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Estimation of the Active Components in Gum Arabic Collected from Western Sudan

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Abstract: ***Gum Arabic is a natural product from the trees of Acacia Senegal. Because the gum Arabic comes from natural sources, the physical, chemical, and mechanical properties of this material may vary and contribute to primer malfunctions. Gum Arabic (GA) or Acacia gum is an edible biopolymer obtained as exudates of mature trees of Acacia Senegal and Acacia seyal which grow principally in the African region of sample in Sudan. The exudate is a non-viscous liquid, rich in soluble fibers, and its emanation from the stems and branches usually occurs under stress conditions such as drought, poor soil fertility, and injury. The important uses of GA date back to the second millennium BC when the Egyptians used it as an adhesive and ink. Throughout the time, GA found its way to Europe and it started to be called "gum Arabic" because was exported from Arabian ports. Chemically, GA is a complex mixture of macromolecules of different size and composition (mainly carbohydrates and proteins). Today, the properties and features of GA have been widely explored and developed and it is being used in a wide range of industrial sectors such as textiles, ceramics, lithography, cosmetics and pharmaceuticals, encapsulation, food, etc. Regarding food industry, it is used as a stabilizer, a thickener and/or an emulsifier agent (e.g., soft drink syrup, gummy candies and creams). In the pharmaceutical industry, GA is used in pharmaceutical preparation, as an antimicrobial activity (AMA), and as a carrier of drugs since it is considered a physiologically harmless substance. Additionally, recent studies have highlighted GA antioxidant properties, its role in the metabolism of lipids, its positive results when being used in treatments for several degenerative diseases such as kidney failure, cardiovascular. Therefore, there is substantial evidence that GA can play a positive health-related role in addition to its well-known properties as an emulsifier. Therefore, the aim of this study to describe general aspects of the source, composition, and properties of (GA). A study was done to determine the influence of Acacia Senegal quality of gum Arabic. gum Arabic samples were collected, dried and analyzed to establish their chemical characteristics. A number of physicochemical methods were used to characterize Acacia Senegal, which the major constituent of the two varieties of Acacia gums which forms gum Arabic, from Sudan origin. Physical and chemical properties such as moisture, ash, intrinsic viscosity, specific rotation, nitrogen and protein percent, acid equivalent weight, total glucuronic acid, and total cationic composition were determined. The average values of moisture and ash percent of A. The gum is yet to be commercially exploited as the physicochemical properties of this gum are yet to be characterized. Various physicochemical methods, scanning electron microscopy (SEM), and Fourier transform infrared spectroscopy (FITR) were employed to characterize this gum in the present study. SEM analysis suggested that the native gum has irregular particle size. In this study to a general discussion of the structure and composition of gum arabic is given. A series of investigations on the scan electron microscopy (SEM), Infra-red (IR) and in a samples of gum arabic and of mixtures of the main components of gum arabic, to simulate the natural material, are reported. The SEM of the Senegal gum indicated a complete amorphous nature. Elemental analysis of the gum revealed specific contents of carbon, hydrogen, nitrogen and sulfur. The major functional groups identified from FTIR spectrum shown in Figure (8) illustrated the functional group in senegal gum. The major functional groups identified from FT-IR spectrum include 3400 cm^{-1}(-OH), (N-H) 1609.79 cm^{-1} (-COO-), 1422.98 cm^{-1} (-COO-) and 2927.48 cm^{-1} (-CH3CO). Analysis of gum by high pure liquid chromatography (HPLC) indicated the presence of sugars. Four fractions of gum sample were obtained by solvent fractionation using absolute ethanol. The fractions were found to have varying amounts of protein(component) and different values of intrinsic viscosity and specific rotation suggesting some variation in the molecular structure after fractionation. These results of Senegal gum (gum arabic) makes focus exudate gum highly recommendable for use in food and pharmaceutical industries. Used the Atomic absorption to determine the elements. It was found that Ca, Mg, Na, K, Fe and Cu Were major elements present in sample. The results of this work may be related to studies on food irradiation and could help to asses effects of radiations and thermal treatment on gum Arabic used in food manufacture and drugs.***

Keywords: Gum Acacia Senegal, chemical properties, SEM, physicochemical, FT-IR, AA, HPLC ,gum structure and quality

1. Introduction

Gum arabic is an exudate natural gum. It is an important commercial polysaccharide which was used at least 4000 years ago. The term gum was applied because the material has gummy characteristics, and the name "gum arabic" because the origin of export was an Arab area, and the Arabs in early history were the important traders and vendors of this material. The name Turkey gum was also used for this material during the Turkish Empire. More than 80 names have been used for the material, depending on the local area where it was collected and on its colour and garden.

Gum Arabic is usually produced from trees which belong to the genus acacia, subfamily mimosoidea and family leguminosea. There are more than 500 species belonging to this family, distributed over the tropical and subtropical areas of Africa, India, Australia, Central America, and South West North America. Gum Arabic is one of the oldest food ingredients. Despite periodical attempts to replace it [22], Gum Arabic is still used widely due to its texturing, film-forming, emulsifying, and stabilizing properties (9). The Joint Expert Committee for Food Additives (JECFA) defined Gum Arabic as a dried exudation obtained from the stem and branches of Acacia Senegal (L) Willdenow or related species of Acacia (79). There are more than 1000 species of Acacia, but, the gum from Acacia Senegal is, perhaps, the most valuable and widely used species of natural plant gums (80).

Ross **[28],** provided a comprehensive taxonomic study of the genus Acacia, which is one of the most widespread in Africa, he considered that the ancestral of Acacia evolved in Central America, and that the subgenera Acacia and Aculeiferum differentiated in the same area. Gum Arabic is a complex mixture of polysaccharides, protein and arabinoglacto protein species. It has been shown to be highly heterogeneous and is found in nature as mixed calcium, magnesium, potassium and sodium salts of a polysaccharic acid (arabic acid). However, other heavy elements such as Zn, Al, Cd, Cu, Cr, Pb, and Co may also be present but in very small quantities (80,68). Some authors mentioned that gum is only exuded when the tree is in an unhealthy condition and will never be produced if the tree is in a healthy condition. The gum may be obtained by making an incision in the bark of such trees, or it may exude naturally. Formation of the gum by unhealthy trees is a pathological condition resulting from a bacterial or fungal infection of the injured.

Gums are heteropolysaccharide complex carbohydrate with high molecular weight; they are sticky substances which exudate from certain plant either as a result of microbial infection or as a result of mechanical injury (80,79, 73). According to (79), exudate gums are formed as a result of microbial infection on the plants and the plants in turn synthesize the liquid substances as a defense mechanism to seal off the wound and prevent further invasion of the tissue. Due to excellent properties of exudate gum such as solubility, viscosity, binding, stabilizing, thickening and emulsifying, they are utilize in an overwhelming number of applications ranging from adhesive industry to beverages, confectionaries, cosmetic, paint, paper, pharmaceutical and food industry (80) . These products serve as basic raw material in several multibillion-dollar industries around the world (80, 9).

Evidently, there are no sufficient studies that confirm the physicochemical, morphological and structural characterization of this gum. Hence this research aims at investigating the physicochemical, morphological, structural and elemental analysis of the gum in order to evaluate its potential industrial applications, mostly in food and pharmaceutical. The results of this research is likely to highlight the physicochemical properties, the arrangement of gum particles, purity levels, percentage of crystallinity and amorphousity, the type of functional groups present and the concentration of mineral elements in order to amplify the possibility of the gum applications in food and pharmaceutical as an emulsifier in food processing, effective binder and suspending agent in drug formulation.

The objectives of this study were to determine the chemical properties of gum arabic from *A. senegal*varieties and factors that influence quality in the four study sites and compare the physicochemical characteristics of the gum arabic of the area with international specifications.

1.1 Acacia Senegal (gum arabic)

Gum arabic has been used for at least 4,000 years in the preparation of food, in human and veterinary medicine, in crafts and as a cosmetic. Gum Arabic is harvested from *Acacia Senegal* because it has superior properties over other 'acacias', and hence it is this gum that has dominated international trade. Currently the biggest markets for *A. senegal*gum are the European Union, North America (mainly the USA) and the Indian Subcontinent (mainly India). The UK imported 1,253 tons in 1998. Sudan, Nigeria and Chad are the three biggest sources of this gum. Gum arabic is traded in large quantities, and is grouped into three grades. Grade 1 (the best) is in large, round or worm-shaped pieces and is white/pale or brownish yellow. Grade 2 gum is in rounded, worm-shaped or branched pieces, and is smaller in size and generally darker in colour than the top quality. The poorest grade gum (Grade 3) is in the form of small brown grains.

Figure 1: Illustration of *Acacia senegal*, (Hashab) plate from Guillemin, J.B.A: *Iconeslithographicaeplantarumaustralasiaerariorum* (1832)

1.1.1 Species information

Scientific name: *Acacia senegal* (L.) Willd.
Common name: gum arabic (more common names listed below)
Synonym: *Senegaliasenegal*
Genus: Acacia
Conservation status: None of the four varieties of this species are threatened. Least Concern according to IUCN Red List criteria.
Habitat: Dry savanna (grassland) and Sahel (desert edge), scattered, often in thickets, and sometimes in extensive pure stands.
Key Uses: Food, medicinal, crafts, cosmetics.
Known hazards: None. *Acacia Senegal* produces the only acacia gum evaluated toxicologically as a safe food additive.

1.1.2 Common names of gum arabic in Sudan (Hashab gum) :-

SEPASAL records 196 local names for this plant. Common names include: tur, tulh, harheyr (Jibbalitemmar (Darfuriarabic); Sudan gum, Kordofan gum (English); gommier, gommiervrai, gomme blonde, gomme blanche (French); khor (Punjab); kumta (Rajputana); Senegal gum, Somali gum (in the trade industry).

1.1.3 Description of gum Arabic fruits

The hairy fruits are yellow-brown, flat and papery, 1.8 to 9 cm long, 1.2 to 3.4 cm wide, 2 mm thick and open on maturity to discharge the seeds. There are four varieties of *A. senegal*. These differ in the presence or absence of hair on the axis of the flower spike, colour of the axis, shape of pod tips, and number of pinnae pairs, trunk branched or not branched from the base and shape of the crown, as well as their geographical distribution. The germination of seed is slow and young plants usually have to contend with competition from grass and browsing stock. Those which survive will begin to yield gum at three to four years of age.

The best yields in West Africa come from trees 12 to 15 years old and up to 20 cm diameter. In Sudan from Kordofan trees aged four years are opened for tapping, which continues to the age of 20 or older, but elsewhere in Sudan six to 18 years is usual. The best yields come from trees in areas with an annual rainfall of only 250 to 300 mm. Trees die at an age of 25 to 30 years, by which time they will have succumbed to borers and termites.

