CHAPTER THREE

GUM ARABIC PROPERTIES AND ITS USE AS ADMIXTURE

3.1Introduction:

In this chapter general Gum types are presented with their definition and properties (Acacia tortilis Gum) with explanation of its properties, Acacia distribution, Classification, Molecular weight, chemical structure properties and applications.

3.2 Gum Arabic in Sudan:

Gum is a product of nature obtained by taping the branches and stems of the tropical Acacia trees concentrated between latitudes 11-14 North. Over 80% of the world, Gum comes from Sudan which is the origin of high quality Gum compared with other Gum producing countries (Table 3.1).

The Gum Arabic CO. ltd. provides different grades of Gum derived from Acocia Senegal. However, the "cleaned" grade and the "handpicked and selected" grade (bigger tears, lighter color) remain the qualities of choice for food, beverage and pharmaceutical applications.

A lesser grade derived from Acacia seyal, known as Gum Talha has diverse technical applications. Table3.2 shows the effect of gum Arabic on many of the properties. [10]

Table 3.1: Comparison between Gum in Sudan and other countries.[10]

Sudan	Other Countries
Uniform stands of monoculture of the right species in large tracks	Mixed species in patches.
Experienced producers, tappers, collectors. Cleaners and graders.	Lack of experience in all fields.
Land tenure settled – recognized prived ownership.	Serious land tenure problems; Gum is produced in the noman, sland.
Producers are mainly settled farmers.	Producers are mostly nomads not interested in Gum development.
The stable system of Gum cultivation cycle is practiced in many areas.	Over-explosion and cutting of trees through shifting cultivation is practiced.
Development of Gum projects at all levels.	Lack of serious development projects.
Production is 85-90% of world production.	Production 10-15% of world production.

Table 3.2: Properties of the Gum Arabic.[10]

The properties	**The effect**
Solubility	Can yield solution up to 55% concentration. Gum Arabic is truly soluble in cold water. Other Gum are either insoluble in cold water or form colloidal suspensions, not true solutions.
Viscosity	High viscosity is obtained only at concentrations of 40-50%.
Film-forming	Gum Arabic‹s superb film-forming properties make it ideal for some confectionery coatings and lithographic plate solutions.
Emulsifier	Gum Arabic‹s process high stable emulsions making it very useful in the preparation of Oil-in-water food flavor emulsions and particularly for citrus oils.
Color	Colorless (top quality) to pale straw color (average quality).
Taste	Gum Arabic has no off-taste of flavoring products co-spray dried with Gum Arabic as the carrier.
Fiber	Gum Arabic can be regarded as95%"soluble fiber", according to the latest evidence by nutritional experts.
Caloric value	Officially recognized in the USA as being under 1Kcal per gram. Generally defined as Polysaccharide Dietary Fiber with reduced Caloric Intake.
Cholesterol Reducer	Human dietary intake studies have indication in blood cholesterol levels when above average amounts of Gum Arabic (25grams per day) are ingested in solution.
Toxicological status	"ADI not specified" (JEFCA + EEC) ; " Generally recognized as Safe " (GRAS|),USA.

3.3 Gum Arabic applications:

Gum Arabic is used in an overwhelming number of applications, mainly situated in the food area. However, there are considerable non-food applications. [10]

Gum Arabic has many applications, noted below:

1. Confectionery: Gum Arabic is used extensively in the production of confectionery products of all types. The usage is based on the properties of sugar crystallization prevention, fate emulsification, binding ability, thickening, coating and glazing properties.

2. Flavour emulsions: Gum Arabic is used in flavour emulsions as an emulsified in the production of flavour emulsion, particularly in citrus emulsions.

3. Flavour encapsulation / flavour fixation: Gum Arabic is used as an encapsulating agent when spray drying flavours. The gum prevents evaporation of the flavor, oxidative deterioration of moisture from the air.

4. Bakery: Gum Arabic is used in glazes and toppings. This utilizes its adhesive properties.

5. Pharmaceuticals: Gum Arabic is used extensively in pharmaceutical products. Usage is based on its emulsification, adhesive, binding and suspending properties plus its high fiber content. Traditionally used in cough syrups for its demulcent properties.

6. Food Adhesive: Gum Arabic is used to adhesive flavours to products such as dry roasted peanuts.

7. Cosmetics: Gum Arabic is used in lotions and protective cream. Usage is based on its stabilizing, binding and viscosity properties.

3.4 Industrial applications:

Gum Arabic has many great industrial applications including:

1. Textiles where it is used as a sizing and finishing agent.
2. Lithography where it is used as a sensitizer, moisturizing agent and a protective film in litho plates and in fountain solutions.
3. Links where it is used as an emulsifier, protective colloid and suspending agent.
4. Adhesives.
5. Paints.
6. High Technology ceramics.
7. Paper coatings.
8. Pesticides / Insectide sprays.
9. Metal corrosion inhibition.
10. Glazing agent.
11. Fireworks/Pyrotechnics.
12. Gum powder mixtures/cartridge powders.

