PREPARATION OF DOUM (*Hyphaene thebaica*) DRINK

By:

Abdel Moneim Bakur Mohammed Gafaar

B.Sc. Honors Faculty of Natural Resources and
Environmental Studies (2005)
University of Kordofan

A dissertation Submitted to the University of Khartoum in Partial Fulfillment of the Requirements for the Degree of Master of Science in Food Science and Technology.

Supervisor:

Dr. Hassan Ali Mudawi

Department of Food Science and Technology
Faculty of Agriculture
University of Khartoum.

January 2010

DEDICATION

TO MY FATHER

TO MY MOTHER

TO BROTHERS & SISTERS

TO MY NEPHEW MONEIM (PEPIRO)

WITH AFFECTION AND GRATITUDE

MONEIM BAKUR

ACKNOWLEDGEMENTS

My profuse thanks are extended to my supervisor Dr. ***Hassan Ali Mudawi*** for supporting advising and encouraging me throughout the course of this study and thanks for his personal guidance and fruitful criticism from which I benefit much. I also thank extended to Dr**.** ***Abdalla Abdelsammad Abdalla*** for his continuous interest and useful suggestion

My profuse thanks are extended to my friends Tagelsir, Awad dion, Mugtaba, Suliman and Hanan for their help me.

I also thank the Department of Biochemistry and Food Science and Gum Arabic Research Center- University of Kordofan and veterinary Research Center- Elobied for their help

Lastly, but not least, sincere appreciation and much thanks are offered to my mother, father, sisters and brothers and deep thanks to friends and colleagues of M.Sc.

I also thank all those who could not find a separate name but have helped directly and indirectly.

TABLE OF CONTENTS

Contents **Page**

CHAPTER THREE

LIST OF TABLES

Tables **Pages**

Preparation of Doum (*Hyphaene thebaica*) Drink

M.Sc. Dissertation

By: Abdel Moneim Bakur Mohammed

Abstract: In this study, doum fruit pulp (slices) was used to prepare four types of beverages in addition to the traditional doum drink. Distilled water, gum arabic, CMC and filtration treatments were separately used to prevent precipitate formation (pulp sedimentation). All products were examined for physicochemical, microbiological and organoleptic qualities.

The traditional doum drink showed a pH value of 5.10, 153 mg/100 ml acidity, 7.3 ˚Brix total soluble solids and 12.83 cps viscosity. It also contained 49.11, 19.33 and 30.64 (mg/100 ml) total sugars, reducing sugars and non reducing sugars, respectively. Doum drink prepared, using distilled water, revealed the same pH (5.15), significantly ($P \leq 0.05$) lower acidity (134.13 mg/100 ml), TSS (6.0 Brix) and viscosity (11.50 cps), and significantly ($P \leq 0.05$) higher total reducing and non reducing sugars (66.84, 22.07 and 44.72 mg/100 ml, respectively) compared to the traditional one.

When gum arabic and CMC were separately added, the beverage showed significantly ($P \leq 0.05$) lower pH (4.76 and 5.03, respectively), but significantly ($P \leq 0.05$) higher acidity, TSS, viscosity as well as considerably higher total, reducing and non reducing sugars compared to the control. Filtration resulted in a doum beverage with the same pH (5.16), significantly ($P \leq 0.05$) lower acidity (93.87 mg/ 100 ml) TSS (7.0 Brix) viscosity (9.7 cps), but significantly ($P \leq 0.05$) higher total, reducing and non reducing sugars (84.20, 47.01 and 36.98, respectively). The fresh traditional doum beverage showed low bacterial total viable count (TVC)

of 1.8 x 10^3 CFU/ml. The TVC was drastically reduced to 3.3 x 10^2 CFU/ml due to filtration. Manipulation with distilled water, CMC and gum arabic increased the TVC of the doum drink to 2.9 x 10^3 - 17.6 x 10^3 CFU/ml. The five types of doum drinks proved to be free from contamination of yeast, mould, coli form, *Staphylococcus aureus* and *Salmonella*.

The filtrated doum drink proved to be organoleptically the best due to its outstanding acceptable sensory properties compared to the other products; in addition it was nearly precipitate free

تحـضـــــــــير مـشـــــــروب الـــــــــــــدوم

اطروحة ماجستير

عبدالمنعـم بكـر محـمد جـعـفـر

المستخلص: أستخدمت شرائح لب ثمار الدوم في تحضير أربعة أنواع من العصائر بالإضافة لمشروب الدوم التقليدي. أستخدمت أربع معاملات هي التحضير بالماء المقطر و إضافة الصمغ العربي و إضافة الكربوكسي مثيل سليلوز(CMC)، والتصفية لمنع تكون الرواسب (ترسبات اللب). أخضعت جميع المنتجات للتحليل الفيزيوكيميائي والميكروبيولوجي والحسي.

كان الأس الهيدروجيني لمشروب الدوم التقليدي 5.10 و الحموضة 153 ملج/100 مل و المواد الصلبة الذائبة الكلية 7.3 درجة بركس واللزوجة 12.83. وأحتوي أيضا علي 49.11و 19.33و30.64 ملج/100 مل سكريات كلية ومختزلة وغير مختزلة، على التوالي. اظهر مشروب الدوم المعد بإستخدام الماء المقطر نفس الأس الهيدروجيني (5.10) بينما كانت كل من الحموضة (134.13 ملج/100 مل)، و المواد الصلبة الذائبة الكلية (6.0 درجة بركس) واللزوجة (11.50) أقل معنويا ($P\leq0.05$) بالمقارنة مع المشروب التقليدي، في حين كانت السكريات الكلية و المختزلة وغير المختزلة (66.84 و 22.07 و44.72 ملج/100 مل، على التوالي) أعلـى معنويا.

عند إضافة الصمغ العربي والكربوكسي مثيل سليلوز (CMC) كل على حدة إنخفض معـــنويا ($P\leq0.05$) الأس الهيدروجيني (4.76 و5.03 على التوالي)، بينـما إرتفعت معنويا ($P\leq0.05$) كل من الحموضة والمواد الصلبة الذائبة الكلية و اللزوجة، بالإضافة للسكريات الكلية والمختزلة وغير المختزلة (71.93 و80.80؛ 25.53 و39.89؛ 47.07 و40.96 ملج/100 مل،على النوالي) مقارنة مع المشروب الأصلي.

أسفرت عملية التصفية عن مشروب دوم ذو أس هيدروجيني (5.16) مماثل للمشروب التقليدي بينما كانت كل من الحموضة (93.87 ملجم/100 مل) والمواد الصلبة الذائبة الكلية (7.0 درجة بركس) واللزوجة (9،7) أقل معنويا ($P\leq0.05$)، في حين كانت السكريات الكلية والمختزلة وغير المختزلة (84.20و 47.01 و36.98 ملجم/100 مل علي التوالي) أعلى معنويا ($P\leq0.05$).

أظهرمشروب الدوم التقليدي الطازج إنخفاضا في عدد البكتيريا القابلة للحياة (TVC) 1.8×10^{3} وحدة مكونة للمستعمرات/مل. إنخفض العدد البكتيري بصورة حادة إلى 3.3×10^{2} وحدة مكونة للمستعمرات/مل نتيجة للتصفية. ادت المعالجة بالماء المقطر و الكربوكسي مثيل

سليلوز(CMC) والصمغ العربي لزيادة العدد البكتيري إلى 2.9×10^{3} – 17.6×10^{3}.أثبتت الدراسة خلو مشروبات الدوم الخمسة من التلوث بالخمائرو الفطريات و بكتيريا القولون و البكتيريا العنقودية والسالمونيـــلا.

برهنت الدراسة أن مشروب الدوم المعامل بالتصفية هو الأفضل نظـرا لخصائصه الحسية المتمـيزة المقبولة مقارنة مع المنتجات الأخرى، كما إنه خـالي تقـريبا من رواسب اللـب.

CHAPTER ONE

1. INTRODUCTION

Fruit juices are important in human nutrition far beyond its use as a refreshing source of liquid. Many fruits contain a variety of minor ingredients, particularly vitamins and minerals, as well as carbohydrates, which are the predominant solid component. Although fruit contains small amounts of protein and fat, these are not important ingredients of juices (Ashurst, 2005).

Fruit juices and soft drinks are widely consumed in ever-increasing quantities and are very important commodities in the trade of most countries. They are available in essentially the same form almost anywhere in the world from polar bases to the tropics, and from the largest developed nations to small and less developed countries. Soft drinks and fruit juices are available in bottles, cans, laminated paper packs, pouches, cups and almost every other form of packaging known.

