemical composition of Jakjak fruits

Parameter	% On wet basis	% On dry basis
Moisture (or) dry matter	15.07 ±0.01	84.92±0.00
Protein	5.65 ± 0.23	6.65±0.26
Fat	1.55 ± 0.30	1.81±0.63
Total carbohydrates	74.44 ± 0.59	87.65±0.69
Crude fiber	30.58 ± 0.09	36.00±0.10
Available carbohydrates	43.86 ± 0.58	51.64±0.68
Total sugars	52.02± 0.98	61.39±0.90
Ash	03.43 ± 0.20	4.04±0.24

These values are means ± Standard deviation

Table 3: Minerals content (mg/100g) of Jakjak fruits

Minerals		**On wet basis**	**On dry basis**
Sodium	**[Na]**	004.40±0.00	005.20 ± 0.00
Potassium	**[K]**	150.80±0.00	186.00 ± 0.00
Calcium	**[Ca]**	020.49±0.00	029.30 ± 0.00
Magnesium	**[Mg]**	018.50±0.00	021.80 ± 0.00
Iron	**[Fe]**	003.40±0.30	004.00 ± 0.05
Manganese	**[Mn]**	000.37±0.00	000. 43 ± 0.02
Cupper	**[Cu]**	000. 37±0.06	000. 43 ± 0.01
Phosphorus	**[P]**	0082.00±0.00	096.50 ± 0.10

These values are means ± Standard deviation

Table 4: Yield and physicochemical analysis of cold extracted jakjak fruit juice

Parameters	Fruit: water extraction ratio		
	1:4	1:6	1:8
Jakjak fruit weight (g)	050.10 ± 0.10[c]	050.13 ± 0.15[c]	050.20 ± 0.17[c]
Extract weight (g)	170.30 ± 0.30[a]	235.87 ± 0.15[b]	310.73 ± 0.30[c]
Extract volume (ml)	165.43 ± 0.40[a]	235.30 ± 0.30[b]	310.20 ± 0.20[c]
Total soluble solids (%)	12.20 ± 0.20[a]	9.50 ± 0.20[b]	7.70 ± 0.20[c]
Hydrogen ion concentration (pH)	005.43 ± 0.31[c]	005.50 ± 0.26[c]	005.53 ± 0.30[c]
Yield [on wet basis] %	041.55 ± 75.4[a]	044.81 ± 91.5[a]	047.85 ± 128.9[a]

These values are means ± Standard deviation

4.3 Quality evaluation of Jakjak Lokum

4.3.1 Nutritional value

4.3. 1.1 Chemical composition and energy value

The chemical composition and energy value of Jakjak Lokum are shown in Table (5). From the results, the product was found to be with high level of total sugars (45.5 %), protein (1.98 %), ash (00.86%) and fat (0.79%), than gelatin Lokum which found low level of total sugars (10.5 %), protein (0.21 %), ash (00.53%) and fat (0.40%) on wet basis. Therefore, the product was found to provide an adequate caloric value (309.3k.cal/100g). The results obtained in this study are in disagreeing with those reported by Alakadiy (2000)and showed no significant different compare to the control lokum samples only for result of reducing sugar concentration where it shows 18.03 compare to 13.88 for the control which may be due to that Jakjak fruit juice contains fructose and other reducing sugars.

4.3.1.2 Chemical and physico-chemical characteristics

The chemical and physic-chemical characteristics of Jakjak Lokum are indicated in Table (6). From the results obtained in this study, the product was found to meet the recommended levels of hydrogen ions concentration (4.55) and titreable acidity (0.46%) as reported by the Dirik (2009)which was gives us pH (3.99-4.79) and titreable acidity (0.08-1.75%).

4.3.2 Organoleptic evaluation

The organoleptic evaluation of Jakjak Lokum was carried out by using panelists from the Food Science and Technology Dept., College of Agricultural Studies, Sudan University of Science and Technology. Jakjak Lokum products were sensory evaluated as described by Ranganna (2001). The results in Table (7) show the recorded scores by the panelists for the different Jakjak samples with respect to their flavour, colour, taste, texture and overall acceptability. In general, all Jakjak Lokum that produced were highly accepted by the panelists. But, significant differences were found between the four products with respect to their colour, texture and overall acceptability, the Jakjak Lokum produced with 1:4 fruit concentrates scored highest, whereas the product produced with 1:8 had the lowest score. The samples were assessed by panelists at the end of a sensory evaluation. There was a downward trend in satisfaction as the fruit concentration decreased. Additionally, the amount of water added in the product mass increased in parallel with the higher percentage of fruit juice concentration. Therefore, across all categories in this study, then firmness, chewiness, and consumer acceptability values of the products decreased as the amount of fruit concentrate (or water) was elevated. This could be due to the increased fruit concentration, which negatively impacted the sensorial qualities of the Jakjak Lokum. Despite this, all sensory values had relatively high scores for all the fruit concentrations. For Jakjak Lokum, while the samples with 1:4 concentrate had the best results in terms of texture and overall acceptability, the other samples produced with 1:6 and 1:8 were favored in terms of color.