Acacia senegal(L.) Willd is a leguminous multipurpose tree species, belonging to the subfamily Mimosoideae of the family Leguminosae, found in gum belt of the Sahelian countries of West Africa, which run through the dry woodland forests of Eastern and Southern Africa (Duke, 1981a). Acacia senegaltree produces gum arabic and capable of surviving all but the most severe of droughts in arid and semi-arid environments in sub- Saharan Africa (26). About 90% of the total gum arabic produced worldwide comes from Acacia senegal, cultivated as a cash crop in agroforestry systems in the Sudan (Duke, 1981a: Keddeman, 1994). Sudan is the major producer and exports more than 80 percent to the world market (Beshai, 1984; Larson and Bromley, 1991; Macrae and Merlin, 2002). (37)

Figure 4: Pieces of raw Gum Arabic

1.2 Sudan country production of gum arabic

The republic of Sudan is one of the most important countries producing gum. Senegal, Mauritania, France, Nigeria, Tanzania, Morocco, Ethiopia, and Somalia also produce significant quantities of gum. It is also produced in South Africa, India and Australian. 3 Most of the gum produced in the Sudan comes from acacia Senegal which growth to about 15- 20 ft. tall and has a life of about 25-30 years. It grows in poor, sandy, reddish soil. It is found particularly in the district of Kordofan. The best quality of gum comes from acacia Senegal and is known as (Hashab) in the Sudan and also known as Kordofangurnhashab , 90% of the gum produced in the Sudan is from these kinds of trees and about 10% of the gum comes from the Seyal variety of acacia which is known in the Sudan western part of the country and in the Nile region. The gum from Seyal trees is exuded naturally without tappingm.

During the rainy season, no gum is formed by the trees. So, the gum is collected during the dry season between October and May or June. A suitable age for trees which can be tapped is 6-7 years. Attempts to extract gum from trees younger than this causes death of the trees. After a few weeks, the gum form in the cuts which are depending on the weather conditions are collected every 10 days during the season). West Africa is the second most important area producing gum arabic. The gum produced in that area is acacia senegal which is known as gum senegal. In comparison of the Senegal gum produced in French West Africa with that from Sudan, the Senegal gum is more yellow or reddish. Is not as clean as Sudan gum and it is more benefit.Sudan gum sets the international standards on quality and all gum exporting countries must conform well to the standards in all aspects. A. senegalvarieties grow abundantly in areas with annual rainfall of 200 to 800 mm and high temperatures in the arid and semi-arid lands of Sudan.

1.3 Physical Properties of Gum Arabic

Gum arabic is amber, amorphous, highly viscous material when it is in fresh form and it is solid after contact with the atmosphere, it is light in colour with shades of yellow, red or brown, depending on the sort of acacia trees, the four countries of origin and the condition of storage. It is nontoxic, odorless, tasteless, soluble in water giving a homogeneous colloidal and colourless system). The physical properties of gum Arabic, established as quality parameters include moisture, total ash, volatile matter and internal energy. Gum Arabic is a natural product complex mixture of hydrophilic carbohydrate and hydrophobic protein components emulsifier which adsorbs onto surface of oil droplets while hydrophilic carbohydrate component inhibits flocculation and coalescence of molecules through electrostatic and steric repulsions in food additives (59). Table (1) shows the international specification of quality parameters of gum Arabic. Moisture content facilitates the solubility of hydrophilic carbohydrates and hydrophobic proteins in gum Arabic. Total ash content is used to determine the critical levels of foreign matter, acid insoluble matter, salts of calcium, potassium and magnesium. The cationic compositions of ash content are used todetermine the specific levels of heavy metals in gum Arabic (59).

1.4 Molecular weight

The molecular weight of gum arabic differs from sample to sample but also depends upon the method of estimation. Anderson and coworkers (m reported the average molecular weight to lie between 260,000 and 1,160,000. Melting point., The melting point, measured by TAFT and MALMO)l,ie s between 190-20C.

Solubility

Gum arabic is completely soluble in cold or in hot water and in some oils, but it is insoluble in most of the well-known organic solvents. TAFT and MALMO) studied the solubility of gum arabic in organic solvents. The solubility of the gum was tested in aliphatic and aromatic alcohols, ketones, ethers, esters, halogen derivatives, glycols, pyridine, hydrocarbons, and liquid ammonia. It is only dissolved in ethylene glycols and glycerol with low-viscosity. Some slight Solubility was observed with acetate esters and acetate alcohol mixtures and was also soluble in aqueous ethanol containing 60% of alcohol Freezing point. TAFT and MALM(4f)o und that the freezing point of a gum arabic solution decreases as the concentration of gum arabic increases.

1.4.1 Solubility and viscosity

GA has high water solubility and a relatively low viscosity compared with other gums. Most gums cannot dissolve in water in concentrations above 5% due to their high viscosity. Instead, GA can get dissolved in water in a concentration of

50% w/v, forming a fluid solution with acidic properties (pH 4.5). The highly branched structure of the GA molecules leads to compact relatively small hydrodynamic volume and, consequently GA will only become a viscous solution at high concentrations. Solutions containing less than 10% of GA have a low viscosity and respond to Newtonian behavior (73, 78). However, steric interactions of the hydrated molecules increase viscosity in those solutions containing more than 30% of GA resulting in an increasingly pseudo plastic behavior. Its high stability in acidic solutions is exploited to emulsify citrus oils.

It is important to give some details about the viscosity of a material not only because it gives information about the utilization of the material but also 5 it gives an idea about the molecular structure of the substance used. The viscosity of GA solutions can be modified by the addition of acids or bases as these ones change the electrostatic charge on the macromolecule. In very acidic solutions, acid groups neutralize so inducing a more compact conformation of the polymer which leads to a decreased viscosity; while a higher pH (less compact molecule) results in maximum viscosity around pH 5.0-5.5. In very basic solutions, the ionic strength increment reduces the electrostatic repulsion between GA molecules producing a more compact conformation of the biopolymer and thus reducing the viscosity of the solution (30, 73)

1.4.2 ENZYMES

Oxidases and peroxidases are found in gum arabic and are both inactivated by the heating of the gum to 800 C for 1 hour). Diastases and pectinases are also found in the gum arabic(28).

1.5 Chemical properties of gum arabic

Gum arabic is a natural polysaccharide of high-molecular weight, mainly calcium, magnesium, and potassium salts and some mineral elements (30,31) It is a water soluble polysaccharide of the hydrocolloid group, on hydrolysis yield arabinose, galactose, rhamnose and glucuronic acid. It is a complex mixture of hydrophilic carbohydrate and hydrophobic protein components and comprised mostly of arabinogalactan and protein moiety (95,73, 78). Hydrophobic protein component functions as an emulsifier that adsorbs onto surface of oil droplets while hydrophilic carbohydrate component inhibits flocculation and coalescence of molecules through electrostatic and steric repulsions in food additives (30).

The chemical properties of gum arabic quality are critical levels of foreign matter, acid insoluble matter, salts of sodium, calcium, potassium and magnesium, phosphorus nitrogen and protein contents with no tannin content. Mineral contents include copper, iron, manganese, zinc, carboron and molybdenum as well as very low levels of arsenic, lead, cobalt, nickel, cadmium and chromium (95). Amino acids are the major constituents of the proteinaceous component of the gum arabic with nitrogen content range of 0.26 to 0.39% (95). International specification defines gum arabic as a dried exudate obtained from the stems and branches of *A. senegal*(L.) Willd.or*Acacia seyal*from the Sudan (95).

Gum arabic reacts with many reagents. A solution of gum arabic will give precipitates or heavy gels if it is treated with the following reagents: borax, ferric chloride, basic lead acetate, mercuric nitrate, gelatine, potassium silicate, sodium silicate, Millons reagent. In general trivalent metallic safts will cause precipitation with gum arabic"O. 7 A solution of gum arabic can be coagulated by ruthenium red, hexol nitrate, or desogenGeigy.Gum arabic can be hydrolyzed when it is treated with dilute acids to give a mixture of L-arabinose, L-rhamnose, D-galactose, and D-glucuronic acid. It also reacts with nitric acid to give mucic, saccharic and oxalic acids.
OSBORN and LEEn studied the solubility of the acacia mucilage solution with concentrated and dilute hydrochloric acid, concentrated and dilute acetic acid, concentrated and dilute ammonium hydroxide and dilute sodium hydroxide. The acacia mucilage is soluble in all these reagents. Also it is soluble in 10% solutions of sodium chloride, mercuric chloride, bismuth chloride, and silver nitrate, but it is not soluble in a 10% solution of ferric chloride and concentrated sodium hydroxide(l).

Sudan gum in the world market because of problems relating to quality (40). The international specifications of gum arabic quality specify the optical rotation and nitrogen content as -26 to -34° and 0.26 to 0.39%, respectively, (30,31). It is believed that gums from different species (*A. senegal*and *A. seyal*) exhibited characteristics that are intrinsically different, even within the same species, varieties and individual different provenances, which produce gum with different characteristics (30). Recognizing these differences in the species, varieties and environment, it is anticipated that the quality of gum arabic from regenerated natural stands of *A. senegal*may have considerable variation in physicochemical functions and toxicological properties (26).

Other factors are different locations, type of soil and compositions, specific varieties and habitats, climate, altitude and age of the tree and social factors. To conform to world market requirements, gum arabic for commerce must fulfill certain chemical specifications (Seif el Din and Zarroug, 1996)

1.6 Chemical composition and structure

Gum arabic is in essence a carbohydrate. The carbohydrates or saccharides are most simply defined as polytrhydroxy aldehydes or ketones and their relatives. Carbohydrates or sugars are found in nature as monosaochaddes o, oligosaccharides which contain from two to ten monosacchaddes, and polysaochaddes which contains more than ten units of monosaccharaides. Connections between the units of ollgo and polysaccharides are called glycosidic linkages. Polysaccharides contain many monosacchadde, units joined in long linear or branched chains. it may be divided into two kinds, namely homopolysaccharides which contain only one type of monosaochadde and hetropolysaccharldes which contains two or more different monomeric units.

Authors show that gum amble consists of D-galactose, L-arabinose, L-rhamnose, and D-glucuronicadd. ANDERSON and HIRST ("showed that a sample of acacia Senegal gum (gum amble) had the following approximate percentages for its various constituents. D-galactose 39%, L-arabinose 28%, L-rhamnose 14%, D-glucuronic add 17% and 4-0-methyl-D-glucmnic acid 1.5%. SMITHm has proved the presence of a 1,3 link between the units of gum amble by the auto hydrolysis of amble add, which produces degraded amble add and a mixture of three reducing sugars.

a) 3-galactosido-L-arabinose(o.

b) prolonged auto hydrolysis of the degraded amble add produces the disaccharides,

3-galactosido-galactoseom.

c) 2,5-dimethyl-L-arabinoseis Identified as one of the hydrolysis products of methylated amble add(". Gum arabic is the saft of an organic acid, arabic acid, with metals such as calcium, magnesium, and potassium.