3.5Acacia tortilis Gum:

Acacia tortilis, often called the “umbrella thorn” for its distinctive spreading crown, is one of the most widespread trees in, seasonally, dry areas of Africa and the Middle East. The umbrella thorn is the dominant tree in many savanna communities and provides an important source of browse for both wild and domesticated animals. [10]

3.5.1 Colloids:

Colloids are compounds which form dispersion, with minute particles (called colloidal particles) disperse, evenly, through the mediums. Familiar colloids include fog, smoke, homogenized milk and ruby-

Colored glass. Thomas Graham (1860) discovered that certain substance, glue, gelatin; starch could be separated from certain other substances e.g. sugar or salt by dialysis. He gave the name colloid to substance that do not diffuse through a semi-permeable membrane like cellophane, and the name crystalloid to those which do diffuse to form true solutions. The dispersed phase particles have a diameter between 5 and 200 nanometers. Homogeneous mixtures with dispersed phase in this size range are knows as colloidal aerosols, emulsions, foams, dispersions or hydrosols. The dispersed phase particles or droplets are affected, largely, by the surface chemistry of the particular colloid. [10]

3.5.2 Hydrocolloids:

A hydrocolloid is defined as a colloid system where the colloid particles are dispersed in water, and depending on the quantity of water available the hydrocolloid can be described as gel or sol. It can be reversible or irreversible. Many hydrocolloids are derived from natural sources for example, agar-agar and carrageenan are extracted from seaweeds, and gelatin is produced by hydrolysis of proteins of bovine and fish origin. Hydrocolloids are also referred to as gums, have been widely used in the food industry as thickeners and agents for gel formation and particle suspension. They work, cooperatively, with surfactants to stabilize emulsions against flocculation and coalescence. [10]

3.5.3 Exudates gums:

Exudates gums are among the oldest natural gums used as thickening and stabilizing agent. Exudates gums are produced by many trees and shrubs as a natural defense mechanism, particularly in semi arid regions of Africa. When the plant's bark is injured, an aqueous gum solution exudes to seal the wound, preventing infection and dehydration of the plant. The solution dries in contact with air and sunlight, to form hard, glassy lumps which can easily be collected. [10]

3.6 Classification:

The classification of Acacia is shown in Table 3.3 in which Gums are classified according to their source.

3.7 Chemical Composition and Structural features of Acacia Gums:

Gums are complex copolymer of polysaccharide obtained as mixed calcium, magnesium and potassium salt, with high molecular mass and a complex structure. However all Acacia gums are Arab inogalactan-proteins (AGP) and it was described as heterogeneous. The heterogeneous nature of the gum has been studied extensively using different techniques: hydrophobic affinity chromatography, anion-exchange chromatography. [10]

Table 3.3: Classification of Gums according to their sources.[14]

Source	Gum
Tree exudates *Acacia Senegal*; *Acacia seyal* and other *Acacia* of African origin. *Astragalus* species (Iran/Turky). *Sterculia urens* (India/African) *Anogeissus Latifolia*	Gum arabic Gum *tragacanth* Gum *karaya*, Gum *ghatti*
Seaweed extracts *Gelidicum* and *Gracilar* species *Euchemacottonii; Euchemaspinosum*; *Choandus cripus* and *Gignrtina* species. *Lamimaria hyperborean; Macrocystis purifera* and *Ascophyiius* nodosum	*Agar* *Carrageenan* *Aginate*
Plant extracts Peels of various citrus fruits and apples pommace	pectins
Seed roots and gums *Cyamopsis tetragonoloba* *Ceratonia* *Cesalainia* *Amorphallus konjac*	*Guar* gum *Locust bean* gum *Tera* gum *Konjac mannan*
Microbial gums *Xanthamonas Camestris* *Auromonas*	*Xanthan* gum *Gellan* gum
Cellulose gums Cellulose pulps and cotton linters	Sodium carboxymethyl cellulose, Methylcellulose, Hydroxpropylmethylcellulose

3.7.1 Molecular structure of gums:

Anderson et al (1966) determined the structure of the gum arabic by subjecting it to a series of Smith degradations using periodates. They obtained seven distinct degradation products. Further analysis of each product using methylation and gel permeation chromatography (GPC) showed that uronic acid and rhamnose residues were eliminated first, indicating that they were located at the periphery of the molecule. The core was found to consist of a β-(1, 3)-galactopyranose chain with branches linked through the 1, 6 positions. Structural fragments based on a model that was consistent with the experimental data which suggested as a representative model of the whole gum is shown in. [10]

3.8 Gum Arabic properties:

Gum Arabic dissolves readily in cold and hot water in concentrations up to 50%. Because of the compact, branched structure and therefore small hydrodynamic volume, gum Arabic solutions are characterized by low viscosity, allowing the use of high gum concentrations in various applications.