Table 5: Chemical composition and energy value of Jakjak Lokum

Parameter	On wet basis	
	Jakjak Lokum	Lokum Control
Moisture	24.62 ± 1.90	25.24 ± 1.25
Protein	01.98 ± 0.12	01.68 ± 0.58
Fat	00.79 ± 0. 15	00.69 ± 0.25
Total sugar	45.51 ± 0.85	42.84 ± 0.26
Reducing sugars	18.03 ± 0.53	13.88 ± 0.67
Non reducing sugars	27.48 ± 0.46	28.96 ± 0.91
Total carbohydrates	71.75 ± 1.68	71.84± 0.91
Available carbohydrates	71.11 ±1.74	71.55±0.96
Starch	06.47 ±0.27	08.39±0.09
Crude fiber	00.64 ± 0.06	00.30±0.01
Ash	00.86 ± 0.05	00.63±0.02
Caloric value	308.2Cal/g	309.3Cal/g

These values are means ± Standard deviation

Table 6: Physico-chemical properties of Jakjak Lokum

Parameter	On wet basis
Hydrogen Ion concentration (pH)	004.55±0.068
Titreable acidity (%)	000.46±0.011

These values are means ± Standard deviation

Table 7:Organoleptic evaluation of Jakjak fruit Lokum candy

Samples	Quality characteristics				
	Flavour	Colour	Taste	Texture	Overall acceptable
A	2. 5 ± 1.12[a]	2.6 ± 1.02[ab]	2.3 ± 0.94[a]	2.2 ± 1.06[a]	2.1 ± 0.97[a]
B	2.5± 1.04[a]	2.5 ± 1.04[a]	2.5± 0.87 [a]	2.1 ± 0.98[a]	2.6 ± 0.87[ab]
C	2.9± 1.16[ab]	2.5± 1.04[a]	2.7± 1.21[ab]	2.5± 1.22[a]	2.6± 1.26[ab]
D	1.4± 0.70 [b]	1.5± 0.77 [b]	1.4± 0.58 [b]	1.8± 0.94 [a]	1.5± 0.75[a]

Mean ± S.D value(s) bearing different superscript letter(s) within columns are significantly different (P≤0.05).
Scale: 1 = excellent, 2 = very good, 3 = good, 4 = acceptable, 5 = unacceptable
A ≡ Jakjak Lokum.fruit: water ratios (1:4).
B ≡ Jakjak Lokum.fruit: water ratios (1:6).
C ≡ Jakjak Lokum.fruit: water ratios (1:8).
D ≡ Lokum control.

Table 8: Physical and physico-chemical characteristics of Jakjak fruits extract

Parameter	Values
Weight of raw material	50 g
Water weight	200 g
Weight of Jakjak extract	170 g
Total soluble solids (T.S.S %)	12 %
Hydrogen ions concentration (pH)	5.80

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

From the results obtained in this study it can be concluded that Jakjak fruits are found to behigh energy value and with appreciable amounts of sodium, potassium, magnesium, calcium and suitable for production of Lokum with high nutritional value and with high acceptability by the panelists.

5.2 Recommendations

1. Further studies are needed to improve the industrial uses of jakjak fruit therefore it can be used in different products.