In recent years, several investigations have been conducted in order to reveal the molecular structure of GA and relate it to its exceptional emulsifying and rheological properties. The chemical composition of GA is complex and consists of a group of macromolecules characterized by a high proportion of carbohydrates (97%), which are predominantly composed of D-galactose and L-arabinose units and a low proportion of proteins (<3%) (14). The chemical composition of GA may vary slightly depending on its origin, climate, harvest season, tree age and processing conditions, such as spray dying (6 ,39; 50; 82). The chemical composition of the GA taken from *Acacia senegal*In fact, have the same sugar residues content of arabinose and 4-O-methyl glucuronic acid. Presents the chemical composition and some properties of gum arabic . Despite having different protein content, amino acid composition init . Recently, Mahendran et al., 2008, reported the GA amino acid composition in *Acacia Senegal*, being rich in hydroxyproline, serine, threonine, leucine, glycine, histidine.

Table 1: Amino acid content in Gum Arabic taken from *Acacia senegal*(Mahendran et al., 2008

Amino acid	(nmol/ mg) GA	% Amino acid
Hydroxyproline	54.200	0.711
Serine	28.700	0.302
Threonine	15.900	0.208
Proline	15.600	0.180
Leucine	15.100	0.198
Histidine	10.700	0.166
Aspartic acid	10.600	0.141
Glutamic acid	8.290	0.122
Valine	7.290	0.085
Phenylalanine	6.330	0.105
Lysine	5.130	0.075
Alanine	5.070	0.045
Isoleucine	2.380	0.031
Tyrosine	2.300	0.042
Arginine	2.120	0.037
Methionine	0.110	0.002
Cysteine	0.000	0.000
Tryptophan	0.000	0.000

ANDERSON et al. to have degraded acacia Senegal gum through seven successive SMITH degradation processes. The study of the O-methyl derivatives of each of the polysaccharides obtained from the first five degradations and the study of the methylated polysaccharides after the fifth degradation together with the partial acid hydrolysis of the methylated polysaccharides and the degmdation of the gum by auto hydrolysis a and the methylation of the autohydrolysed gum all lead to a modified structure of gum arabic, which is shown in structure (10,85) .

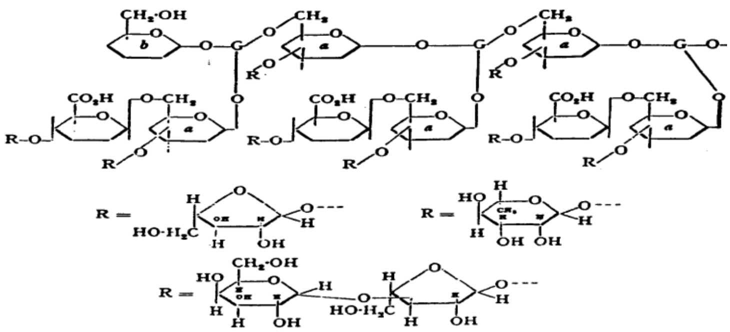

Figure 3: Structure possible of a fragment of gum arabic (SMITH)

1.7 Physicochemical properties

The GA is a heterogeneous material having both hydrophilic and hydrophobic affinities. GA physicochemical responses can be handled depending on the balance of hydrophilic and hydrophobic interactions. GA functional properties are closely related to its structure, which determines, for example, solubility, viscosity, degree of interaction with water and oil in an emulsion, microencapsulation ability, among others.

1.8 Characteristics of Gum Arabic

Gum Arabic is a solid of a pale to orange brown colour which, when ruptured, secretes a vitreous substance. Gum Arabic of excellent quality is tearshaped, round, with an orange-brown colour. After it is crushed or shattered, the pieces are paler in colour and have a vitreous appearance. Contrary to other vegetable gums, gum Arabic dissolves very well in water (up to 50%). The viscosity of A. Senegal is weak (16ml/g on average). The resulting solution is colourless, tasteless and does not interact easily with other chemical compounds (56). Chemically, gum Arabic is a slightly acidic complex compound, made up of glycoprotein and polysaccharides and their calcium, magnesium and potassium salts. The principal polysaccharide is Arabic acid, a polysaccharide linking a D-galactose with branches composed of Larabinose, L-rhamnose and D-glucuronic acids. Essentially, the proteins are classified as arabinogalactanes, rich in hydroxproline. Figure 3 shows pieces of raw gum Arabic. The photos are intended to display the shape, texture and transparency of gum Arabic (23). Table 2 shows the characteristics of gum A. senegal . Relatively, A. senegal contain higher in galactose, rhamnose and glucuronic acid.

Table 3: International specifications of quality parameters of gum Arabic Property Range

Parameter	*Acacia senegal*
Moisture content (%)	13-15
Ash content (%)	2-4
Internal energy (%)	30-39
Volatile matter (%)	51-65
Optival rotation (degrees)	-26- -34
Nitrogen content (%)	0.26-0.39
% Nitrogen	0.365
% Protein	2.41
Specific rotation (degrees)	-30
Average molecular mass (kDa	380

Cationic composition of total ash (550°C)

Copper (ppm)	Iron (ppm)	Manganese (ppm)	Zince (ppm)
52-66	730-2490	69-117	45-11

Table 4: Characteristics of gum from a. sengal Acacia senegal

% galactose	44.00
% arabinose	27.00
% rhamnose	13.00
% glucuronic acid	14.50
4-O-meth1 glucuronic acid	1.50
% nitrogen	0.36
Specific rotation/degrees	-30.00
Average molecular mass (mw)	380,000

1.9 Industry and Uses of gum arabic

The international specifications used to assess the quality of gum arabic in the world market are based on the Sudan gum obtained from A. senegal variety *Senegal*. Gum arabic is used as an emulsifier, binder an stabilizer in the food and pharmaceutical industries (59). Other industrial products that use technical grades of gum arabic include adhesives, textiles, printing,lithography, paints, paper sizing and anti-corrosive coating for metals as well as manufacture of matches and ceramic pottery and pottery glazing (Cossalter, 1991; 62). Glicksman (1969) has given detailed uses of gum arabic are a function of its physical and chemical properties, as colourless, tasteless, odourless and readily soluble in water, to give aqueous solutions of low viscosity, pH, electrolytes, ageing, compatibility and emulsifying properties. The US Food and Drug Administration, the British Pharmacopoeia and the FAO/WHO Joint Expert Committee on Food Additives (JECFA), have established strict regulations for all food additives which aim to protect the consumer of processed foods containing additives. Gum arabic, like all other food ingredients, is subjected to extensive toxicological research by countries, organizations and users of the produce to ensure the safety of gum arabic from toxicological hazards (30, 31).

Inscriptions from the 18th Dynasty refer to gum as 'komi' or 'komme'. Gum arabic has been used for at least 4,000 years by local people for the preparation of food, in human and veterinary medicine, in crafts, and as a cosmetic. *Acacia senegal*produces the only acacia gum evaluated toxicologically as a safe food additive**.** GA is being widely used for industrial purposes such as a stabilizer, a thickener, an emulsifier and an encapsulating in the food industry, and to a lesser extent in textiles, ceramics, lithography, cosmetic, and pharmaceutical industry (93). In the food industry, GA is primarily used in confectionery, bakery, dairy, beverage, and as microencapsulating agent. Gum Arabic has several domestic uses namely in manufacturing ink, making adhesives, crafts making, in cosmetic products, in confectionary and in foodstuff. It is also utilized locally in special meals and as chewing gum. Focusing specifically on human consumption, gum arabic is an excellent dietary product because it contains less than 1cal for every gram. The Hottentots in southern Africa can survive for several days on nothing but gums, while Moorish populations in northern Africa sustain a daily portion of 170g of gum (29). Nowadays the gum is present in a wide range of everyday products. 60-75% of the world production of gum arabic is used in the food industry and in human and animal medicine.

1.9.1 Food Industry

A large amount of gum arabic production is used in the food industry. It is used in the food industry because of its inherent stability and because it is non-toxic, odourless, colour less, tasteless, and completely water-soluble. It does not affect the flavor, odour, or colour of the food ingredients(Ilo. Confectionary: Because gum arabic has an ability to prevent the crystallization of the sugars and the thickening the aqueous media. It is used as a glaze in candy products and as a component of chewing gum, cough drops, and candy lozenges. Also, gum arabic plays a role as an emulsifier, keeping the fat uniformly distributed and preventing the floating of the fat on the surface and forming easily oxidizable, greasy filmo).

Dalty products: Gum arabic has been used as a stabilizer in frozen products, such as ice cream, ices, and sherbets, because it absorbs the water, and it prevents the growth of ice crystals. It also produces a fine texture from these products. SCHOLD'o has patented a method using gum arabic for the preparation of package able milk or cream. WALDERrA used gum arabic to protect the formation of colloids during the preparation of baby food.

Figure 4: Arabic-used-in-confectionery-industry

1.9.1.1 Confectionery and baking

Gum arabic is widely used in the baking industry because of its viscosity and its adhesive property. It is used in glazes and topping and it also gives smoothness when it is used as an emulsion stabilizer. Also, when it is used in a bun glaze, gum arabic gives stability in conjunction with its free-flowing and adhesive characteristics(le). GA is employed in a variety of products including gum, lozenges, chocolates, and sweets. In these products, GA performs two important functions: to delay or to prevent sugar crystallization, and to emulsify fat to keep it evenly distributed throughout the product.

In baking, GA is extensively used for its low moisture absorption properties. GA solubility in cold water allows greater formation of clear solutions than in sugar solutions. It has also favorable adhesive properties to be used in glace and meringues, and it provides softness when used as an emulsion stabilizer. Baking properties of wheat and rye flours can be improved by adding a small amount of GA since its capacity for retaining moisture reduces the hardening of bread.

1.9.1.2 Flavour fixative

The spray-dried technique is used to add different kinds of flavours which may be oxidized or volatile. The gum arabic forms a thin film around the flavour particle and protects them from oxidation, evaporation and from absorption of moisture from the airy). The tests on spray dried emulsions of aldehydes showed that the colloidal film protected them from oxidation for years, while the unprotected materials oxidized in seconds (21). Flavour emulsifier. **JOHN STONE**= has mixed a gum arabic with many flavor emulsions such as orange, lemon, lime, root beer, and cola. The addition of gum arabic to these materials gave them the required properties and provided smoothness. Citrus oil emulsions consisting of citric acid, lemon oil, glycerol, water, and coloring matter, take on the most convenient properties when mixed with gum arabic-gum karaya mixtures.

1.9.1.3 Dairy products

GA is used as a stabilizer in frozen products like ice-cream due to its water absorption properties. The role of GA in these products is to cause a fine texture and growth by inhibiting the formation of ice crystals which is achieved by combining a large amount of 10 Products and Applications of Biopolymers water and holding it as water of hydration, being its higher melting point the main attraction of ice-cream.

1.9.1. 4 Beverages

GA is used as an emulsifier in beverages such as citrus juices, beer, and cola drinks. GA ability to stabilize foams is used in the manufacture of beer and soft drinks. Besides, it can be used for clarifying wines.

1.9.2 Microencapsulation

In the food industry, microencapsulation is an important process to improve the chemical stability of sensitive compounds, to provide the controlled release of microencapsulated compounds and to give a free flowing powder with improved handling properties (16 and 76; Sheu and Rosenberg, 1993). The encapsulating material must preserve and protect the encapsulated compounds during manufacture, storage, and handling to release them into the final product during manufacture or consumption. Solubility and low viscosity emulsion properties have facilitated the use of GA as an encapsulating agent for retention and protection of chemically reactive and volatile commercial food flavoring. Reineccius (1988) has reported on the encapsulation of orange oil using GA as wall material. Its main drawback is its cost for the oversubscription.