1.1 Juices:

The term fruit has many different meanings depending on context. In botany, a fruit is the ripened ovary together with seeds of a flowering plant. In many species, the fruit incorporates the ripened ovary and the surrounding tissues. Fruits are the means by which flowering plants disseminate seeds (Lewis, 2002). Nutritional value of Fruits is generally high in fiber, water, minerals and vitamin C. Fruits also contain various photo chemicals and as research indicates they are required for proper long-term cellular health and disease prevention (Lewis, 2002). Regular consumption of fruit is associated with reduced risks of cancer, cardiovascular disease, stroke, Alzheimer disease, cataracts, and some of the functional declines associated with aging (Liu, 2003).

Usually the juices were pressed from over-ripe fruits and drunk immediately. If they hold for one day or more they partially ferment. The biggest imputes has been given to both fruit and vegetable juice by nutritionists, who want to make more vitamins, minerals and natural sugars available to the infants, invalids and senior citizens. The objective has been possible by horticulturists who develop “juice varieties” of fruit and vegetables. The growth of fruit and vegetable juices has been phenomenal and related to several breaks-through in technology. Chiefly among these were methods of eliminating sediment, flash pasteurization, concentrating, blending, freezing and drying or crystallization. The development of ready-to-drink juices, blends, concentrates and dry mixes has come about through series of technical developments during the last half century (Curtis, 1997).

1.2 Doum Palm:

Historically, the doum palm, *Hyphaene thebaica*, has been cultivated in Egypt since ancient times and has long been considered a sacred tree, symbolizing masculine strength. It was also planted in the belief that it protected and supplied people with shade, water and food after death (Wikipedia, 2010).

1.2.1 The fruit of doum tree:

The fruit has a quite spongy wall that is very rich in carbohydrates and is a good source of iron and niacin (FAO, 1988). Fruit pulp of doum, that covering of the fruit is edible and can either be pounded to form a powder or cut off in slices, the powder is often dried then added to food as flavoring agent; also fruit pulp is chewed to control hypertension. It tastes like gingerbread and when soaked in water until the pulp becomes soft and syrupy is much enjoyed by children (FAO, 1988). Sweet and bitter forms of the pulp are also known.

1.2.2 Nutritional Value:

Salih (1991) reported that doum contained 7.0% ash, 15.0 % crude fiber, 0.5% fat, 3.2% crude protein. Minerals were found to be 0.13%, 0.18%, 0.09% and 3.02% for Ca, Mg, Na and K respectively. Doum extract could be an important dietary source of phenolic compounds with high antioxidant and anticancer activities (Abou Elalla, 2009). Also the pulp is known to have antioxidant properties, antimicrobial activity and can also be used in stabilizing food against oxidative deterioration (Mohamed *et al.*, 2010).

1.2.3 Phytochemical properties:

Research on the fruit pulp of *H. thebaica* showed that it contains nutritional trace minerals, proteins and fatty acids, in particular the nutritionally essential linoleic acid (Kamis *et al*., 2003).

Identification of compounds, by thin-layer chromatography, showed that the fruit contains significant amounts of saponins, coumarins, hydroxycinnamates, essential oils and flavonoids, and the fruit also lowers blood pressure in animal models (Sharaf *et al*., 1972).

Also, the aqueous extract of doum fruits showed an antioxidant activity; this is due to the substantial amount of their water-soluble phenolic contents (Hsu *et al*., 2006) as well as anti-microbial activity (Mohamed *et al*., 2010).

1.3 Justification:

The formation of precipitated layer at the bottom of doum fruit traditional drink was the main problem hindering the industrial exploitation of doum pulp as base for commercial drinks, the precipitation might be due to the method of preparation of the drink, its high fiber content or due to the large size of doum fiber particles.

Generally, polysaccharides are the main cause of precipitation of fruit drinks. Cellulose ranks second in importance in the formation of a precipitated layer in fruit beverages due to their high molecular weights. Starch probably ranks third in the formation of precipitate. In addition, the hardness of water, the method of filtering of the extract, type of the fruit and the viscosity of drink probably affect formation of precipitates (A.Azim *et al*., 1981). Therefore, Stabilizing additives have been widely used in processed fruit drinks.

1.4 The Objectives:

The objectives of the present study were:

- To produce different doum drinks (traditional, with distilled water, with gum Arabic or CMC and filtered).
- To reduce or eliminate the precipitated layer so as to produce an attractive and marketable drink.
- To determine some of the physicochemical and microbial properties of the prepared doum drinks.
- To evaluate the above mentioned products organoleptically.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 Doum palm tree:

2.1.1 Taxonomy

Current name: *Hyphaene thebaica* (Hyphaene is derived from the Greek word ‘hyphaino’ referring to the fibres from the leaves, which are used for weaving).

Authority: (L.) Mart.

Family: Arecaceae.

Synonym**(s)**: *Corypha thebaica L.* and *Hyphaene guineense Schum. & Thonn*.

Common names: Dom (Arabic), doum palm, Egyptian doum palm, gingerbread palm (English), zembaba (Amharic), mkoma (Swahili), arkobkobai and kambash (Tigrigna) (Wikipedia, 2010).

2.1.2 Botanic description

Hyphaene thebaica is a deciduous palm 5-7 m high, with a girth of 90 cm. Trunk is Y-shaped, and the tree is easily recognizable by the dichotomy of its stem forming up to 16 crowns. The bole is fairly smooth but clearly showing the scars of the fallen leaves. Bark dark grey. Leaves 120 x 180 cm, fan shaped, in tufts at the ends of branches with the blade divided into segments about 60 cm long, margins entire; leaf stalk about 60 cm long, armed with curved thorns; petiole more than 1 m long, sheathing at the base with numerous upwardly curving hooks. Male and female flowers are on separate trees. The inflorescence is similar in both sexes, up to 1.2 m long, with short branches at irregular intervals and 2-3 spikes arising from each branch. Male flowers shortly stalked, solitary in pits of the spadix, spathe-bracts encircling the spadix, pointed. The female palm produces woody fruits that persist on the tree for a long time. They are 6-10 x 6-8 cm, smooth, rectangular to cubical, with rounded edges, shiny brown when ripe, about 120 g each when fresh, 60 g when dry, each containing a single seed. Seed 2-3.5 x 3 cm, ivory in colour, trunkate at base, apex obtuse (Wikipedia, 2010).

Hermaphrodite trees do occur rarely, but their fruits are smaller and sterile. In the Sudan, flowering occurs from February to April and fruiting from November onwards. First fruiting is after 6-8 years. Fruit ripens after 6-8 months, and fruiting takes place at the end of the dry season. In Nigeria, fruit appears in March and persists until the following season's flowers appear (Wikipedia, 2010).

2.1.3 Distribution:

Hyphaene thebaica is one of 11 species of this genus to be found in Africa. Widespread in the Sahel, it is known from Senegal to Egypt and the Sudan. East Africa records for this species usually refer to *H. compressa* H. Wendt. It is also found in parts of the Sahara where water occurs, in oases and wadis (Vogt, 1995).

The tree is native to Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Congo, Cote d'Ivoire, Democratic Republic of Congo, Egypt, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Kenya, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Sudan, Tanzania, and Togo. It is exotic to India (Wikipedia, 2010).

In Sudan it is found mainly along river and stream banks on silty soil. It can, however, be found away from rivers on more stony sites (Vogt, 1995).

2.1.4 Functional uses:

Tree: The doum tree is used in dune control and for shade.

Leaves: The leaves are probably the most important part of the palm, providing the raw material used in basketry, making mats, thatching, making string and in roofing (where the roots are also sometimes used). They are also browsed to a limited extent by livestock especially in dry periods (Vogt, 1995). Leaves may also be used as fuel (Wikipedia, 2010).

Wood: The wood is occasionally used for firewood and charcoal but more often in construction, providing supports and rafters for houses, posts for fencing and for building rafts. It can be cut by axe but is very difficult to saw due to the many fibers which make up the wood. Timber from male palms is said to be better than that of female palms as it is wood-borer proof, termite proof, decorative and durable (Vogt, 1995).

Root: Root fibres obtained after 2-3 days of soaking and beating of the roots are used for making fishing nets(Wikipedia, 2010).In local medicine roots are used in treatment of schistosomiasis (Vogt, 1995).

Sap: The sap is used to make a black dye often applied on leather (Vogt, 1995).

Fruit: The covering of the fruits is edible and sharply aromatic (hence the name Gingerbread palm) and can either be pounded off to form a powder, or cut off in slices. The powder from it is often dried and then added as a flavoring agent to food. In Turkana, Kenya, the powder is also used to make a mild alcoholic drink by adding water and milk and leaving it to stand (Vogt, 1995).