2. More researches should be done to optimize methods for jakjak fruit juice extract.

3. More studies about the chemical and bioactive compounds are required.

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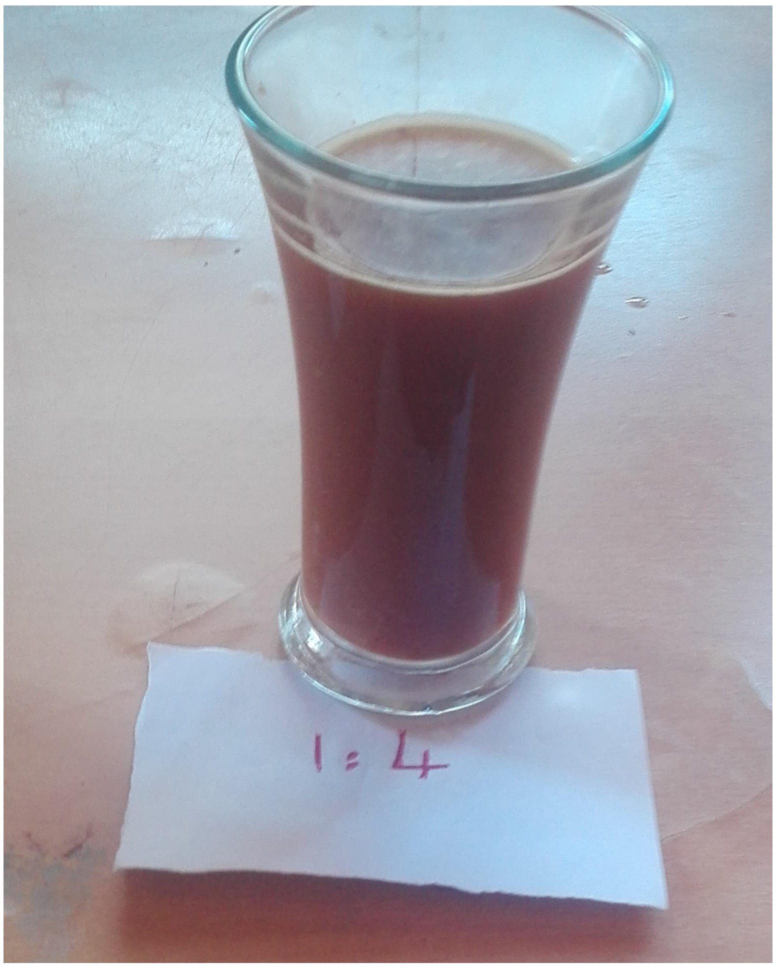
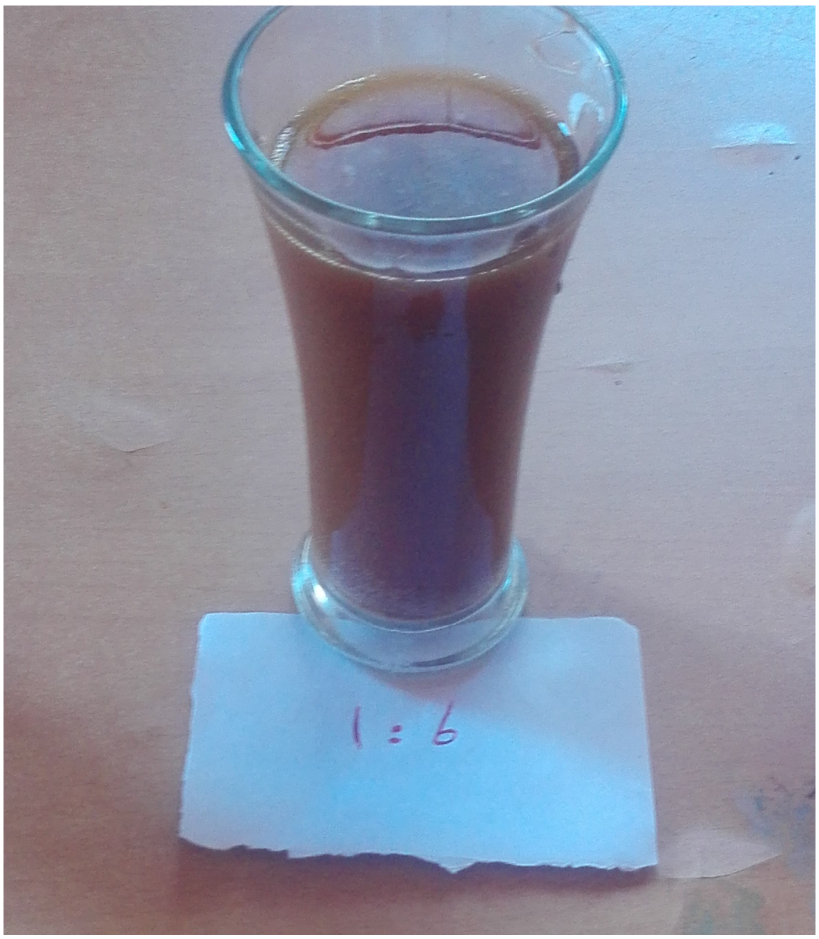
Appendices

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