However, due to its efficacy with regard to other wall materials such as maltodextrin (Krishnan et al., 2005) and modified starch, reported by various studies (76), the cost may not be relevant as long as extra protection or stability are achieved for microencapsulated high-value products, and in food or pharmaceutical fields. GA is mainly used for fat microencapsulation because it produces stable emulsions in the case of most oils in a wide pH range, and it has the ability to form films (58). Barbosa et al., 2005 studied the photo stability of the microencapsulated carotenoid bixin in different edible polysaccharide. They found out that microencapsulated bixin in GA was three to four times more stable than the one microencapsulated with maltodextrin, and about ten-fold than in homogeneous solvents.

1.9.3 Pharmacological action

Because the gum arabic has inherent emulsifying and demulcent and emollient characteristics, it is used in many applications in the pharmaceuticals area, from the stabilization of emulsions to the formation of tablets. Also, because the solution of gum arabic can retain its viscosity over a wide range of PHO-1v8a) lutes it is useful in this field. Although GA is being widely used as an experimental vehicle for drugs in physiological and pharmacological experiments, and it is supposed to be an inert substance, recent reports have confirmed that GA has some biological properties as an antioxidant (83; 13 & 67,51) on the metabolism of lipids (84., 35), positive contribution in treating kidney, (Matsumoto et al., 2006; Bliss et al., 1996, 13), cardiovascular (45) and gastrointestinal diseases (89, 75). Gum Arabic more than an Edible Emulsifier 9 GA has been extensively tested for its properties as non-digestible polysaccharide which can reach the large intestine without digestion; in the small intestine, it can be classified as dietary fiber. Due to its physical properties, it reduces glucose absorption, increases fecal mass, bile acids and has the potential to beneficially modify the physiological state of humans (8). GA is slowly fermented by the bacterial flora of the large intestine producing short chain fatty acids (64). Therefore, its tolerance is excellent and can be consumed in high daily doses without intestinal complications. In addition, GA is able to selectively increase the proportion of lactic acid bacteria and biphidus bacteria in healthy subjects.

Figure 5: gum-arabic-used-in-pharmaceutical-industries

In the United States Pharmacopeiamtm here is a list of preparation using gum arabic:

- 350g of gum arabic and 2g of benzoic acid added to purified water to make 1000 ml, this mucilage solution performed to aid in the suspension of insoluble drugs and also to prevent the precipitation of heavy metals from solution.
- Acacia syrup. Gum arabic is mixed with sodium benzoate, vanillin tincture and sucrose for use as a flavour vehicle because of its demulcent affect and its protective colloid action. A good syrup of diabetic foods is prepared from gum arabic, saccharin, methyl-p-hydroxybenzoate, and, water.
- Suspending agent. OSBORN and DEKAY04f) found that gum arabic is a convenient emulsifier and suspender for calamine suspensions, kaolin suspensions, liquid petroleum emulsions and cod liver oil emulsions. It has been found that it is an excellent medium for preparing a stable, nonsetting magnesia suspension.

Poorly soluble medicinal substances, such as steroids, fat-soluble vitamins, and barbitureates, that are suspended in gum arabic can be facilities by the incorporation of wetting agents or other emulsifiers ('29). Antiseptic preparation has been made with a mixture of colloidal silver bromide and gum arabic. Silver arabate has antiseptic properties which is suitable for use as a substitute for silver nitrate and organic silver compounds in the treatment of ophthalmic infections. Silver compounds for the internal treatment of mucous membranes have been patented by VON NEERGAARDM. These compounds swell and liquefy in contact with moist tissues and are prepared from water-soluble silver compounds such as the nitrate.

1.9.4. Antioxidant action

Several reports suggest that GA has antioxidant capacity. However, there are controversial results of it, mainly in vivo studies. For example, GA has been reported to exert a protective effect against gentamicin and cisplatin nephrotoxicity (5., 4), and doxorubicin cardiotoxicity (1) used as biological models in rats. However, (13) reported that treatment of rats with GA causes only a slight palliative effect of gentamicin nephrotoxicity. Later, Trommer&Neubert (2005) studied lipid peroxidation antioxidant and reducing effects in vitro of various polysaccharides (including GA). They found that GA reduces lipid peroxidation of skin in a dose-dependent. In contrast, (13) reported that administration of GA at concentrations of 2.5%, 5.0% and 10.0% in drinking water for eight consecutive days to rats did not significantly alter the concentrations of free radical scavenger's glutathione (GSH) and acid ascorbic acid (AA), and superoxide dismutase (SOD), or lipid peroxidation. Gum Arabic: More Than an Edible Emulsifier 11 Consequently, the antioxidant activity of GA in biological systems is still an unresolved issue, and therefore it requires a more direct knowledge of the antioxidant capacity of GA that can be obtained by in vitro experiments against different types of oxidant species. The total antioxidant activity of a compound or substance is associated with several processes that include the scavenging of free radical species (eg. HO., ROO.), ability to quench reactive excited states (triplet excited states and/or oxygen singlet molecular 1O2), and/or sequester of metal ions (Fe2+, Cu2+) to avoid the formation of HO. by Fenton type reactions. In the following sections, we will discuss the in vitro antioxidant capacity of GA for some of these processes.

1.9.5 Medicine

In pharmaceuticals, it is used as a stabiliser for emulsions, a binder and coating for tablets, and as an ingredient in cough drops and syrups. A soothing and softening agent, gum arabicis xtensively employed in folk medicines. Among many other uses, it is used internally for coughs, diarrhoea, dysentery, haemorrhage, and externally to cover inflamed areas. In 1920 gum arabic was used for the treatment of low blood pressure caused by haemorrhage or surgical shock. Intravenous saline injection was not successful because the salt escaped rapidly, so the addition of 7% gum arabic solution reduced the dissipation rate of the sodium chloride In1933, intravenous injections of gum arabic solution were used for the treatment of nephritic edema. In plastic surgery, a 50% gum arabic adhesive has been used successfully in grafting destroyed peripheral nerves0).

1.9.5.1 Gum arabic and Cholesterol

Although related gums have been shown to be hypocholesterolemic when ingested, there is no evidence for this effect with acacia. A daily intake of 25 and 30 g of GA for 21 to 30 days reduced total cholesterol by 6 and 10.4%, respectively (**Ross et al., 1983**, Sharma 1985). The decrease was limited only to LDL and VLDL, with no effect on HDL and triglycerides. However, Topping et al. (1985) reported that plasma cholesterol concentrations were not affected by the supply of GA, but triglyceride concentration in plasma was significantly lower than in controls. Various mechanisms have been proposed to explain the hypocholesterolemic effect of GA (43; 84). Some studies have suggested that the viscosity of fermentable dietary fiber contributes substantially to the reduction of lipids in animals and humans (42; 67). However, other studies suggested that this property is not related to plasma lipids (35). The mechanism involved is clearly linked to increased bile acid excretion and fecal neutral sterol or a modification of digestion and absorption of lipids (67). Gum acacia is usually used to modify the physical properties of foods. It was used in a clinical study of cholesterol reduction at a dose of 15 g per day.

1.9.5.2 Periodontal disease

Whole gum mixtures of acacia have been shown to inhibit the growth of periodontic bacteria, including Porphyromonasgingivalis and Prevotellaintermedia in vitro when added to culture medium in concentrations ranging from 0.5% to 1%.

1.9.5.3 Clinical data

At a concentration of 0.5%, acacia whole gum mixture also inhibited bacterial protease enzymes, suggesting acacia may be useful in limiting the development of periodontal disease. In addition, chewing an acacia-based gum for 7 days has been shown to reduce mean gingival and plaque scores compared to a sugar-free gum; the total differences in these scores was significant ($P < 0.05$) between groups suggesting that acacia gum primarily inhibits the early deposition of plaque.

1.9.5.4 Other uses

Acacia gum is a demulcent, and soothes irritated mucous membranes. Consequently, it is used widely in topical preparations to promote wound healing and as a component of cough and some gastrointestinal preparations. In the past, the gum has been administered intravenously to counteract low blood pressure following surgery and to treat edema associated with nephrosis, but this administration caused renal and liver damage and allergic reactions, and its use was abandoned.

1.9.5.5Health benefit

Acacia gum may be useful in those with kidney disease, for instance chronic renal failure.

1.9.5.5.1Acacia gum and kidney disease research studies

Acacia gum supplementation of a low-protein diet in children with end-stage renal disease. Patients with end-stage renal disease (ESRD) die in the absence of renal replacement therapy (RRT). In developing countries RRT is not uniformly available and treatment often relies on conservative management and intermittent peritoneal dialysis (IPD). This study investigates the possibility of using acacia gum supplementation to improve the quality of life and provide children with ESRD with a dialysis-free period. Three patients referred to our hospital with ESRD during a 3-month period were enrolled in a therapeutic trial to investigate the efficacy of acacia gum (1 g/kg per day in divided doses) as a complementary conservative measure aimed at improving the quality of life. Inclusion criteria included a pre-dialysis creatinine clearance of <5 ml/min, current dietary restrictions and supplementation, at least one dialysis session to control uremic symptoms, absence of life-threatening complications, and sufficient motivation to ensure compliance with the study protocol. One patient complied with the protocol for only 10 days and died after 6 months, despite IPD. Two patients completed the study. Both reported improved well-being. Neither became acidotic or uremic, and neither required dialysis during the study period. Both patients maintained urinary creatinine and urea levels not previously achieved without dialysis. In conclusion, dietary supplementation with acacia gum may be an alternative to renal replacement therapy to improve the quality of life and reduce or eliminate the need for dialysis in children with end stage renal disease in some developing countries. (Pediatric Nephrology. 2004).

Physiol Res. 2014. High-mobility group box-1 protein in adenine-induced chronic renal failure and the influence of gum arabic thereon. Pathogenesis of adenine-induced chronic renal failure may involve inflammatory, immunological and/or oxidant mechanisms. Gum arabic (GA) is a complex polysaccharide that acts as an anti-oxidant which can modulate inflammatory and/or immunological processes. Therefore, we tested here the effect of GA treatment (15 % in the drinking water for 4 weeks) in plasma and urine of rats, on a novel cytokine that has been shown to be pro-inflammatory, viz, DNA-binding high-mobility group box-1 protein (HMGB1). Adenine (0.75 % in the feed, 4 weeks) significantly increased indoxylsulphate, urea and creatinine concentrations in plasma, and significantly decreased the creatinine clearance. GA significantly abated these effects. The concentrations of HMGB1 in urine before the start of the experiment were similar in all four groups. However, 24-h after the last treatment, adenine treatment increased significantly the concentration of HMGB1 when compared with the control. GA treatment did not affect the HMGB1 concentration in urine. Moreover, the concentration of HMGB1 in plasma obtained 24 h after the last treatment in rats treated with adenine was drastically reduced compared with the control group. This may explain its significant rise in urine. In conclusion, HMGB1 can be considered a potentially useful biomarker in adenine induced CRF and its treatment.