Seed: The seed inside the fruit is very hard and known as (Vegetable Ivory) is having been used commercially for making buttons and small carvings, but since the introduction of plastic, demand for this has dropped virtually to nil. Also, the sprouted seed is edible (palm cabbage) and the charcoal from the seed kernel is traditionally used to treat sore eyes in livestock (Vogt, 1995).

2.1.5 Chemical composition of doum fruit:

The mesocarp (pulp) of the fruits of H. thebaica was found to contain 12.65% ash, 89.25% carbohydrate, 0.95% oil, 316 mg/g glucose, very low protein content of 0.01% and calorific values of 3655.9 kcal/kg. The anti-nutritional factor, tannin, content was 8.30 mg/g. It also contains Ca (245.10 mg/100 g), Mg (236.45 mg/100 g), Fe (47.96 mg/100 g), Cu (0.38) and Zn (0.62). The minerals concentrations in the mesocarp seem to be adequate enough to provide livestock with the required metal essential for the biochemical activities. (Nwosu *et al*., 2008).

2.2 Juice:

2.2.1 Fruit Juice:

Fruit juice is the unfermented but fermentable liquid obtained from the edible part of sound, appropriately mature and fresh fruit or of fruit maintained in sound condition by suitable means including post harvest surface treatments applied in accordance with the applicable provisions of the Codex Alimentarius Commission (CODEX STAN 247, 2005). A single juice is obtained from one kind of fruit. A mixed juice is obtained by blending two or more juices or juices and purées, from different kinds of fruit. Some juices may be processed with pips, seeds and peel, which are not usually incorporated in the juice, but some parts or components of pips, seeds and peel, which cannot be removed by Good Manufacturing Practices (GMP), will be acceptable (CODEX STAN 247, 2005).

There are two basic juice product types that dominate today's markets, Reconstituted and single-strength juices (Ashurst, 2005).

The majority of fruit juice is made by reconstituting concentrated juice with water to a composition similar to that of the original state. Reconstituted juices are often packed in aseptic long-life containers such as TetraPaks.

There is in many countries a growing market for fresh 'single-strength' juice made by squeezing fruit, subjecting it to some processing, packaging it and selling it within a cold chain distribution system. Such juice is usually referred to as 'not from concentrate' and will have a shelf life that varies from 1 or 2 weeks to 2 or 3 months.

2.2.2 Concentrated Fruit Juice:

Concentrated fruit juice is the product that complies with the definition given above, except water has been physically removed in an amount sufficient to increase the Brix level to a value at least 50% greater than the Brix value established for reconstituted juice from the same fruit (CODEX STAN 247, 2005).

In the production of juice that is to be concentrated, suitable processes are used and may be combined with simultaneous diffusion of the pulp cells or fruit pulp by water provided that the water extracted soluble fruit solids are added in-line to the primary juice, before the concentration procedure (CODEX STAN 247, 2005).

Juice for concentration is normally subjected to screening to remove cellular debris and then fed to a one- or multi-stage evaporation process to remove most of the water and other volatile material. Evaporators today are highly efficient processing units: up to nine stages are used, sometimes with thermal recompression to obtain maximum efficiency (Ashurst, 2005).

2.2.3 Processing technology:

The juice is prepared by suitable processes, which maintain the essential physical, chemical, organoleptical and nutritional characteristics of the juices of the fruit from which it comes. The juice may be cloudy or clear and may have restored aromatic substances and volatile flavor components, all of which must be obtained by suitable physical means, and all of which must be recovered from the same kind of fruit. Pulp and cells obtained by suitable physical means from the same kind of fruit may be added (CODEX STAN 247, 2005).

In general terms, fruits are collected, sorted, washed, and then subjected to a type of mechanical compression appropriate to the fruit concerned. Although there are general fruit presses that can be used for more than one fruit type, fruits such as citrus, pineapple and stone fruits are usually processed in specially designed equipment. Some fruit types (e.g. pome fruits such as apples and pears) require mechanical treatment (milling) coupled with a biochemical process (involving enzymes) to break down the cellular structure and obtain best yields. It is possible to achieve almost total liquefaction by means of an appropriate enzyme cocktail.

Additionally, a diffusion or extraction process can be used to obtain best yields from certain fruits. If juice is to be sold as ‘not from concentrate’ it is usually screened and pasteurized immediately after pressing – an operation with two main objectives. The first is to control the growth of spoilage micro-organisms that live on the fruit surface (mainly yeasts and moulds). The second is to destroy the pectolytic enzymes that occur naturally in fruit that would otherwise break down the cloudy nature of the juice. If, however, a clear juice is required (e.g. apple or raspberry), enzymes can be added to accelerate this natural process.

Evaporators are used for concentrating juices and also to recover the volatile aromatic substances that are partly responsible for giving fruit juices their sensory characteristics. The re-addition of such volatiles is widely practiced at the point when concentrates are reconstituted into single strength juices. The issue of whether this should be obligatory has been clarified. European Council Directive 2001/112/EC (the Fruit Juices Directive) makes the addition of such volatiles at reconstitution obligatory. The UK 2003 Regulations (which are based on this Directive) state that reconstituted fruit juice is the product 'obtained by replacing, in concentrated fruit juice, water extracted from that juice by concentration, and by restoring the flavors' (Ashurst, 2005). After concentration, juices are normally held in storage until they are reconstituted. Some concentrated juices, particularly orange, require freezing at below −10˚C for effective preservation. Others, particularly apple, can be held at around 10–15˚C without risk of deterioration. The degree of concentration plays an important part in determining storage conditions: in the above examples, orange juice is normally concentrated to about 65 ˚Brix and apple to 70 ˚Brix. An alternative method of storage is to hold juices under aseptic conditions in drums or other containers. No particular temperature constraints then apply for microbial stability but there are a substantially increased risk of colour browning and taste deterioration if juices are held aseptically at temperatures above about 10 ˚C. Some juices are held in sulphited conditions (e.g. 1500–2000 p.p.m sulphur dioxide) but this is suitable only for juices destined for uses other than reconstitution as fruit juice (Ashurst, 2005).

There has also been a range of developments leading to the removal of acidity, color and minerals from clear juices such as apple. The product of such a combination of processes can be clear, colorless carbohydrate syrup that can be used in a variety of food processes. There seems little doubt that the legal status of such a product is not fruit juice; yet it is often, optimistically, so called. Another contentious issue is the further processing of fruit pulp, and especially citrus pulp. The addition of water to such a pulp can give an extract containing around 5% solids, which can be concentrated to around 65% and used to dilute (more expensive) pure juice (Ashurst, 2005).

2.2.4 Packaging:

Traditionally, most beverages were packed in glass. This has many attractive features, it is an excellent protective medium, but its overriding disadvantages are its weight and brittleness. Despite this, high volumes of soft drinks and juices are still packaged in glass, some of it multi-trip packaging. The development of the board–polymer–aluminum package used to form in-line boxes, which are packed aseptically, has been perhaps the outstanding packaging development for beverages. The pack provides an almost ideal combination of protection, minimal weight and economic size.

Various plastics have been used (HDPE, LDPE, PVC and PS), but the most important one is polyethylene terephthalate (PET). Bottles of this material are formed in a two-stage process. So-called pre-forms are made by injection moulding and, in a second process, are then stretch– blow-moulded to produce a bottle. PET has properties like those of glass, but it does not have the same disadvantages of weight and brittleness. PET can be laminated with other plastics, such as nylon and ethylene vinyl alcohol (EVOH), to give extremely good barrier properties, and polyethylene naphthalate (PEN) may enable production of a plastic bottle that can be pasteurized at high temperatures (Ashurst, 2005).

2.2.5 Adulteration:

The adulteration of fruit juices is widespread. Although adulteration is becoming increasingly sophisticated, it is normally seen as falling into one of three types (Ashurst, 2005):

(1) Over dilution of juices with water;

(2) Use of cheaper solid ingredients (particularly sugars);

(3) Blending of cheaper with more expensive juices.

2.2.6 Nutrition:

Fruit juice is important in human nutrition far beyond its use as a refreshing source of liquid. Many fruits contain a variety of minor ingredients, particularly vitamins and minerals, as well as carbohydrates, which are the predominant solid component. Although fruit contains small amounts of protein and fat, these are not important ingredients of juices.

Nutrients frequently consumed in sub-optimal concentrations by humans are proteins, calcium, iron, vitamin A, thiamin (vitamin B1), riboflavin (vitamin B2) and ascorbic acid (vitamin C). Some of these nutrients occur in higher concentrations in fruit juices than in other foods.

