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WHAT IS GUM ARABIC? AN OVERVIEW

Osama H.M. Idris

Agrigum International Limited,
St Mary's Court, The Broadway, Old Amersham,
Buckinghamshire, HP7 0UT, UK

E-mail: oidris@talktalk.net

ABSTRACT

Purpose: To encourage Gum Arabic exporters and investors in Sudan to spray dry their high demand Gum Arabic crop instead of exporting raw or semi raw Gum Arabic products. To increase the knowledge of Gum Arabic producers and consumers in Sudan and abroad regarding the diversity of Gum Arabic applications.

Social implications: Exporting spray dried Gum Arabic from Sudan will add value to the crop. The increased in foreign currency will have a positive impact on the income of farmers and Gum Arabic manufacturers. Increased Gum Arabic earnings will encourage the planting of more Gum Acacia trees. The Gum Acacia tree root has nodules containing Rhizobia bacteria; this helps to fix nitrogen in the atmosphere. Nitrogen fixation fertilizes poor soils and allows the reuse of exhausted soils and fights desertifi cation.

Originality/value: This paper will highlight the wide range of applications of Gum Arabic, and how to spray dry the Gum Arabic products.

Keywords**:** Gum Arabic; Gum Acacia; spray drying; agglomeration; kibbling; manufacturing; properties; applications.

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INTRODUCTION

Gum acacia (INS No. 414) is defined by the FAO/WHO Joint Expert Committee on Food Additives (JECFA) in FNP 52 Add 7 (1999) as: "Gum Arabic is a dried exudates obtained from the stems and branches of *Acacia senegal* (L.) Willdenow or *Acacia seyal* (fam. Leguminosae)".

Gum acacia, also known as Gum Arabic, is exuded from Acacia trees – mainly from *Acacia Senegal*, known as Hashab and *Acacia seyal* called Talha. The main gum acacia producing countries are Sudan, Nigeria, Chad and Senegal. Sudan is considered to be the world's largest producer of Gum Arabic. Both species spread naturally in the central belt of the low rainfall savannah between latitudes 10° and 14° north, where they exist in pure or mixed stands, in the clay plains in the east and sandy soils in the west. In addition to its significant economic role for the country, Gum Arabic plays an important part in rural life, providing a steady income to rural families, especially in dry years when crops fail (Abdel Nour, 1997). The Acacia trees present in arid areas, with its deep and extensive root system, retains and binds the soil and thereby limits desertification. Moreover, it improves or restores poor soils and those damaged by the nitrogen load. In order to maintain the environmental benefits of improved soil fertility and the socioeconomic benefits of the Gum Arabic farming system, the prices paid to smallholders must be stabilised at a fair level, otherwise a shift to other crops or practices might take place (Elmqvist et al., 2005).

Gum acacia is the oldest and best known of all the polysaccharides plant exudates. It was used by the Ancient Egyptian in their paintings as an adhesive for mineral pigments, and as an adhering agent to make flaxen wrappings for embalming mummies.

Gum acacia is a highly heterogeneous complex polysaccharide consisting of galactose, arabinose, rhamnose, glucuronic acid and 4-O-methylglucuronic acid (Williams et al., 2000). The carbohydrate compositions can vary, depending on the location, the age of the tree and site of tapping, and from season to season. Also, gum acacia consists of a small amount of protein (~0.8% with *Acacia seyal* and ~2.0% with *Acacia senegal* gums), which forms an integral part of the gum structure. Gum acacia has been fractionated by Multi Angle Laser Light Scattering

Table 1 Physico-chemical characteristics and nutritional data for *Acacia Senegal* and *Acacia seyal* gums – Typical Values

Parameter	*Acacia senegal gum*	*Acacia seyal gum*
Appearance	Amber transparent hard nodules	Red/Brown fragile fragments
Nutritional Value	1.7 Kcal/g	1.7 Kcal/g
Total Fat	0%	0%
Complex Carbohydrates	95%	95%
Soluble Dietary Fibre	$>$85%	$>$85%
Protein	2.0%	0.8%
Tannins	0%	0.11%
Potassium	8500 ppm	2000 ppm
Calcium	9000 ppm	11,000 ppm
Magnesium	1400 ppm	1200 ppm
Viscosity (25% solution w/v)	100 cps	80 cps
Emulsion capacity	High	Low
Specific Optical Rotation	-30°	$+50^{\circ}$
pH	4.50	4.40
Ash	3.2%	2.7%

Source: Idris and Haddad (2012).