Your article on gum arabic and those with chronic renal failure is interesting to me because my wife has less than 5% renal function. Ideally we would like to minimize the amount of dialysis she requires and this seems like something we could discuss with the doctors. Do you know if gum arabic affects the action of immunosuppressant drugs such astacrolymus? I ask because she has a grafted liver.

1.9.5.5.2 The effects of gum arabic oral treatment on the metabolic profile of chronic renal failure patients under regular haemodialysis in Central Sudan.

This study aimed at assessing the effect of acacia gum oral treatment on the metabolic profile of chronic renal failure patients. A total of 36 chronic renal failure patients (under regular hemodialysis) and 10 normal subjects participated in this study. We conclude that oral administration of gum arabic could conceivably alleviate adverse effects of chronic renal failure. (Nat Prod Res. 2008.Faculty of Medicine, Department of Biochemistry and Nutrition, University of Gezira, Wad Medani, Sudan).

1.9.5.5.3 Effects of gum arabic(Acaciasenegal) on water and electrolyte balance in healthy mice.

Acacia gum is a dietary fiber is used in the traditional treatment of patients with chronic kidney disease in Middle Eastern countries. We explored the effects of acacia gum on the water and electrolyte balance of healthy wild-type mice. Treatment with acacia gum resulted in moderate but significant increases of creatinine clearance and altered electrolyte excretion, i.e., effects favorable in renal insufficiency. (Renal Nutrition. 2008).

1.9.6 Toxicology

Acacia is essentially nontoxic when ingested. Acacia contains a peroxidase enzyme, which is typically destroyed by brief exposure to heat. If not inactivated, this enzyme forms colored complexes with certain amines and phenols and enhances the destruction of many pharmaceutical products including alkaloids and readily oxidizable compounds such as some vitamins. Acacia gum reduces the antibacterial effectiveness of the preservative methyl-p-hydroxybenzoate against Pseudomonas aeruginosa , presumably by offering physical barrier protection to the microbial cells from the action of the preservative. A trypsin inhibitor also has been identified, but the clinical significance of the presence of this enzyme is not known.

1.9.7 Cosmetics

Gum arabic is used in cosmetics as an adhesive for face masks and powders, and to give a smooth feel to lotions.In cosmetics gum arabic is found in a wide range of applications. In lotions and protective creams, it stabilizes the emulsion, increases the Viscosity, and assists in making a homogenous mixture. It forms a protective coating and it gives the skin a smooth feel. It is also used as a binder in the formulation of the compact cakes, rouges, and as an adhesive in the preparation of facial masks. Also, gum arabic is used as a foam stabilizer in the production of liquid soap. Gum arabic has also entered the prescriptions which are used in hair creams and fixatives and as a binder in face powder compact. In protective creams, gum arabic can be used as a stabilizer and film-former(U.

1.9.8 Construction

Industrially, gum arabic is applied as an adhesive, as a protective colloid and safeguarding agent for inks, sensitizer for lithographic plates, coating for special papers, sizing agent for cloth to give body to certain fabrics, and coating to prevent metal corrosion. Gum arabic is also used in the manufacture of matches and ceramic pottery.

1.9.8.1 Adhesives

Gum arabic is generally used in a wide range of the adhesives industry. It is mixed with water to form an adhesive solution, and it is sold in powder to make a safe solution for miscellaneous paper products. WOLFEM 11 employed gum arabic with sodium hydroxide as an adhesive agent for paper products. The glue of gum arabic is deslraWe because one finds it easy to prepare, light in colour, odourles and very stable. These glues can be improved by the addition of metal safts such as calcium nitrate and aluminum sulphate, but they have the shortcoming that they will be degraded when heated and the colourless of the glue will change to bronze and related colours. Gum arabic is also used as a glue for cellophane. Also, a good transparent cement can be made with gum arabic. Wall paper paste has been based on a mixture of gum arabic, bentonite, and starch. Sometime gum arabic is used as a binder for water cements such as gray and iron cementso-m. In construction the wood is used locally for poles and fence-posts, the light-coloured wood for tool handles and dark heartwood for weaver's shuttles. Strong ropes are made from the bark fibres of the long surface roots. Where the trees are large (for example near the River Niger) they are cut into planks at least 12 cm thick for making canoes for hunting hippopotamuses. The wood is hard and heavy and takes a beautiful polish, with the sapwood being yellowish white and the heartwood nearly black and irregular. The wood is made into throwing-sticks which, in contrast to the Australian boomerang, can be made to fly straight and used for hunting and pageantry.

1.9.9 Inks

The use of gum arabic (or gum acacia), which is derived from an exudate from the bark, dates from the first Egyptian Dynasty (3400 B.C.). It was used in the production of ink, which was made from a mix of carbon, gum and water. Gum arabic is an important constituent of many special purpose inks becauseit has an excellenpt. Protective colloid action.Gum Arabic and lampblack mixed together to form a suitable ink stick which was used in the same process for over 3000 yearsom).

Many of the inks use gum arabic in the formula, including record ink, which is used in government writings. Soluble inks, used just to mark the cloth in the textile area. Gum arabic is a suitable binder for water colour inks because it has excellent suspending properties where this kind of ink must remain In suspension.

Gum arabic is used with ethanol as a thickener and suspension agent in fast drying inks, also it is used in fabric and laundry marking inks. In typographic ink gum arabic is used as a binder to keep the ink out of separation. The Conductive inks have a range of application in the electronic area. The most 12 important use of this Ink is In preparing printed circuits. The Most conductive Inks are based on carbon b lack, powdered graphite .P powdered s silver or copper are used and the suspension agent can be a lacquer or gum arabic (33).

1.9.10 Lithography:

Gums are used as sensitizers for lithography plates. A solution consists of gum arabic and dichmmates and can form water-insoluble substances by the effect of the light. A layer of this mixture can be formed on plastic, paper, metallic and stone surfaces and unexposed material can be removed easily by water or dilute acids. Gum arabic for this use must be of the best quality and be prepared in a special way for this purpose.

2. Materials and Methods

2.1 Materials

The ORIGIN of the SAMPLES

The gum arabic material was collected from HASHAB trees (acacia SENEGAL) from the KORDOFAN area of SUDAN. The basic constituent components of gum arabic: D-galactose, L-arabinose, L-rhamnose, and D-glucuronic add have been obtained from RIEDEL DE HEAN COMPANY, HANOVER, WEST GERMANY, and WINLABE, UX

2.2 Purification of gum sample

Dried crude gum (l0g) was stirred in cold distilled water (250ml) for 2 hours at room temperature. The supernatant was obtained by centrifugation and made up to 500 ml and ethanol solution was added (l: 4 v/v) to precipitate all the carbohydrate. The precipitated material was washed again with ethanol, followed by distilled water and dried at room temperature milled with Kenwood blender (UK) and later sieved using a bin (mesh size-250microns) kept in labeled plastic container for subsequent analysis.

2.3 Preparation samples for the Irradiation

The natural samples of homogeneous colour were selected and were crushed carefully by mortar and pestle to a fine powder. This powder was then dried in a vacuum desiccator for several days .

2.4 Chemical Properties

2.4.1 Compositional Analysis

gum Arabicarable's composition is mainly carbohydrate polymers, there are also protein components that have been shown to be important to its surfactant properties. Thus, the analysis of the nitrogen (table) content is more informative than the carbon and hydrogen content in that it relates to the protein content of the gum arabic. The samples were analyzed in the USDA/ARS/Dairy Forage laboratory using a varioMAX with each sample being run in duplicate. This equipment uses the Dumas protein method, which is similar to that used by ATK analyzer, but is a different chemistry from the Kjedahl method. ATK (ref. 12). Elemental analysis for CHN was performed on a Perkin Elmer 2400 series II CHNS/O analyzer with sample being analyzed six times (ref. 13). Although the absolute values differ between the two methods, both supported a lower nitrogen content for the Brenntag gum and a slightly higher nitrogen (protein) content in the gum Arabic sample. The difference in nitrogen content could be better explored in future work by performing amino acid analysis.

2.4.2 Scanning Electron Microscopy (SEM).

Morphological features of the gum were studied with a JSM – 5600LV scanning electron microscope of JOEL (Tokyo, Japan). The dried sample was mounted on a metal stub and sputtered with gold in order to make the sample conductive, and the images were taken at an accelerating voltage of 10KV and at 500x magnification (55). The photo micrographic processed specimen were obtained in SEM (Philips, Lancashire, XL 30.

2.4.3 Fourier Transform Spectroscopy

FTIR spectra of freeze-dried Acacia senegal gum powders were acquired from . The dry powder was mixed with KBr and pressed into pellets under mechanical pressure. The FT-IR spectra were obtained by scanning between 4000 and 400/cm. A Perkin–Elmer ATR–FTIR Spectrometer Spectrum 400 was used to obtain FTIR spectra. 400 – 4000 cm _1 was the scanning range and 1 cm _1 was the resolution. After the crystal area was cleaned, the solid material was placed onto the small crystal area; the pressure arm was positioned over the crystal/sample area. Force was applied to the sample, pushing it onto the diamond surface and the spectrum was collected.

Each spectrum was the average of three acquisitions of 64 scans each recorded with a speed of 0.96 cm_1. Scans were corrected for the air contribution and an automatic Spectra were analysed using OMNIC v7.1 software. For better identification of differences between Acacia gums, A. senegalspectrum was subtracted and Multi-detector high performance size exclusion.

The gum arabic samples were examined by infrared spectroscopy because these spectra are usually sensitive to chemical composition. The spectra of carbohydrates are rather complex and tend to be similar because different sugars still tend to contain the same numbers of the same functional groups. The infrared spectra of the samples tested to identify the spectrum of sample. The sample overlapped with that of GA (gum Arabic). The spectral intensities were matched at 1422.98 cm'1. This absorbance band is largely attributed to skeletal motions of the carbon rings, CH and CH_2 wagging motions all of which should be relatively common among the samples. This is judged to be a small difference, which is mainly attributable to carbon/oxygen vibrations and is illustrated in figure (15).

2.4.4 High Performance Liquid Chromatography (HPLC)

HPLC is a rapid form of chromatography and more advanced than PC and TLC. It separates compounds (monosaccharaides mixture and oligosaccharides) easier and gives more accurate quantification (Geyer, 1982).There are a number of HPLC processes for separating carbohydrate which depends on chemical and physical properties for resolution.

2.4.5 High Performance Liquid Chromatography (HPLC) (Analysis of neutral Sugars)

The galactose, arabinose and rhamnose content of the whole gum and various fractions of *Angeissusleiocarpus*gum were determined by high performance liquid chromatography (HPLC). Prior to analysis, the samples were hydrolysed into their constituent sugars. The gum Samples were hydrolysed as described by Randall et.al (1989) according to the following procedure: gum samples were weighed (0.03) accurately into stoperedpyrex test tubes (15cm3) and sulphuric acid (4.0% w/w, 10cm3) added to each. The tubes were placed in water bath at 100°C for 4 hours. The hydrolysed solutions were neutralised by adding barium carbonate (2.0 gram) and left to mix overnight at room temperature.