Fruit juice contains other substances claimed to have useful pharmacological activity. For example, limonin and other related limonoid substances are believed to have a role in inhibiting certain forms of cancer. Sorbitol has a laxative effect. Ascorbic acid, tocopherols (vitamin E), beta-carotene and flavonoids has antioxidant activity that can quench the singlet oxygen that can induce precancerous cellular changes. There are indications that these flavonoids have a useful protective action, in particular against some respiratory diseases, but they are readily decomposed in the body and it is impossible to maintain an effective concentration in the blood (Ashurst, 2005).

2.3 Formation of a precipitate in fruit juices:

Freshly prepared juice contains variable amounts of fine cellular debris with colloidal materials i.e. pectic substances, gums, proteins and other components. Spontaneous clarifications usually take place after the formation of protein-tannin complex. Insoluble pectates or multiple changes giving precipitate containing suspended material and a range of juice components.

Polysaccharides are the main cause of precipitations in fruit drinks, among the polysaccharides, pectins are best known for their natural stabilizing properties i.e. gelling nature. The pectic substances are defined by Kertes, (1951) as a group of complex colloidal carbohydrates derivatives, which occur in or prepared from plants, they contain a large proportion of anhydroglacturonic acid which is thought to exist in a chain-like unit. The cellulose ranks second in importance in the formation of precipitates due to its high molecular weight. Starch probably ranks third in importance. In addition, the hardness of water, the method of screening the juice, the fruit percentage, and the viscosity of drink, affect the formation of precipitate in fruit drinks (A.Azim *et al*., 1981).

2.4 Stabilizers and emulsifiers in beverages:

Stabilizers are additives used to help maintain emulsion or prevent degeneration in beverage (Buffo and Gary, 2000). They maintain emulsification, which prevent sedimentation, by keeping additional ingredients suspended in the product. Stabilizers add viscosity to enhance flavor and give body to a beverage, they also ensure that nutraceutical portion stays suspended as well as eliminating ingredients settling along with the gritty taste (Woodroof and Phillips, 1978).

Beverages emulsions are oil-in-water emulsions that are normally prepared as concentrates then diluted in sugar solution in order to produce the finished beverage. These emulsions are comprised of two categories: flavor emulsions and cloud emulsions. The former provides the beverage with flavor and cloudiness in certain formulae, whereas the latter provide only cloudiness with minimal or no flavor. In soft drink the beverage emulsion may provide flavor, color and suitable cloudy appearance (Buffo and Gray, 2000).

Among the most common stabilizers are hydrocolloids such as xanthan, gum arabic and gum acacia. Gum arabic is preferred in many applications for its shelf stability, particularly during refrigerated or frozen storage of the emulsion. Gum arabic is useful in stabilization for its ability to stabilize emulsions without adverse viscosity. These properties also make it useful for making instant spray-dried flavors to use in dry beverage mixes (Buffo and Gray, 2000).

2.5 Applications of Gum Arabic and Carboxyl Methyl Cellulose in the Food Industry:

A large variety of cellulose gum types is available, offering a viscosity and particle size range to convey the desired properties. The types were selected according to the kind of drink or base being prepared.

Gums for their high viscosity in solutions and inability to crystallize, are particularly suited to serve in foodstuff such as: thickeners for beverages, stabilizers for oil and water emulsions and as wider application where function is to prevent agglomeration and setting of minute particles. They are also used to incorporate flavors in confectionery such as pastilles and gum drops, and the preparation of lozenges. The role of gum arabic in confectionary products is usually either to prevent crystallization of sugar or to act as an emulsifier (Glicksman and Saud, 1983).

2.5.1 General properties of Gums:

- Cheap.
- Easily soluble in cold or warm water.
- Impart neither taste nor odour.
- Incompatible with the ingredients contained in fruit drinks.
- Withstand the low pH value found in fruit drinks
- Improve body and mouth feel.

2.5.2 The specific properties of Gums:

- Inhibit the pulp deposit during storage.
- Suppress the formation of an oil ring at the neck of bottle.
- Improve the appearance of the product.
- Mask the after taste to certain artificial sweeteners and the modulate perception of flavor.

Sodium CarboxyMethylCellulose (CMC) meets the purity criteria set by the European Union (EU), the Food and Agricultural Organization of the World Health Organization (FAO/WHO) and the food chemicals Codex of USA. The European Commission has assigned the number E466 to CMC in the classification of food additives of the European Union. The new EU directive on miscellaneous additives classifies CMC in the Annex 1 as "Generally permitted food additives for use in foodstuff (Hercules, 2002).

The used CMC concentration depends on the T.S.S, the pulp content in the base or in the juice and on the emulsion used, but typically between 0.1 – 0.4% (Hercules, 2002).

2.5.3 Characteristics of Gum Arabic:

Gum arabic is highly valued and much priced for the following characteristics:

- Viscosity: Solutions below about 10% gum arabic give low viscosity (Williams *et al*., 1990).
- Relation Structure/ Emulsifying properties: To explain the emulsifying and stabilizing power of *Acacia* gums, it has been proved that fraction of the molecule having high protein contents play an important role. The glycoproteins and arabinogalactan- protein fractions are fixed at interface oil/ water. Glucuronic acid develops negative charges around each oil droplets and creates electric repulsion forces (Williams and Phillips, 2007).
- Solubility: Gum arabic can yield aqueous solution up to 55% concentration. It is truly soluble in water, even cold water (Awad Elkarim, 1994).
- Crystallization: The aqueous solution of gum Arabic does not crystallize even when a very concentrated solution is subjected to a very low temperature. This is advantageous in the many and varied applications of gum arabic (Awad Elkarim, 1994).
- Biodegradation: There is little or no degradation of gum arabic by microorganism. This characteristic of the gum is of great importance in food industry (Awad Elkarim, 1994).
- Toxicity: Gum arabic is non toxic (Ross *et al*., 1983).

Acid stability: Gum arabic is stable in acid solution. And products such as citrus oil emulsions exhibit good shelf stability (Imeson, 1997).

2.5.4 Functional uses of gum arabic in foods:

Gum arabic is used in different foods for its different functions (Williams and Phillips, 2007).

- It is used in flavors and beverages as emulsifying, stabilizing and wetting agent; for oil, flavor and juice encapsulation and for pulp suspension, emulsification and thickening. It is also used for tannin suspension and colloidal stabilization.
- It is used in confections as coating and film forming agent, as source of fiber, to prevent sugar crystallization and as softener and emulsifier.
- It is used in poultry, meat and dressings to improve moisture, fat, flavor and brine retention; to improve texture and freeze- thaw stability. It is also used as gelling, water and fat stabilizing and emulsifying agent and for heat stabilization.
- In dairy products as milk gelling, thickening and film forming agent, to enhance the mouth feel and the creamy texture, and for fat, protein and foaming stabilization in addition to ice cream stabilization.
- It is used for surfacing, glazing and adhesion of spices and/or flavor, as moisture and oxygen barrier, to improve sugar adhesion and texture and bowl life of grocery products.

2.5.5 Safety of Gum Arabic as Food Additives:

International attention has been given to the safety of food additives since 1956 when the FAO and WHO through the formation of A Joint Expert Committee on Food Additives (JECFA) comprising the acknowledge international expert, began to demand, collect and evaluate data upon which decision regarding safe level of use of approved additives could be based (UN/WHO, 1961).

In 1961; specification for the identity and purity of gum arabic based on American Food Chemicals Codex Specification, were prepared and an evaluation "Not limited except by food manufacturing practice" was made (FAO, 1969). These specifications were received in 1973 without change in the accepted unlimited level of gum arabic (FAO, 1973).

CHAPTER THREE

3. MATERIALS AND METHODS

3.1 Materials:

3.1.1 Doum fruit pulp:

Fully ripped edible Doum fruit slices were procured from Abumasaoud local market in Elobied, North Kordofan State, Sudan. The ready to eat pulp was packed in poly ethylene bags for consumers.

3.1.2 Gum Arabic (mechanical powder):

Gum arabic powder was obtained from Warm Seas Company, Elobied–Sudan.

3.1.3 CarboxyMethylCellulose (CMC):

CMC was kindly provided by Crystal Company, Khartoum North-Sudan.

3.2 Preparation of doum drinks:

Five different types of doum drinks were prepared as follows:

3.2.1 Traditional method of doum drink preparation:

The traditional method commonly used in western Sudan (Nyala town, South Darfur State) was adopted. About 250 g slices of doum fruit pulp were weighed, soaked in 2 liter tap water for 5 hours, sieved using kitchen strainer. Then 150 g refined cane sugar were added. The final product was filled in polyethylene terephthalate (PET) bottles then kept for further investigation and named as Doum tra.