(MALLS) into three principle fractions (Idris et al., 1998), which are Arabinogalactan (AG), Arabinogalactan-Protein (AGP) and Glycoprotein (GP). The physicochemical and nutritional data for *Acacia senegal* and *Acacia seyal* gums are shown in Table 1. The data shows that *Acacia senegal* gum has a higher potassium content and emulsion capacity when compared to *Acacia seyal* gum, while *Acacia seyal* shows a slightly higher calcium content and slightly lower viscosity and ash content. Specific optical rotation is one of the most important quality control tools used by the gum acacia suppliers and manufacturers to differentiate between both gums (Idris and Haddad, 2012).

GUM ARABIC PRODUCTION

The weather temperature has a considerable influence as to when the gum season starts. If the weather is hot enough directly after autumn (October/November), the leaves will start falling; this is a signal to start tapping the *Acacia senegal* trees. The traditional tapping tool was an axe, but modern practise in the Sudan is to use a sharp spear (Sonke) to pierce through an upper branch (or stem) just beneath the bark (not to damage the cambial zone). The spear is then moved up and down along the length of the branch to remove part of the bark and expose an area of the cambial layer about 30 cm long and 5 cm wide (Idris and Haddad, 2012). Expert tappers always ensure that no peeled bark is left on the tree that could stick to the gum nodules. *Acacia seyal* trees normally exude the gum naturally, although recently farmers have also started to tap these.

When the tree is subjected to stress conditions such as drought (*Acacia seyal*) and wounding (Williams et al., 2000), the gum oozes from the stems and branches of the tree within a zone between the inner bark and the cambial zone (Joseleau and Ullmann, 1990). The trees must be aged five years or older for gum production to occur, suggesting therefore that gum production is in direct competition with tree growth. Gum exudes in nodule form up to 60 mm in diameter, which are then dried in the sun. *Acacia senegal* forms hard, glass-like lumps that are transparent to amber in colour. *Acacia seyal* forms fragile fragments that are amber to brown in colour. A number of hypotheses have been suggested for the biosynthesis of the gum, which is referred to as 'gummosis'. It was proposed that gummosis is a pathological process resulting from a bacterial or fungal infection of the injured tree (Blunt, 1926), and efforts were made to isolate the bacteria and moulds that may be involved in the formation of the gum (Khalid et al., 1988). Others believe that gummosis is part of the normal plant metabolism or directly related to starch metabolism, and that gum acacia is produced in response to physiological disturbances induced by stress (Anderson and Dea, 1968).

The exudate gum hardens in the sun to form nodules that are manually collected after 4–6 weeks from tapping, followed by 3–5 collections every two weeks, depending on the weather conditions and the health of the tree (Imeson, 1992).

Drying the gum after collection is a very important process to prevent fermentation and forming of agglomerated gum nodules (jammed gum). The gum is spread evenly to dry for a few days. It is recommended to avoid direct sun drying as the gum nodules break into small fragments and siftings. Drying the gum under 45% shade will help in drying the gum nodules without compromising the Hand-Picked Selected (HPS) and lump quality gums.

The crude gum is pre-cleaned manually from sand and bark using sieves and trays. This is traditionally done by women, who manually sort the gum according to the size of the lumps and remove foreign matter (FAO, 1995).

MANUFACTURING OF GUM ARABIC

Mechanical process: Figure 1 shows the mechanical process, which involves cleaning, grading and generating a range of different particle sizes from the original lump gum. The mechanical process also includes the kibbling stage – a grinding process – that breaks up the gum nodules into various specific particle sizes of approximately 0.5 mm to 6.0 mm. The kibbling process increases the surface area of the gum particles and this allows the gum to dissolve faster in water compared with the lump gum. Mechanical powder can also be produced by further milling the kibbled gum, using mostly pin mills. Although the produced kibbled and milled gums are subjected to various mechanical cleaning steps, they still contain some amount of bark and foreign materials.