The hydrolysates were filtered (0.45,what man) and analysed using an HPLC system (Model No.410 Refractometer,Model No.717 Autosample, Model No.600 Controller. Waters Operating Corporation, Mass .01757,USA.) Linked to a S5 amino column (250 mm X 4.6 mm;Waters. USA). The sample was injected (lOudm3) in to the column and eluted using a mobile phase of 75:25 V/V acetonitrile: water (filtered and degassed before use). Analysis were performed at ambient room temperature (30C°) and the flow rate maintained at 1.0 cm3 min'1. The retention times of the monosaccharides were monitored using a differential refractometer (R 410, waters). The retention times obtained were compared to those determined using D- galactose, L-arabinose and L- rhmnose (Sigma Chemical CO., Ltd.) as standards. The area percent of each peak was calculated by millinum program, which connected with RI. 410 detector. The sugar percent was calculated as: Component sugar (i) % = Area percent of component fi) x 100 Total area percent show in table (5).

2.5 Physicochemical analysis of gum Arabic (senegal)

The moisture content was determined by drying to constant weight at 1050c (in a muffle furnace) (55). Nitrogen content of the gum was determined by kjeldah method (55) using Gerhadkjeldotherm and vapodest system (Germany). Crude protein was calculated from the nitrogen content using the conversion factor of 6.25. pH, relative viscosity, water holding capacity, emulsifying capacity, specific rotation and swelling index were measured accordingly to (55).

2.6 Elemental analysis of senegal gum

Elemental contents of native senegalgum were analyzed using atomic absorption spectrophotometer (AAS), A-analyst model 400 (England) for the presence and concentration calcium, magnesium, , zinc and iron and flame photometer Hitachi 482 (Germany) for the presence and the concentration of potassium, and sodium

2.6.1 Atomic Absorption Spectroscopy

Is the measurement of the radiation absorbed by the unexcited atoms of the chemical substance that has been aspirated into a flame or in the absence of aflame directly into the path of radiation. Nuclear magnetic resonance (nmr) has lately been used with great success in the differentiation among the fine structures of very similar polysaccharide molecules e.g. *Acacia Senegal* gum, resembling different "finger prints" (Defaye and 93).

3. Results and Discussion

3.1 Quality of gum arabic

The international specifications of quality parameters of gum arabic are given in Table 1. The international specifications state that quality parameters of gum arabic must conform to certain chemical specifications and these must be adhered to by both the producers and processing enterprises (Table 1). The parameters are meant to identify and characterize the toxicological risks and hazards and provide the assurance that gums have not come from other tree species, to maintain and sustain high gum quality in the world market.

3.2 Scanning Electron Microscopy

Scanning electron microphotographs (SEM) of acacia senegal gum obtained is represented in Figures 5, 6,7 at different magnifications. The microphotographs of gum are indicative of an amorphous material. The particles are mostly seen as aggregates of irregular shapes and dimensions which were fibrous in nature. The SEM results of the present study suggest that, hydration capacity of senegal gum depends on the surface property. The shape and structure or surface topography of the gum may be affected by the method of extraction and purification or preparation of the product (74, 93, 56) had reported that, particle size and specific surface area influence the hydration behavior of gums, which in turn influence their intrinsic viscosity and molecular mass. They also reported that particle size influenced the hydration kinetics and molecular mass of senegal gum which is a galactomannan-rich tree gum.

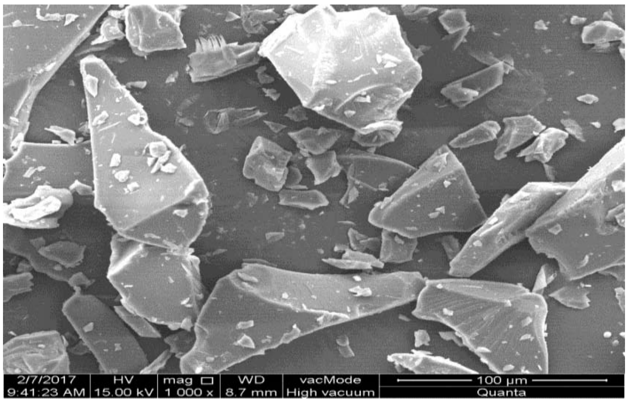

Figure 5: Gum arabic Scanning electron microscopy of mucilage at 100 magnification using Philips

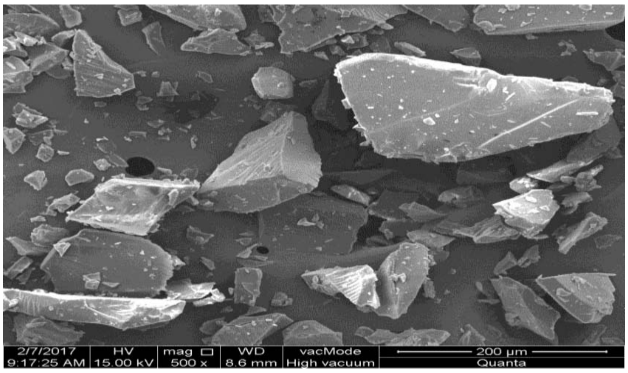

Figure 7: Gum arabic Scanning electron microscopy of mucilage at 200 magnification using Philips

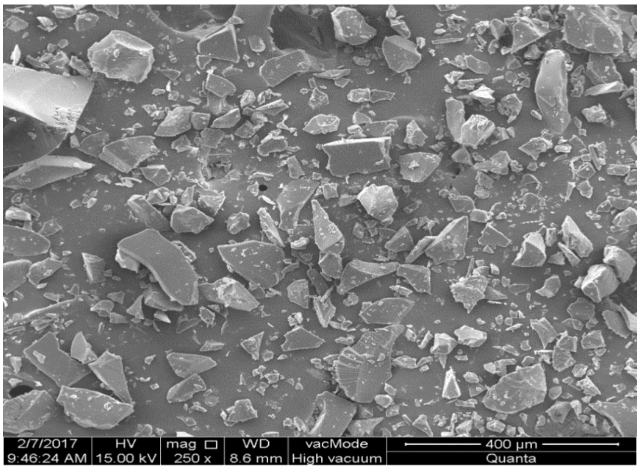

Figure 6, 7, 8: Gum arabic Scanning electron microscopy of mucilage at different magnification using Philips, Lancashire, XL-30 SEM

3.3 Fourier Transform analysis

Software was used to interprete. Spectra exhibited the typical bands and peak characteristic of polysaccharides. The spectra of acacia senegal gum shows band occurring at 3400.23 cm^{-1} results from the presence of amide N-H and C=O stretch and amine N-H. The peak obtained at 3400.28 - 2927.43 cm^{-1}, results from the presence of hydroxyl (-OH and -CO) groups. The peak obtained at 2357.32- 2332.27 cm^{-1} results from stretching modes of the alkyl C-H stretch, carboxylic acid and (N-H) group. FTIR spectrometry has been extensively applied to characterize the polymer's molecular and material structure. Characterization using FTIR spectroscopy often results in the identification of functional groups and the modes of their attachment to polymer backbone (12). The FTIR spectra exhibit the typical bands and peak characteristic for Senegal gum. The FT-IR spectrum of gum arabic is presented in Figure 8. 'CHEMIX' School O and O-H stretch and methylene (-CO-) C-H stretch. The peak obtained at 2332.27 - 1609. 79 cm^{-1} results from stretching mode of the alkyl C-H and C=C stretch, amide N-H and C=O stretch. The broad band occurring at 1422.98cm^{-1}, results from the presence carboxyl (-COOH) groups. The peak obtained at 1080.15 – 424.80 cm^{-1}results from stretching modes of the C-Br) , (C-I) bonds of halo compounds groups and band 601.55 cm^{-} indicate to (-N-H). Natural gums usually contain fractions of sugar acid units which would usually impart a weakly anionic character to the gum macromolecule. Absorption bands around 1609 .79and 1422.98 cm^{-1} are typical of carboxylate groups of the galacturonic acid residues as reported by Okafor, Chukwu, Udeala, (2001) and 24). The region between 1500 and 1800 cm^{-1} is typically used to detect presence of carboxylic groups.