3.2.2 Doum Drink with distilled water:

Two hundred and fifty grams of doum fruit pulp were weighed, steeped in 2 liter distilled water for 5 hours, strained using kitchen sieve strainer. Then 150 g refined cane sugar were added. The drink was packed in

PET bottles then subjected to pasteurization (65-70 C, 15 min) and designated as Doum distl.

3.2.3 Doum Drink with gum arabic:

Two hundred and fifty grams of doum fruit ready to eat pulp were weighed, macerated in 2 liter tap water for 5 hours, sieved using ordinary strainer. Then 150 g refined cane sugar and 3% gum arabic powders were added. The drink was filled in PET bottles, pasteurized (65-70 C, 15 min) and labeled as Doum gum.

3.2.4 Doum Drink with CarboxyMethylCellulose:

Two hundred and fifty grams of doum fruit pulp were weighed, soaked in 2 liter tap water for 5 hours, sieved using kitchen strainer. Then 150 g refined cane sugar and CMC 1g/l were added. The drink was filled in PET bottles then pasteurized (65-70 C, 15 min) and named as Doum CMC.

3.2.5 Doum Drink prepared by Filtration:

Two hundred and fifty grams slices of doum fruit pulp was weighed, soaked in 2 liter tap water for 5 hours, sieved using kitchen strainer. Then 150 g refined cane sugar were added. Finally the drink was filtered using Whatman filter paper (No. 4). The drink was filled in PET bottles then subjected to pasteurization (65-70 C, 15 min) and named as Doum filt.

3.3 Physico - chemical Analysis:

3.3.1pH measurement:

The pH was determined using a pH-meter (Hanna instruments 8521). Two standard buffer solutions of pH 4.00 and 7.00 were used for calibration of the pH meter at room temperature.

The pH meter was allowed to stabilize for one minute and then the pH of the samples was directly reported.

3.3.2 Titrable acidity:

Total acidity (mg/100 ml) expressed as citric acid was determined according to Ranganna (1977). Ten ml of sample were titrated against 0.1N NaOH to pH 8.1. Total acidity was calculated using the following equation:

$$\text{Total acidity (mg citric acid/100 ml drink)} = \frac{\text{ml (NaOH)} \times \text{N (NaOH)} \times \text{eq. wt acid} \times 100}{10}$$

3.3.3 Total Soluble Solids (TSS):

The total soluble solids (TSS) were determined at room temperature using hand refractometer with degree °Brix scale 0 – 50 according to AOAC (1984) standard methods.

3.3.4 Viscosity:

The viscosity of each sample (50 ml) was measured according to the method of Quinn and Beuchat (1975) using Brookfield viscometer, spindle no. 4, speed 30 rpm at room temperature. The viscosity was expressed in centipoises (cps).

3.3.5 Total and Reducing sugars:

Total and reducing sugars were determined according to Lane and Enon titrometric methods (AOAC, 1984).

Hundred ml of each product were filtered through Whatman filter paper (No. 4) and transferred to a 250 ml volumetric flask. 100 ml of distilled water were carefully added and then neutralized with 1.0 N NaOH to pH 7.5 – 8.0. About 2 ml of lead acetate were added and the flask was then shacked and left to stand for 10 minutes. Then 2 g of sodium oxalate were added to remove the excess lead. Distilled water was again added to make the volume to mark (250 ml). The solution then filtered and 50 ml of the filtrate were pipetted into a 250 ml volumetric flask. Concentrated Hydrochloric acid (6.5 ml) was added to the new mixture. The contents of the flask were boiled gently for 10 minutes to invert the sucrose and when cooled, a few drops of phenolphthalein were added. In order to neutralize the mixture, a 20 % NaOH solution was continuously added until the color of the mixture disappeared, and the volume was made to the mark before titration.

Standard method of titration: Ten ml of a mixed solution of Fehling (A) and (B) were pipetted into conical flask. A burette was filled with the clarified sample. The solution was then added to the conical flask to reduce Fehling solution until 0.5 – 1.0 ml was still required to complete the titration. The contents of the flask were mixed and heated to boiling for 2 minutes. Three drops of methylene blue indicator were added. Titration was then completed until the color was completely disappeared.

Calculation:

$$\text{mg Total sugars in 100 ml} = \frac{\text{Factor} \times 100}{\text{Titer}}$$

(The factor is obtained from the Table of invert sugars) The filtrate can be used directly for titration according to Lane and Enon using the following equation for calculation:

$$\text{Reducing sugars (mg/100 ml)} = \frac{\text{mg/100 ml} \times \text{dilution} \times 100}{1000 \times \text{volume taken}}$$

3.4 Microbiological Analysis:

The microbiological analysis was carried out according to Harrigan (1998).

3.4.1. Total viable count of bacteria (TVC):

Plate count agar (PCA), prepared according to the instructions of the manufacturers, and was used for enumeration of bacteria. The medium was allowed to boil until it was completely dissolved and then autoclaved for 15 min at 121 ˚C under 15 Ib/inch^2 pressure.

Well homogenized samples were serially diluted with 0.1% peptone water up to 10^{-6}. One ml aliquot from a suitable dilution was transferred aseptically into sterile Petri dishes. To each plate about 15 ml of melted and cooled PCA were added. The incubation was evenly mixed with media by rotating the plates and allowing solidifying. The inverted plates were then incubated for 48 hrs at 37 ˚C. The TVC (CFU/ml) was determined using a colony counter.

3.4.2 Yeast and mould enumeration:

Potato dextrose agar (PDA), prepared according to the instructions of the manufacturers, was used for enumeration of yeast and mould. The medium was allowed to boil until it was completely dissolved and then autoclaved for 15 min at 121 ˚C under Ib/inch^2 pressure.

Well homogenized samples were serially diluted with 0.1% peptone water up to 10^{-6}. Aliquots (0.1 ml) from a suitable dilution were transferred aseptically into solidified PDA plates. Samples were spread all over the surface of the plates using sterile bent glass rod. The plates were then incubated for 48 to 72 hrs at 28 ˚C. Counting (CFU/ml) was carried out by using colony counter.

3.4.3 Total coli form bacteria:

MacConkey broth, prepared according to the instruction of the manufacturers, was used for detection of coli form bacteria by the multiple tube technique. The medium was distributed in 9 ml quantities standard test tubes with inverted Durham tube and then autoclaved for 20 min at 121˚C.

Well homogenized samples were serially diluted (10^{-1}, 10^{-2} and 10^{-3}) with 0.1% peptone water. One ml from each dilution was aseptically inoculated into triplicates of 9 ml sterile MacConkey broth in standard test tubes. The inoculated tubes were then inoculated for 48 hrs at 37 ˚C. Positive tubes gave gas in the Durham tubes and change the color of the medium.

3.4.4 Detection of *Salmonella*:

Nutrient broth, prepared according to the instruction of the manufacturers, was used for detection of *Salmonella.* The medium was transferred to sterile 100 ml bottle and then autoclaved for 15 min at 121˚C. Ten ml of well homogenized sample were aseptically added to the media and incubated at 37 ˚C for 24 hrs.

One ml of the inoculated Nutrient broth was aseptically transferred to a test tube containing 10 ml sterile cystin broth and incubated at 37 ˚C for 24 hrs. The previously incubated media was then inoculated into a sterile Bismuth sulphite agar plate by means of sterile loop and incubated at 37 ˚C for 24 to 72 hrs. Black sheen discrete colonies indicate the presence of *salmonella.*

3.4.5 Detection of *Staphylococcus aureus*:

Baird parker medium, prepared according to the instruction of the manufacturers, was used for detection of *Staphylococcus aureus.* The medium was autoclaved for 15 min. at 121˚C under Ib/inch^2 pressure.

Well homogenized samples were serially diluted with 0.1% peptone water up to 10^{-6}. Aliquots (0.1 ml) from each dilution were transferred aseptically into the surface of each well dried Baird parker plate. The plates were then incubated for 24 to 26 hrs at 37 ˚C. Black shiny convex colonies surrounded by clearing zone of 2 to 4 min. in width indicate the presence of *Staphylococcus aureus.*

3.5 Organoleptic Evaluation:

The five types of Doum drink were subjected to panel test which was carried out at the lab of Dept. of Biochemistry and Food Science, University of Kordofan. Samples were tested using Ranking Test as described by Ihekoronye and Ngoddy (1985). Judges were requested to examine the products according to quality attributes and then rank the products from the best (rank 1) to the least in quality (last rank). Results were statistically analyzed by Tables provided by the Ihekoronye and Ngoddy (1985) at 5% level of significance.