Spray drying process: the spray drying process shown in Figure 2 starts by dissolving the kibbled gum in water, followed by several filtration stages to remove the impurities. The gum solution is then decanted, centrifuged, then passed through ultra-fine filters to remove the fine insoluble materials. In order to free the gum from any contaminated pathogenic micro-organisms and to reduce the total bacterial yeasts and moulds count, the gum solution is subjected to a pasteurisation process (Idris and Haddad, 2012). The pasteurised gum solution is sprayed into fine droplets by atomisation or jets in a stream of hot air; this rapidly evaporates the water. Cyclones are used to separate dry gum powder from dry air (Williams, 1990).

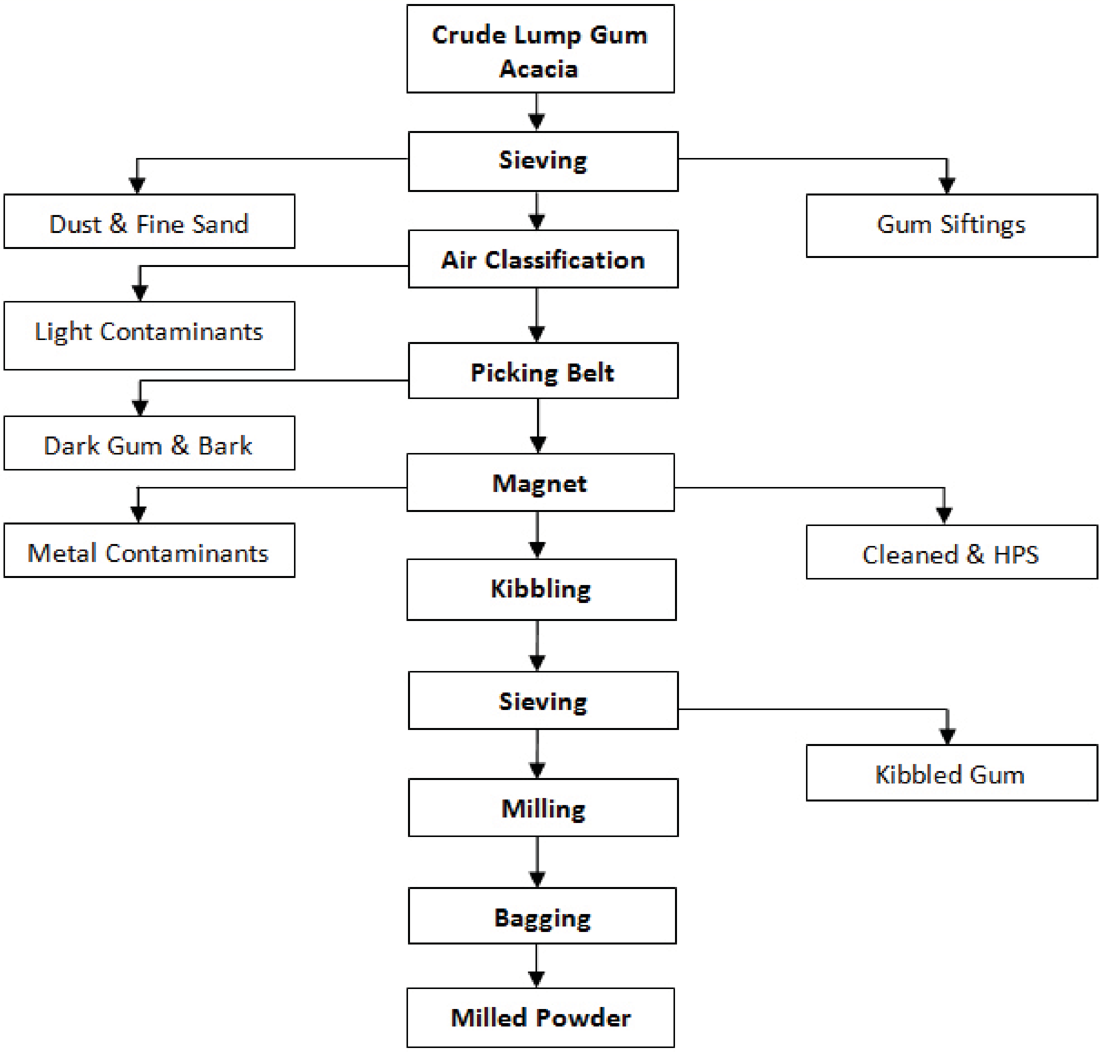

Figure 1 Gum Arabic Mechanical Process Chart

The spray drying process allows gum to be efficiently purified to give a consistent product. This can then be used directly in applications without recourse to further cleaning, chemical, physical or microbiological procedures. The vast majority of the food and pharmaceutical industries now specify spray dried gum acacia because of its benefits in all types of applications. Spray drying of Gum Arabic in Sudan will add value to the crop. The increase in the generation of foreign currency from the export of spray dried Gum Arabic is expected to have a positive impact on the income of farmers and Gum Arabic manufacturers.

Agglomeration process: the agglomeration process summarised in Figure 3 involves suspending the spray dried gum acacia powder on a bed of air, then spraying water or gum solution onto this to cause particles to stick together. The produced agglomerated powder is then dried and sieved to produce a product with a consistent and narrow range of particle size (Idris and Haddad, 2012).