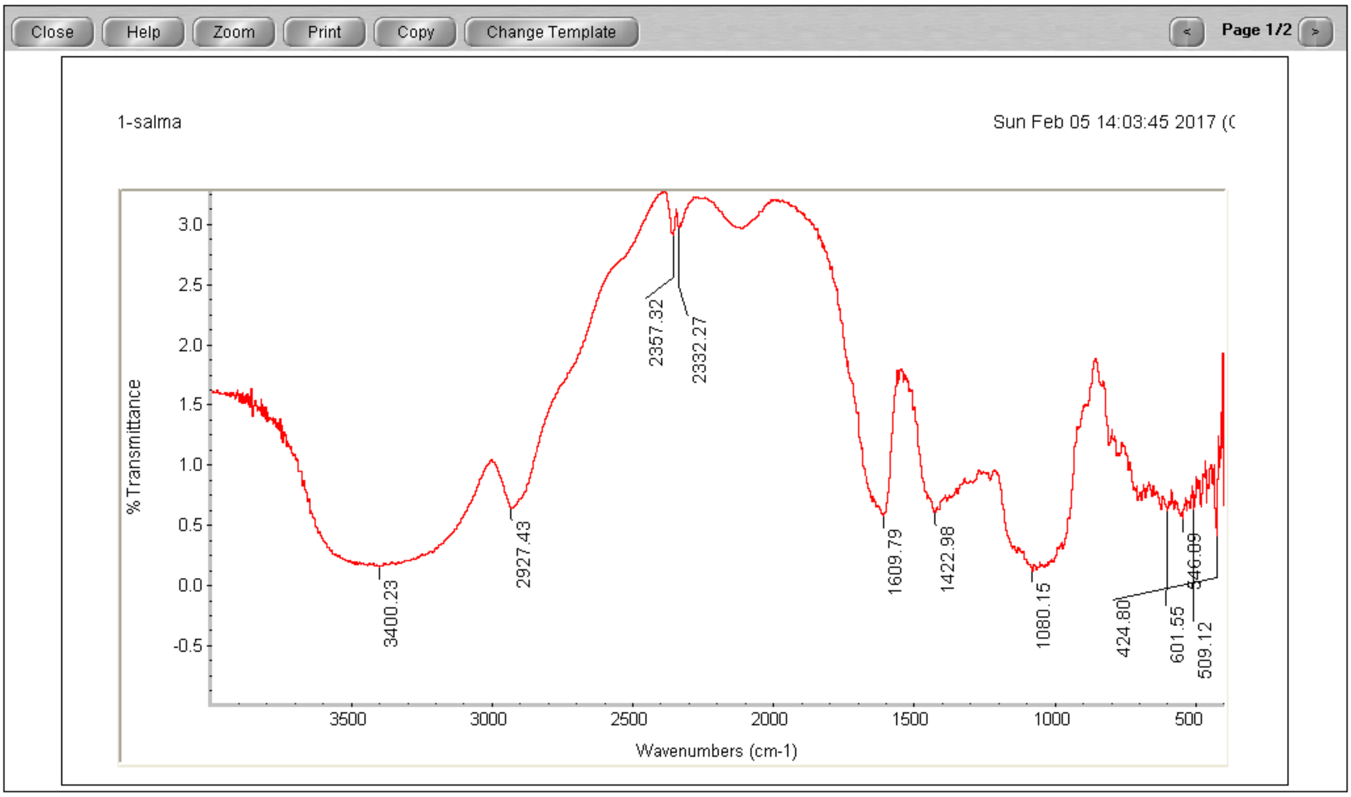

Figure 8: IR spectroscopy of Gum Arabic sample

3.4 Sugar composition by High performance liquid chromatography (HPLC)

Plant gums are an important group of plant constituents with pharmaceutical and technical uses. The separation and sensitive determination of various carbohydrates is currently of great interest in nutrition, medical cell biology and biotechnology research. Carbohydrates are difficult to analyze because they are very polar compounds, exhibit similar structural characteristics, and do not have a suitable chromosphere. The R_f value of standards arabinose, fructose, mannose, rhamnose and xylose matched with the obtained R_f values of test substances (mucilage). The result obtained from 1D, FTIR and HPLC chromatography studies indicated the presence of arabinose, fructose, mannose, rhamnose, xylose and glucose. The results obtained from the study are corroborative of R_f values of the standard sugars and Sugar values are reported in table (1) as percent of the dried gum arabic samples. Total carbohydrate percent is the additive value of the five measured sugars.

Table 5: Sugar analysis

Sample GA	*Type of suger and percentage (%)*	*% standard deviation of assay **
Arabinan	18	0.0
Galactan	54.96	0.1
Rhamnan	12.4	0.0
Glucan	Nd	0.4
Xylan	0.0	0.1
Mannan (%)	Nd	0.2
Total Carbohydrate (%)	84	0.6

*The standard deviation numbers shown are not obtained from the values in the chart. They indicate the values obtained in the laboratory from an internal standard which is included in each batch of sugar analysis. Sugar analysis indicated similar composition in the major sugars detected (arabinose, galactose, and rhamnose). The sample (GA-1) contained significantly lower levels of rhamnose and higher arabinose compared with the other four gum arabic samples. Total carbohydrate levels were similar in all samples

Table (6) of sugars Quantitative results with deference area

name	Ret. Time	Area	Height	Conc
arabinose	1. 7.350 2. 7.339 3. 7.333 4. 7.115	1. 562181 2. 317079 3. 114533 4. 117683	1. 24480 2. 13555 3. 5015 4. 3086	2.462 1.250 00.500 0.450
Galactose	1. 9.509 2. 9.489 3. 9.479 4. 9.191	1. 579719 2. 182131 3. 73874 4. 267619	1. 17491 2. 5434 3. 2193 4. 4487	1. 2.577 2. 1.250 3 .0.250 5. 1.374

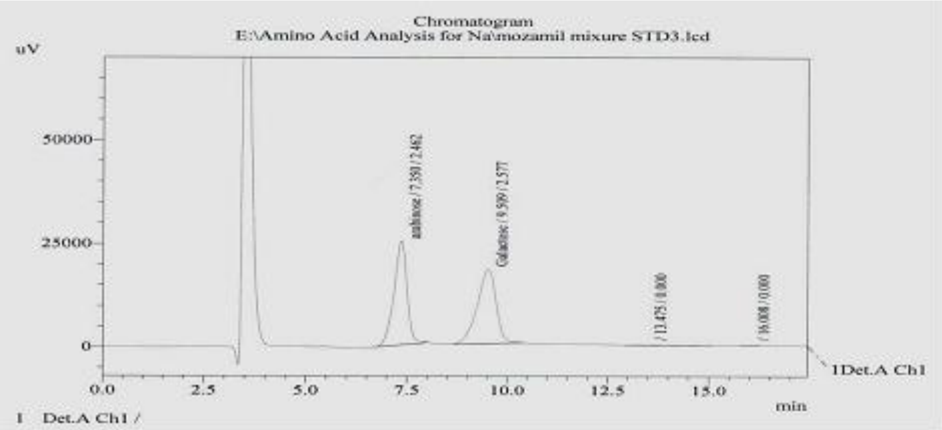

Figure 9: Illustrate sugar quantitative in gum Arabic

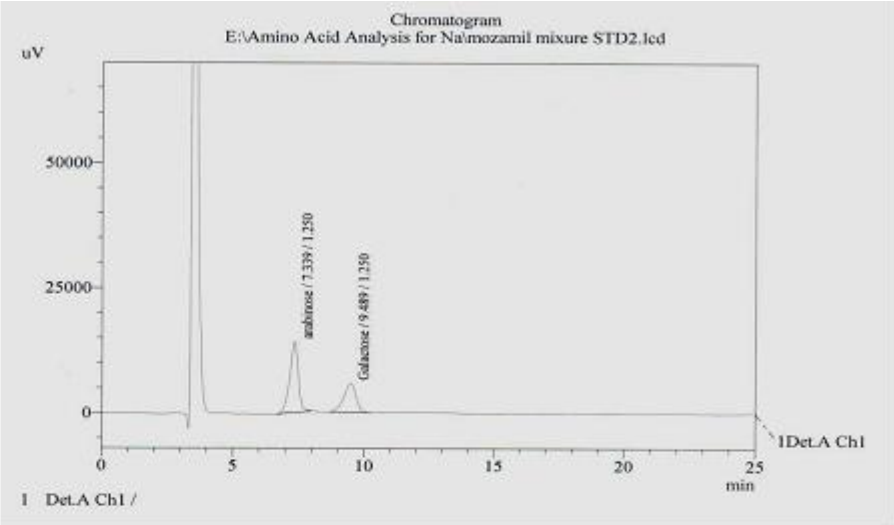

Figure 10: Illustrate sugar quantitative in gum Arabic

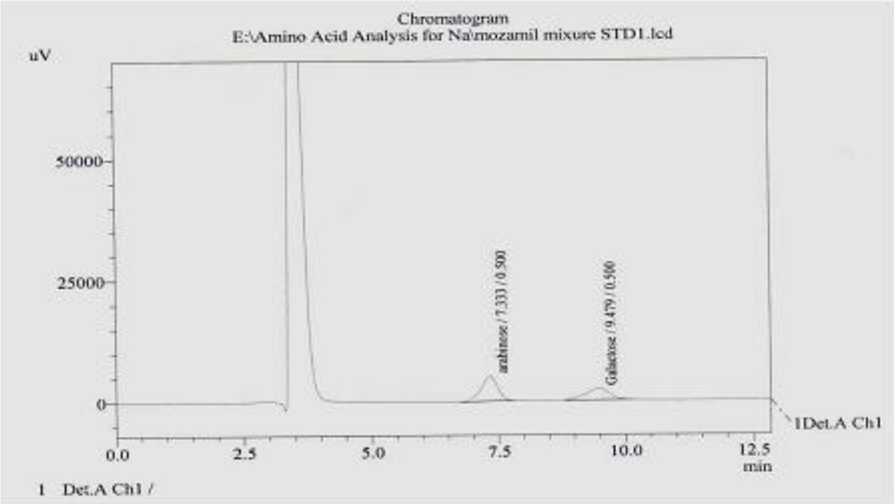

Figure 11: Illustrate sugar quantitative in gum Arabic

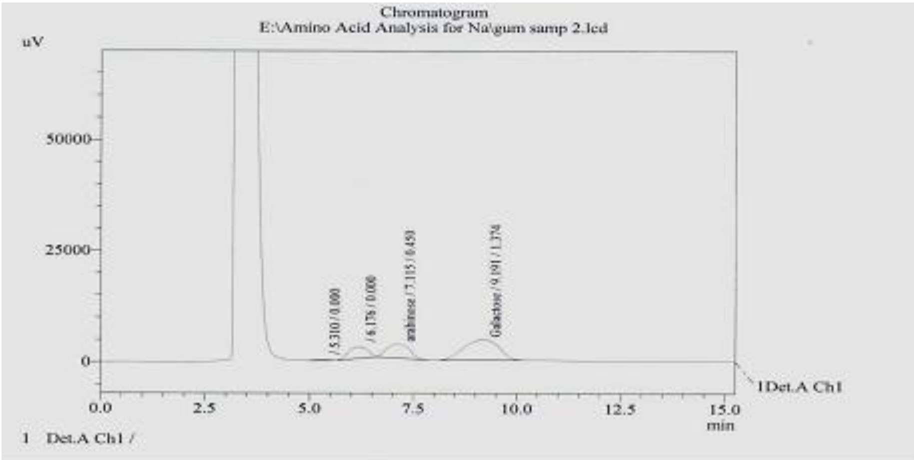

Figure 12: Illustrate sugar quantitative in gum Arabic

Table 7: Standard of sugars Quantitative results with deference area

1D	name	Quantitative method	function	Rr 1/ Rr 2	Mean RF	RFSD/ RFSD	Fit Type	Zero through	Weight regression	Detector name
1	arabinose	External standard	F(x)= 220993*x +18190.7	009960850/ 0.9921854	235867	15553.6 / 6.59423	linear	Not through	None	Detector A
2	Galactose	External standard	259570* x – 89149.9	0.9846203 / 0.9694772	175114	49178.5 / 28.0838	linear	Not through	None	Detector A

Table 8: Sugars analysis results with deference ratio

Suger	*Conc ratio*	*Mean area*
Arabinose 1	1. 0.500	114533.0
	2. 1.250	317078.7
	3. 2.500	562180.9
Galactose	1. 0.500	7387.2
	2. 1.250	182130.6
	3. 2.500	579719.1

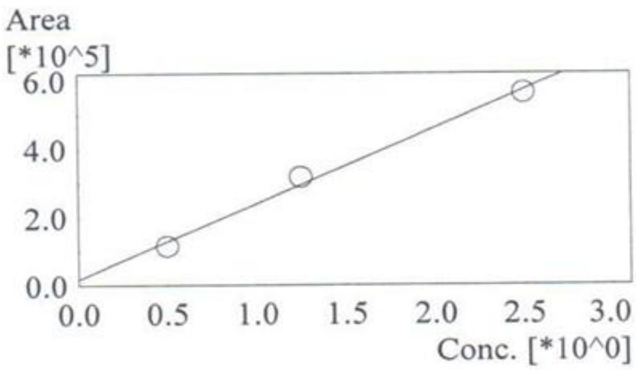

Figure 13: Concentration of arabinose sugar

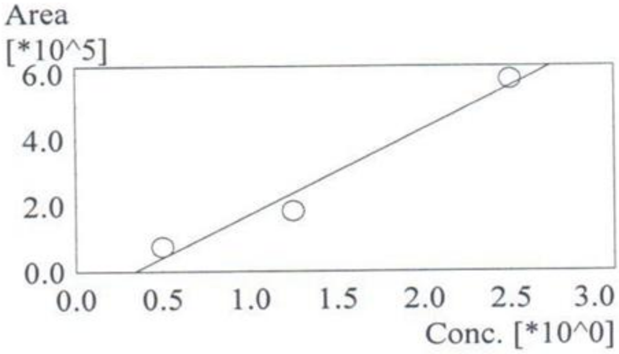

Figure 14: Concentration of Galactose sugar

Table 9: Physicochemical characteristics of (acaiasenegal) gum.