3.6 Statistical Analysis:

Data assessed by analysis of variance (ANOVA) (Snedecor and Cochran, 1987) using CRD with three replicates. Means were compared using Duncan's Multiple-Range Test (Duncan, 1955) with probability ($P \leq 0.05$).

CHAPTER FOUR

4. RESULTS AND DISCUSSION

In this study, Doum fruit pulp slices were used to prepare five types of drinks: using the traditional method (Doum tra), distilled water (Doum distl), 3% gum arabic (Doum gum), 1 g/L CarboxyMethylCellulose (Doum CMC) and filtration (Doum filt). The above treatments were employed to eliminate or reduce pulp sedimentation.

4.1 The Physicochemical Properties of Doum Drinks:

The physicochemical properties of the five doum drinks are presented in Table 1.

4.1.1. pH:

The pH of the traditional doum drink was (5.10). Doum filt and doum distil showed pH values of 5.16 and 5.15, respectively. No significantly different ($P \leq 0.05$) were observed among the above mentioned beverages. On the other hand, Doum gum and Doum CMC drinks demonstrated analogous pH values of 4.76 and 5.03, respectively.

Present findings were higher than the range of 2.5–4.0, at which satisfactory results of beverages preservation are achieved (Woodroof and Phillips, 1978). Recently, the pH of doum beverage primed from concentrated (53 TSS) doum pulp extract was found to be 4 (Abaker, 2010). pH values ranging from 2.9 to 3.3 were reported for baobab beverages containing different concentrations of gum arabic (Abdalla *et al*., 2010). Moreover, Alrikain (2004) reported pH value of 4.0 for the fresh admired Sudanese drink gudeim prepared from the wild fruits of *Grewia tenax*.

It is obvious that application of gum arabic and CMC significantly ($P \leq 0.05$) reduced the pH value compared to Doum tra (control), whereas filtration and using distilled water did not affect the pH.

4.1.2. Titrable acidity:

The drink that prepared by addition of gum arabic showed significant ($P \leq 0.05$) the highest acidity (213.33 mg citric acid/100 ml). On the contrary, Doum CMC, Doum tra and Doum distl drinks demonstrated significantly ($P \leq 0.05$) slighter lower acidity (157.87, 153.00 and 134.13 mg/100ml, sequentially). However, the filtrated drink (Doum filt) exhibit significantly ($P \leq 0.05$) the lowest acidity (93.87 mg/100ml). Lately, Abaker (2010) reported 31-34 mg/100 ml total acidity for different doum beverages.

Gum arabic significantly ($P \leq 0.05$) elevated the acidity matched to the control. In contrast, filtration and preparation with distilled water significantly ($P \leq 0.05$) reduced it. Addition of CMC exerted no effect on the acidity of doum drink.

4.1.3. Total soluble solids (TSS):

As presented in Table 1, the tested drinks showed significantly different ($P \leq 0.05$) total soluble solids. Filtration as well as utilizing distilled water notably reduced the TSS from 7.3 Brix sequentially ($P \leq 0.05$) to 7 and 6 Brix. Conversely, application of CMC and gum arabic markedly raised the Brix to 8 and 10, respectively.

The exceeding TSS values agree with recommended range of 7 to 14 Brix of the American Beverage Association. Abaker (2010) reported Brix values ranging from 12 to 14 for carbonated and non carbonated doum drinks. However, related total soluble solids value of 9.4 Brix was reported for gudeim fresh juice (Alrikain, 2004). For Roselle carbonated beverage 14

Brix was formerly reported (Abd Allah, 2007), likewise a higher value of 15.7 Brix was reported for tamarind carbonated drink (Mustafa, 2007).

4.1.4. Viscosity:

Concerning viscosity, significant ($P \leq 0.05$) variations were observed among the different doum beverages (Table 1). Elevated values of 17.5 and 16.8 cps were recorded consecutively for Doum gum and Doum CMC, whereas Doum tra and Doum distl exhibited moderate figures of 12.8 and 11.5 cps, respectively. Doum filt gave lower viscosity of 9.7 cps. Current results were comparable to the range 6.7-15.5 reported for baobab beverages containing 1 to 3% spray dried gum arabic (Abdalla *et al*., 2010).

Gum arabic and CMC brought significant ($p \leq 0.05$) enhancement in the viscosity of the drinks compared to Doum tra. Using distilled water as well as filtration apparently reduced the viscosity. Recently, Abdalla *et al*. (2010) concluded that the gradual increase in the percentage of cleaned gum (from 1% to 3%) resulted in a corresponding elevation in the viscosity of baobab beverages.

Table (1) The Physicochemical properties of doum drinks:

Samples	pH	Titrable acidity (mg/100 ml)	TSS (˚Brix)	Viscosity (cps)
Doum tra	$5.10^{a} \pm 0.10$	$153.00^{b} \pm 13.00$	$7.3^{c} \pm 0.00$	$12.83^{c} \pm 0.15$
Doum distl	$5.15^{a} \pm 0.30$	$134.13^{c} \pm 0.23$	$6.0^{e} \pm 0.00$	$11.50^{d} \pm 0.20$
Doum gum	$4.76^{b} \pm 0.06$	$213.33^{a} \pm 9.77$	$10.0^{a} \pm 0.00$	$17.50^{a} \pm 0.70$
Doum cmc	$5.03^{b} \pm 0.06$	$157.87^{b} \pm 3.69$	$8.0^{b} \pm 0.00$	$16.83^{b} \pm 0.15$
Doum filt	$5.16^{a} \pm 0.06$	$93.87^{d} \pm 3.69$	$7.0^{d} \pm 0.00$	$9.70^{e} \pm 0.09$

- Each value is an average of three replicates. Values are means ± SD.
- Means not sharing a similar superscript letter(s) in a column are significantly different at ($P \leq 0.05$) as assessed by Duncan's Multiple Range test.

4.2. Sugars Content of Doum Drinks:

Total, reducing and non reducing sugars contents (mg/100 ml) are shown in Table 2.

4.2.1. Total sugars:

The five types of doum drinks were found to contain significantly ($P \leq 0.05$) different total sugar contents. Doum filt showed the maximum level (84.20 mg/1oo ml) followed by Doum CMC (80.80 mg/100 ml) then Doum gum (71.93 mg/100 ml) and Doum distl (66.84 mg/100 ml). Though, Doum tra demonstrated the minimum total sugar concentration (49.11 mg/100 ml). It is clear that the four treatments significantly ($P \leq 0.05$) increased the total sugar content of doum drinks. Formerly, total sugars contents of baobab beverages containing 1-3% gum arabic were found to be 301.2-336.7 mg/100 ml (Abdalla *et al*., 2010).

The gradual increase in the total sugar contents can be attributed the gradual clarification of the drinks which may improve the sensitivity of the method used for determination of the total sugars.

4.2.2. Reducing sugars:

Interestingly, reducing sugars contents showed the same trend of the total sugars The uppermost concentration (47.01 mg/100ml) was found in Doum filt, reasonable contents (39.89 and 25.53 mg/ml) were detected sequentially ($P \leq 0.05$) in Doum CMC and Doum gum. The lowest concentration (19.33 mg/100ml) was exhibited by the traditional drink (Doum tra).

Abdalla *et al*. (2010) stated that the reducing sugars content of baobab beverages containing cleaned gum was in the range of 274.5 to 290.5

mg/100 ml, while that for beverages containing spray dried gum varied from 295.7 to 313.9 mg/100 ml.

4.2.3. Non reducing sugars:

As indicated in Table 2, Doum distl and Doum gum beverages showed equivalent levels of non reducing sugars (44.72 and 47.07 mg/100ml, respectively), which were significantly ($P \leq 0.05$) higher compared to the remaining products. Doum CMC drink contained significantly ($P \leq 0.05$) superior non reducing sugars content (40.96 mg/100ml) matched to that for Doum filt and Doum tra (36.98 and 30.46mg/100ml, respectively). However, the later two drinks demonstrated significantly ($P \leq 0.05$) different non reducing sugars concentrations.

Table (2) Sugars content (mg/100 ml) of doum drinks:

Samples	Total sugars	Reducing sugars	Non reducing sugars
Doum tra	$49.11^{e} \pm 2.21$	$19.33^{e} \pm 1.15$	$30.64^{d} \pm 2.13$
Doum distl	$66.84^{d} \pm 0.00$	$22.07^{d} \pm 0.59$	$44.72^{a} \pm 0.64$
Doum gum	$71.93^{c} \pm 2.31$	$25.53^{c} \pm 0.85$	$47.07^{a} \pm 2.04$
Doum CMC	$80.80^{b} \pm 0.00$	$39.89^{b} \pm 0.35$	$40.96^{b} \pm 0.33$
Doum filt	$84.20^{a} \pm 0.00$	$47.01^{a} \pm 2.01$	$36.98^{c} \pm 1.98$

- Each value is an average of three replicates. Values are means ± SD.
- Means not sharing a similar superscript letter(s) in a column are significantly different at ($P \leq 0.05$) as assessed by Duncan's Multiple Range test.