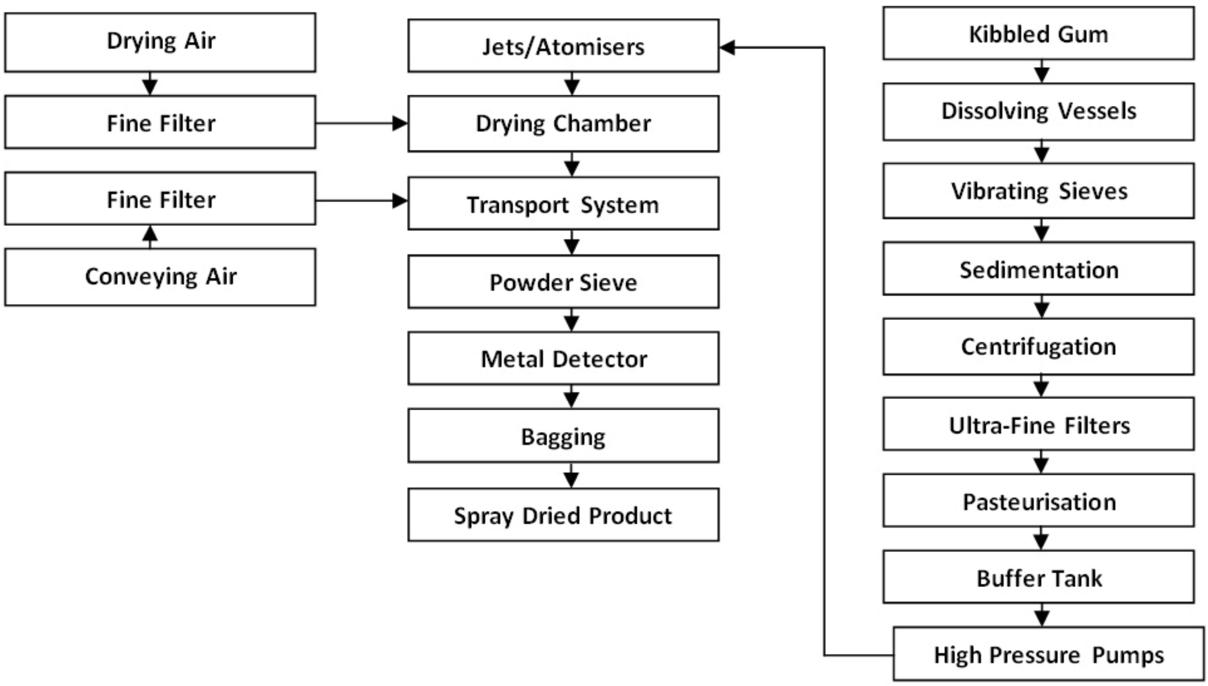

Figure 2 Gum Arabic Spray Drying Process Flow Chart

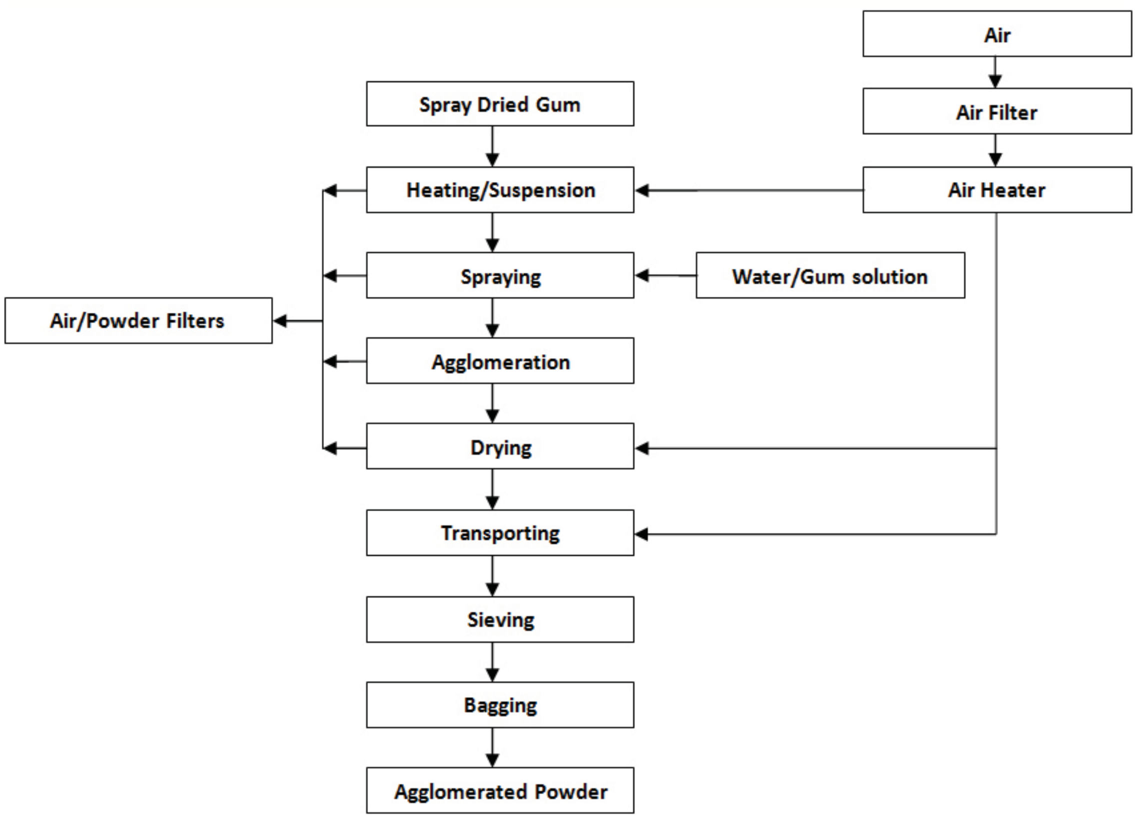

Figure 3 Gum Arabic Agglomeration Process Flow Chart

The advantage of the agglomeration process is that it produces environmentally friendly, dust-free gum acacia powder products, and improves significantly the dispersability, sinkability, solubility and dissolving characteristics of the spray dried gums. Customers using the agglomerated gum powder do not need very powerful mixers to dissolve the gum.