Protein content (%)	2.06
pH	5.3
Moisture content (%)	13.5
Ash content (%)	4
Internal energy (%)	35
Volatile matter (%)	54
Optical rotation (degrees)	-26.5
Nitrogen content (%)	0.29
Relative Viscosity	21.5
Water holding capacity (%)	83.96
Swelling index (%)	10.00
Refractive index	1.34
Specific rotation (o)	-25.06
Emulsifying capacity (cm-1)	17.49

3.5 Metals Analysis

Metal contents of the gums can be important to their performance because the metal ions can influence the interactions between chains. Monovalent metal salts, such as magnesium (Mg) ,ferric (Fe) , zinc (Zn) potassium (K)and calcium (Ca), do not promote interchain interactions. On the other hand, divalent and trivalent metal salts most likely tie the chains together. The data for the gums are given in table (2) .

Table 10: Illustrate metals content majored in gum Arabic sample by atomic absorption (A.A .S)

Sample (GA-1)	Elemental concentration in mg/g
Al	0.009%
Ca	0.65%
Cu	0.004
Mg	0.65 %
K	0.05%
Na	0.01%
Fe	2.7 %
P	0.21%

4. Discussion

Quality of gum Arabic

Gum Arabic is mostly used in the different sectors of the food. It is a non- digestible food ingredient that has many applications in the food and pharmaceutical industries.

Gum arabic is being used extensively as a constituent of drugs and food stuffs. The international specifications of quality parameters of gum arabic are given in Table(1). The international specifications state that quality parameters of gum Arabic must conform to certain chemical specifications and these must be adhered to by both the producers and processing enterprises (Table 1). The parameters are meant to identify and characterize the toxicological risks and hazards and provide the assurance that gums have not come from other tree species, to maintain and sustain high gum quality in the world market.

Scanning electron microphotographs (SEM) of the gum sample is depicted in Figures 5,6,7 at 500x magnification and 50 m scale. It exhibit fibrous long non-distinct shaped large fibres. These properties could be of importance when considering applications based on surface characteristics. It is clear from plate that the gum has irregular particle size. It has been reported that particle size and specific surface area influence the hydration behaviour of gums, which in turn influence their intrinsic viscosity and molecular mass (26, 29). Scanning electron microscopic studies (SEM) are used to examine the characteristic distinct crystalline morphology of some commercial gums at magnification from (x100) to (x6000). Values above this magnification lead to decaying of sugar particles. The observation recorded has revealed that SEM studies of various polysaccharides could be used to find out the purity of substance e.g. in food and medicinal applications (18, 26).

The IR spectrum is shown in Figure (8). The finger print region of the spectrum consists of two Characteristic peaks between 424.80 and 509.21 cm-1, attributed to the C-I and C-Br bond stretching halo compound (71). The band at 601.55 cm-1 was assigned to the N-H bending of amine (95). Contribution from carbonyl stretches in the 1080.15 cm-1 stretching region indicate the presence of C-O primary alcohol linkages. The broad band at 1422.98 cm-1 is due to COO linkage carboxylic acid. The band 1609.79 medium indicate to α ,β – unsaturated ketone, Fig. 8, a characteristic absorption band at 2332.27– 2357.32 cm _1 representing the presence of hydrogen bonded C-H and N-H group was observed. The characteristic absorption band in the region of 3400–3500 cm _1 N-H, C=O, OH for amino group must have been masked by the broad OAH group absorption band. The bands at 2927.43 cm _1 indicate the presence of sugars, galactose, arabinose, and rhamnose, also the presence of alkane CAH stretch and aldehyde CAH stretch. The polymers also showed the characteristic band of C,C stretch, amide NH bend, NO_2 from both aliphatic and aromatic galactoproteins, and amino acids around 1602 cm _1609.79 .

The glucuronic acids have specific vibrations such as the band at 1422.98 due to COO symmetric stretching and AOH bending.

Vibration stretches associated with free inter and intermolecular bound hydroxyl groups which make up the gross structure of carbohydrate (78). These are all consistent with a polysaccharide structure that is neither starch nor cellulose, but has some peptide cross-links and some amino sugars (40). An infrared spectrum represents a fingerprint of a sample with absorption peaks, which correspond to the frequencies of vibrations between the bonds of the atoms making up the material. Because each different material is a unique combination of atoms, no two compounds produce the exact same infrared spectrum. Therefore, infrared spectroscopy can result in a positive identification (qualitative analysis) of every different kind of material. In addition, the size of the peaks in the spectrum is a direct indication of the amount of material present**(**68**).**

The FTIR was performed on powdered samples of GA. The FTIR spectra are shown in Figures 8 The*A. senegal*illustrate broad and strong absorption band in the range 500-3500 cm–1 and these absorptions were assigned to the different stretching vibrations. Table (2) shows the physicochemical parameters. The swelling capacity in water expressed in percent was 10% (Table1).The result shows that the gum has a high swelling index compared to a standard gum Arabic with swelling index of 8.5% (49). The gum may perform well as binder and matrix agent. The relatively high swelling index at pH = 5.3 implies that the gum may be useful as a matrix former in controlled drug-release. Swelling is a primary mechanism in diffusion controlled release dosage form (36). The pH measurement shows that the gum solution was slightly acidic. The pH value of 5.3 (Table 2) is in good agreement with reported pH values for gum arabic and anarcadiumoccidentale .L (Cashew gum) by several authors (9). The acidity of the plant gum is not unexpected since many of them are known to contain salts (Ca, Mg, K, Na and Fe) of acidic polysaccharides, the activity of which is due to uronic acids in their structure (34). The pH of an exudate gum is an important parameter in determining its suitability in formulations since the stability and physiological activity of most preparations depend on pH (27, 29, 30). Moisture content of the gum was 13.5% (Table 1) and compares favourably with the minimum standards (< 15%) for good quality gum according to European specification (88). This suggests its suitability in formulations containing moisture sensitive drugs.

Given suitable temperature moisture will lead to activation of enzymes and the proliferation of microorganisms, thereby affecting its shelf life. It is important to investigate the importance of an exudate gum, for industrial application lies not only on the cheap and easy availability of the material but the optimization of production processes such as drying, packaging and storing (91). The total ashes value of the gum was found to be 4% (w/w) (Table 2) this falls within the acceptable level of less than 4% for gum arabic reported by (92) for food and pharmaceuticals. Ash content is an important property considered as a purity parameter in gums. The very low values of ash show that ficuselastica exudates gum has a good quality of mineral content with low level of contamination (92). Relative viscosity of gum solution at (30^{o}C) was found to depend on gum concentration [2]. The relative viscosity of the gum was found to be 21.5 (Table 2). Molecular association in fluids greatly influences their rheological behaviors. Increase in viscosity with concentration is probably due to increase in the molecular weight of the gum (26).

The value for protein content obtained 2.29% (Table 2) fairly agrees with that of acacia gum (0.5 – 2.7%)(68). The moderate protein content in the gum sample is noteworthy. This is because protein content is known to have effects on the emulsifying behaviour of gum with the best emulsion capacity and stability found in gums with higher nitrogen content (93, 88).

The specific rotation of the aqueous gum was found to be optically active (-25.6%) (Table 2). This shows that the sugar present is laevorotatory. Emulsifying capacity was determined in form of Turbidity. The emulsifying capacity was found to be17.49cm-1 (Table 2). A higher turbidity is an indication of a better emulsion capacity. In addition to protein content of gum index of the gum sample was found to be 1.34 (Table 2). This may prove to be a qualifying index for this gum. Adeyanju (9). Water holding capacity of the gum was found to be 83.96%. The water holding capacity of gum is the ability to hold water and does not only depend on the functional group of carbohydrate that are hydrophilic but also on the protein present in the gum, since they also contain functional groups that are able to bind with water molecule. Thus addition of other substance can be accommodated and this may improve the texture of the overall product (78, 28,64).

The results of this study clearly show that gum Arabic have good physicochemical properties and good concentration of essential elements which compared favourably with standard gum and WHO/FAO requirement. Thus Senegal gum can be utilized in gum based industries, most importantly in food and pharmaceuticals as emulsifier in food processing and effective binder in drug formulations. This study outlines certain aspects of effects of irradiation and metals determined. In the present work free radicals have been generated in gum arabic and its four major components D-galactose, L-arabinose, L-rhamnose and D-glucuronic acid powders using IR, HPLC irradiation and scan electron microscopy**.**

The *Acacia Senegal* gum was hydrolysed and examined using HPLC to determined component sugars Results showed that Degraded gum of *Acacia Senegal* gave L-rhamnose (17.03%), L - arabinose (18%), D-galactos (54.96%) and six different unknown oligosaccharides named as oligo.l (0.29%), oligo.10 (31.1%), oligo.13 (16.35%) oligo.14 (1.50%), oligo.15 (0.22%) and oligo.l7 (18.40%). 5. Polysaccharide of gum Senegal with little published information on itscharacterization. It is a natural, biodegradable, non-toxic material and requires lower production cost. The overall findings of the study indicated that mucilage isolated from the Senegal gum have an inherent property which can be used in various dosages forms**.** The SEM revealed that mucilage is amorphous in nature which indicated that wet granulation technology could be suitable for dosage formulation. Significant mineral and elemental composition was obtained. The FTIR, solid 1D ^{1}H and high pure liquid chromatography confirmed presence of non-reducing sugars. All these results demonstrate that, mucilage is a useful pharmaceutical aid and can be used for effectively controlling the release of drugs from the designed matrix systemsAnalytical studies, and structural features of *Anogiessuslieocarpus*gum showed that the *lieocarpus*gum is closer to *Acacia Senegal* gum. Again this study showed the heterogeneity of the plant gum.

The result of elemental analysis of gum showed that *Ficuselastica*is rich in sodium, calcium, magnesium, iron, potassium, manganese and ferrric. Mineral elements compositions are reported based on the dry matter (DM) (Table 10).

5. Recommendation

Research work on influence of chemical properties of on quality of gum arabic from *Sudan,* varieties has not been given adequate attention under dry land environments of Sudan. There is need therefore to investigate the influence of chemical properties of soils in relation to quality of gum arabic obtained from the natural stands of *A. senegal*varieties between and within sites under the ASAL conditions of Marigat division, Baringo District.

1) Data obtained from the study can be used for setting specification of this gum.
2) Since the gum contain some tannin a toxicological study should be done on the gum to determine its safety for used in food industries.
3) Further details of structural study should be carried out on the gum to obtained the final structure of the gum.
4) The study must continue to findings the mucilage isolated from the seeds have an inherent property which can be used .

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