4.3. Microbial Assay of Doum Drinks:

As illustrated in Table 3, the fresh traditional doum beverage showed low bacterial total viable count (TVC) of 1.8 x 10^3 CFU/ml. The total viable count was drastically reduced to 3.3 x 10^2 CFU/ml due to filtration. Preparation with distilled was slightly increased the TVC of the doum drink to 2.9 x 10^3 CFU/ml. addition of CMC markedly elevated the TVC to 8.3 x 10^3 CFU/ml. The total viable count of bacteria was enormously raised to 17.6 x 10^3 CFU/ml owing to addition of gum Arabic.

Interestingly, the five types of doum drinks were proved to be free from contamination of yeast, mould and coli form bacteria. Also the beverages were devoid from pathogenic bacteria (*Staphylococcus aureus* and *Salmonella*). The fresh baobab beverage was reported to have only negligible (10 CFU/ml) total viable count of bacteria (Abdalla *et al*., 2010). However, Gudeim juice was found to contain sequentially 3.82, 1.85 and 3.07 log1o CF/ml total plate count (TPC), coli form and yeast and mould (Alrikain, 2004).

Table (3) Microbial Assay of doum drinks:

Samples	Total viable count of bacteria (CFU/ml)	Total count of Fungi		Total coliform	*S. aureus*	*Salmonella*
		Yeast	Mould			
Doum tra	1.8×10^3	Nil		-ve	-ve	-ve
Doum distl	2.9×10^3	Nil		-ve	-ve	-ve
Doum gum	17.6×10^3	Nil		-ve	-ve	-ve
Doum cmc	8.3×10^3	Nil		-ve	-ve	-ve
Doum filt	3.3×10^2	Nil		-ve	-ve	-ve

4.4. Organoleptic Test of Doum Drinks:

According to the results of panel test (ranking) shown in Table 4, Doum filt drink showed significantly ($P \leq 0.05$) the best color, appearance, precipitate volume and overall quality when matched or compared to the rest of the products. Doum gum beverage exhibited the most inferior quality characteristics. Doum tra, Doum distl and Doum CMC drinks showed significantly identical color, appearance, precipitate volume and overall quality, which was superior to that of Doum gum. Interestingly, the five products gained significantly ($P \leq 0.05$) related aroma and bodyness, even so Doum filt was relatively the most excellent.

Apparently, the taste and bodyness attributes were not affected by the treatments (filtration as well as addition of gum and CMC). On the other hand filtration improved color, appearance, overall quality and reduced the precipitate volume. Nevertheless, addition of CMC only slightly reduced the precipitate volume, but insignificantly ($P \leq 0.05$) defect the other quality characteristics. Significant ($P \leq 0.05$) deterioration in color, taste, appearance, overall quality and precipitate formation was observed as a result of gum Arabic application compared to the traditional drink (control). Preparation of doum beverage using distilled water slightly improved color, appearance, overall quality and precipitate formation, but sparingly worsen aroma, taste and mouth feeling.

Table (4) Organoleptic Test of doum drinks:

Samples code	Sum of ranks						
	Color	Aroma	Taste	Precipitate	Appearance	Mouth feeling	Overall quality
Doum tra	55[b]	44[b]	49[b]	59[b]	50[b]	40[b]	49[b]
Doum distl	43[b]	48[b]	50[b]	42[b]	46[b]	51[b]	45[b]
Doum gum	79[c]	64[b]	66[c]	81[c]	70[c]	63[b]	75[c]
Doum cmc	56[b]	59[b]	51[b]	51[b]	63[b]	58[b]	56[b]
Doum filt	21[a]	39[b]	40[b]	17[a]	29[a`]	39[b]	30[a]

Sum of ranks having different superscript letter (s) in a column differ significantly ($P \leq 0.05$). [a < 38] [b = 38 – 64] [c > 64]

.

CHAPTER FIVE

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS:

In this study, doum fruit pulp was used to prepare four types of beverages in addition to the traditional doum drink. Distilled water, gum arabic, CMC and filtration treatments were separately used to prevent precipitate formation (pulp sedimentation). All products were examined for physicochemical, microbiological and organoleptic qualities.

- Beverage containing gum arabic and CMC showed significantly ($P \leq 0.05$) lower pH values but higher acidity, TSS, viscosity and sugars.
- Filtration resulted in a doum beverage with significantly ($P \leq 0.05$) lower acidity, TSS, viscosity and significantly ($P \leq 0.05$) higher sugars.
- The five types of doum drinks were proved to be free from contamination of yeast, mould, coli form, *Staphylococcus aureus* and *Salmonella*.
- Filtrated doum drink was confirmed to be the best product owing to its highly acceptable sensory characteristics. The product was also virtually free from precipitated pulp.

5.2 RECOMMENDATIONS:

In view of the promising results of the present study it's recommended that:

- The filtrated doum drink showed organoleptically acceptable qualities, therefore, development of such novel product should be encouraged.
- More studies on keeping quality, shelf life and packaging of the present product are needed.
- Substances responsible for precipitate formation in doum drinks require further investigation to reveal their nature.
- Much attention and scientific awareness should be devoted to traditional Sudanese foods and drinks, particularly those derived from doum fruit, in order to be utilized at industrial level.
- Many efforts should be directed to mechanically obtain Doum slices.

REFERENCES

A.Azim, **A. M. Nour; A/Gayoum, A. A. and Abdalla, E. (1981).** Elimination of Precipitate in Concentrated Orange Drink Product in the Sudan. Sudan, J, Food Science Technology 13:1-6. (Cited from Mohammed, 2004).

Abaker, A. A. M. (2010). Some chemical constituents of doum fruit pulp (*Hyphaene thebaica*) and its utilization in the preparation of beverages and jam manufacture. M.Sc Dissertation. University of Gezira, Sudan.

Abd Allah, S.O. (2007). Preparation of a carbonated beverage from roselle (*Hibiscus sabdariffa* L.) concentrate. Msc Thesis, University of Khartoum, Sudan.

Abdalla, A. A.; Yagoup, N. E.H. and Mudawi, H. A. (2010). Production and quality evaluation of baobab (*Adansonia Digitata*) Beverages Journal of Applied Sciences Research, 6(6): 729-74

Abu-Elalla, F. M. (2009). Antioxidant and anticancer activities of doum fruit extract *(Hyphaene thebaica)* African Journal of Pure and Applied Chemistry Vol. 3 (10), pp. 197-201.

Alrikain, A. E. M. S. (2004). The yield and characteristics of gudeim (*Grewia tenax*) juice. M.Sc Thesis. University of Khartoum, Sudan.

AOAC (1984). Official Method of Analysis.14th Edn. Association of Analytical Chemists. Washington, D. C, USA.

Ashurst, P. R. (2005). Chemistry and Technology of Soft Drinks and Fruit Juices. Second Edn. Blackwell Publishing Ltd, UK.

Awad Elkarim, M. M. E. (1994). Analysis studies on some crude and processed gum Arabic Samples with regard to quality aspects. M.Sc. Thesis, University of Khartoum, Sudan.

Buffo, R. and Gary, R. (2000). Beverages emulsions and utilization of gum *Acacia* as emulsifier/stabilizer. Perfumer and Flavorist, 25: 24 – 44.

CODEX STAN 247(2005). Codex General Standard For Fruit Juice and Nectars.

Curtis, L. (1997). Food product Design: Juice Up. WWW. Food product design. Com/ articles/archives/0797CS.

Duncan, B.D. (1955). Multiple ranges and multiple F-test. BIOMETRICS, 11: 1-42.

FAO (1969). Nutrition Meetings Report, Rome, Series No. 46A: 97-98.

FAO (1973). Food and Nutrition, Rome, Paper No. 25: 93-98.

FAO/WHO (1988) Traditional food plants, FAO Food and Nutrition paper 42. Rome.

Glicksman, A.M and Saud, R.E. (1983). In whistler, R. L. ed "Industrial Gums" 2nd ed. Academic Press New York.

Harrigan, W. F. (1998). Laboratory Methods in Microbiology. Academic Press, California, USA.

Hercules (2002). Technical Information. Squashes, Fruit Juice Beverages and Soft Drinks with Blanose Cellulose Gum 7HOF and 7H5SCF. Widnes/UK. Pp: 1-3.