Gum Arabic has excellent emulsifying properties, the hydrophobic polypeptide backbone strongly adsorbs at the oil-water interface, while the attached carbohydrate units stabilize the emulsion by electrostatic repulsion. Fractionation studies show that, although emulsifying properties generally improve with increasing molecular weight and protein content (Table3.4), the best results are obtained with mixture of different fractions. Seemingly, the heterogeneous nature of the gum makes it an excellent emulsifier. [10]

Table 3.4: Chemical composition of gum Arabic.[10]

compound	Composition %
Galactose	36
Arabinose	30
Rhamnose	12.6
Glucuronic acid	19.2
protein	2.2

3.9 Botanical aspects of Acacia tortilis:

Acacia tortilis is one of about 135 African Acacia species. Unlike Australian Acacias, African Acacias are armed with thorns and produce highly palatable pods. Acacia tortilis is a variable species, with six intra specific taxa including four recognized subspecies: tortilis, spirocarpa, heteracantha, and raddiana . Although some French and Israeli authors consider ssp. raddiana a separate species, recent revisions treat it as a subspecies. As with other African Acacias, tortilis is a polyploid complex most are tetrapoloids. [10]

3.9.1 Botanical description:

Acacia tortilis varies from multi – stemmed shrubs less than 1m umbrella shaped, and trees up to 20m tall with rounded or flat topped and crowns. Bark grey, grayish brown to yellow, smooth or fissured. Young branches are glabrous. Spines mixed, some white, straight, slender, up to 7.5 cm long, and short hooked brown spine 2-6mm they occur on plant. Leaves dark green (0.5 – 3.0 cm) long, (2-5) pairs. Petiole glandular. Pubescent, (0.2 - 3 mm) long. Flower pale yellow cluster in 1cm diameter round heads. Pods flat, coiled or spirally shaped. Seeds olive green to red brown, smooth, elliptic slightly compressed, 6*35 mm areole marginal, U – shaped, and 4-5 mm long, coiled, seeds lie longitudinally in the pod (figure 3.1).[10]

3.9.2 Botanical classification:

Figure 3.1 Hashab tree

Kingdom:	Plantae
Division:	Magnoliophyta
Class:	Magnoliopsida
Order:	Fabales
Family:	Fabaceae
Subfamily:	Mimosoideae
Tribe:	Acacieae
Genus:	Acacia
Species:	A .tortilis
Binomial name:	Acacia tortilis Hayne
Local name	sayal

3.9.3 Distribution and growing condition:

Acacia tortilis is a drought-resistant species that grows in areas with annual rainfall as low as 40 mm and as much as 1200mm, with dry seasons of 1-12 months. The tree favors alkaline soils and voids waterlogged sites, but apart from that it will grow on a wide range of sites. Acacia tortilis forms a deep tap root in sandy soils, in Sahara has roots reaching 35m deep. On shallower soils it grows fairly well, less than 0.25m deep, though it develops long lateral roots that can become a nuisance in nearby fields, paths, and roadways. In shallow soil, the plants remain shrubby and must be widely spaced to allow for their lateral root growth.

In Sudan tortilis occurs as bush lands in Northern, Central and North East Sudan, on banks of large wadis, and sites receiving considerable amounts of run-off water, for instance the edge of the Nubian sandstone plateau and the Nile in Shendi district. Near Khartoum and to its south there are groves of large trees in villages. Other areas of occurrence are the Kordofan sand with rainfall of 200-400mm, on the detritus slopes round the base of rocky hills, under rainfall of 500-600mm, and on the eroded clays fringing the Atbara. In White Nile, Kassala, Gedaref, and El Ghogalab. [10]

3.10 Physical properties of Acacia tortilis gum :

1. Color: The color of the gum nodules is pale yellow to brown.
2. Shape: The shapes of the gum nodules, as exuded naturally, are irregular or tear shaped.
3. Solubility: Acacia tortilis gum is highly soluble in water forming transparent solution, and classified as a soluble gum.

3.11 Purification of crude gum:

The gum samples used in this work were relatively pure; however, impurities such as wood pieces and sand particles were carefully removed by hand. Then each sample was reduced to a fine powder using a mortar and pestle and kept in labeled self sealed polyethylene bags.[10]

The following chapter provides laboratory work in which development of compressive strength of concrete is the main target of the chapter, together with related properties of concrete.