Hsu, B.; Coupar, I. M. and Ng, K.(2006). Antioxidant activity of hot water extract from the fruit of the Doum palm, Hyphaene thebaica. Food Chemistry. 98: 317-328.

Ihekoronye, L.J. and Ngoddy, P.O. (1985). Integrated Food Science and Technology for the Tropics. Edu. MacMillan Publishers, London.

Imeson, A. (1997). Thickening and gelling agents for food. Second Edn. Blakre Academic 7 Professional, an imprinter of Champan 7 Hall, 2-6. Bondary Ro, London, SE/8HN, UK.

Kamis, A. B.; Modu, S.; Zanna, H. and Oniyangi, T. A. (2003). Pre-liminary biochemical and haematological effects of aqueous suspension of pulp of hyphaene thebaica (l) mart in rats. Biokemistri. 13:1-7.

Kertes, Z. I. (1951). The Pectic Substances. Newyork: Inter Science Publishers. Inc., pp 193. (Cited from Mohammed, 2004).

Lewis, S. (2002). CRC Dictionary of Agricultural Sciences. CRC Press, Pp 375-376.

Liu, R. H. (2003). Health Benefits of Fruit and Vegetables are from Additive and Synergistic Combinations of Phytochemical. American Journal of Clinical Nutrition, Vol. 78, No. 3, 517S-520S.

Mohamed, A. A.;Khalil, A. A. and El-Beltagi, H.E. (2010). Antioxidant and Antimicrobial Properties of kaff maryam *(Anastatica hierochuntica*) and Doum Palm *(Hyphaene thebaica)* GRASAS Y ACEITES, 61 (1), ENERO-MARZO, 67-75, 2010, ISSN: 0017- 3495, DOI: 10.3989/gya.064509.

Mohammed, A. E. (2004). Elimination of A Precipitated layer in Concentrated Squash of Tabaldi (*Adansonia Digitata*) Fruit. M.Sc. Thesis, University of Khartoum, Sudan.

Mustafa, G.A. (2007). Preparation of Carbonated Beverage from Locally Grown Tamarind Fruit (Aradaib). M.Sc Thesis, Sudan Academy of Science, Khartoum, Sudan.

Nwosu, F. O.; Dosumu, O. O. and Okocha, J.O. (2008). The Potential of Terminalia catappa (Almond) and Hyphaene thebaica (*Doum palm*) Fruits as Raw Materials For Livestock Feed. Department of chemistry, University of llonin,P,M,P1515 llonin, Nigeria.

Quinn, **M.R. and Beuchat, L.R. (1975).** Functional properties changes resulting from fungal fermentation of peanut flour. J. Food Sci., 43:1270 -1275.

Ranganna, **S. (1977).** Manual of Analysis of Fruits and Vegetable Products. Tata McGraw-Hill Publishing Company Limited, New York, USA.

Ross, A. H. M.; Eastwood, M. A.; Brydon, W. G. and Anderson, D. M. W. (1983). The Metabolic Effect of Gum Arabic (Acacia senegal) in Humans. American Journal of Clinical Nutrition, 37: 368- 375.

Salih, O.M. (1991). Biochemical And Nutritional Evaluation of Famine Foods of the Sudan PhD thesis Faculty of Agriculture Univ. of Khartoum. Sudan.

Sharaf, A.; Sorour, A.; Gomaa, N. and Youssef, M. **(1972).**Some pharmacological studies on Hyphaene thebaica. Qualitas Plantarium Materiae Vegetables. 22(1), 83-90.

Snedecor, G.W. and Cochran, **W.G. (1987).** Statistical methods, 7 edn. Iowa th State University Press, USA

UN/WHO (1961).WHO Chronicle, 12: 52-55.

Vogt, K. (1995). A field guide to the identification, propagation and uses of common trees and shrubs of dry land Sudan. SOS Sahel International (UK).

Wikepedia (2010). Free encyclopedia,
http://en.wikipedia.org/wiki/*Hyphaene_thebaica*

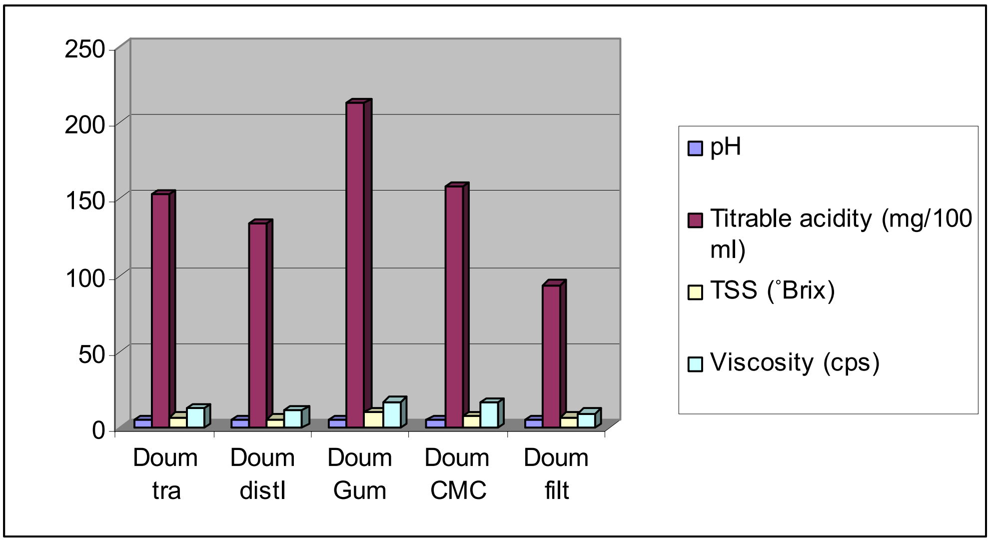
Williams, P. A. and Phillips, G. O. (2007). "Gums and Stabilizers for the Food Industry. Royal Society of Chemistry, Cambridge UK (2008).

Williams, P**. A.; Phillips, G. O. and Randall, R. C. (1990).** Structure Function Relationship of Gum Arabic. In: Gums and Stabilizers for Food Industry. Vol. 5, IRL Press, Oxford, Uk.

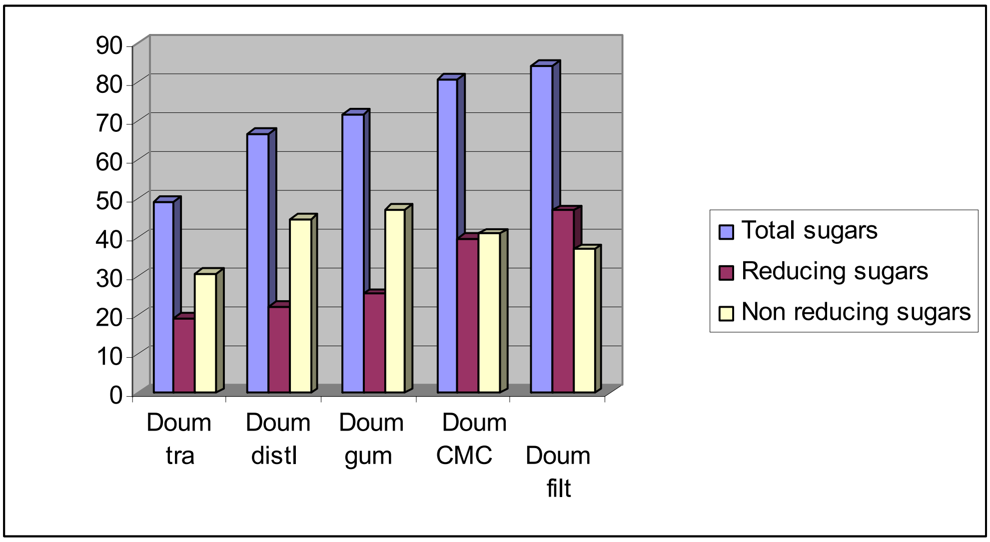
Woodroof, J. K. and Phillips, G. F. (1978). Beverages: Carbonated and non carbonated. Third Edn. Avi Publishing company, INC.

APPENDICES

Appendix (1) The Physicochemical properties of doum drink:



Appendix (2) Sugars content (mg/100 ml) of doum drinks:



Appendix (3) Doum filt

Doum drink prepared by filtration

Appendix (4) Doum CMC

Doum drink prepared with Carboxy Methyle Cellulose

Appendix (5) Doum Tra

Doum drink prepared by Traditional method

Appendix (6) Doum Gum

Doum drink prepared with Gum arabic

Appendix (7) Doum Distl

Doum drink prepared by Distilled water