GUM ACACIA FUNCTIONAL PROPERTIES

Gum acacia has many properties that make it unique such as:

- *Solubility*: gum acacia is unique among natural hydrocolloids in that it is highly soluble in hot and cold water. Most gums cannot be dissolved in water at concentrations higher than 5% due to their high viscosity, but gum acacia can yield solutions up to 50% concentration. The ability of gum acacia to form these concentrated solutions without an excessive increase in viscosity is due to the high degree of branching within the gum structure (Street and Anderson, 1983) and therefore small hydrodynamic volume. Gum acacia is insoluble in oils and in most organic solvents and is soluble in aqueous ethanol up to a limit of about 60% ethanol.
- *Emulsifying properties*: gum acacia from *Acacia senegal* is a very effective emulsifying and stabilising agent and has found widespread use in the preparation of varied oil-in-water beverage emulsions. It is not less than the gold standard of emulsifiers used in beverages (Matthias, 2010). The gum contains a protein deficient, low molecular weight AG, a protein-rich GP and a high molecular weight AGP complex (Randall et al., 1988). The AGP complex is preferentially absorbed into the oil droplets, and it is this which stabilises the emulsion. The large hydrophilic polysaccharide blocks of the AG fraction extend into the aqueous phase and prevent coalescence due to the steric repulsion between droplets. Processing factors such as pasteurisation and demineralisation of the gum promote emulsion stability, most likely by promoting protein unfolding and eliminating the screening effect, respectively (Buffo et al., 2001).

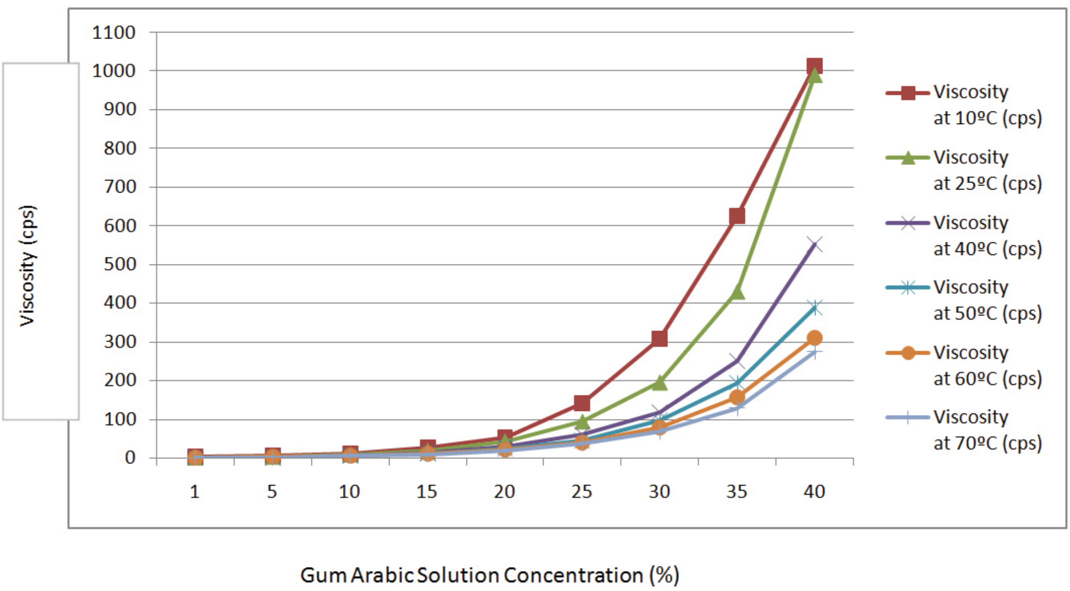

Figure 4 Viscosity of Agri-Spray Acacia® RE (Acacia senegal gum) at Different Concentrations and Temperatures. (Brookfield LVTD viscometer with small sample adapter & spindle Ref. SC4-18/13R)

- *Viscosity*: most gums form highly viscous solutions at low concentrations (<5%). However, at such relatively low concentrations, gum acacia yields solutions that are essentially Newtonian in behaviour and have very low viscosities compared to other polysaccharides of similar molecular mass. Figure 4 shows study results of the effect of concentration and temperature on the viscosity of Agri-Spray Acacia® RE (*Acacia senegal* gum) product (Idris and Haddad, 2012). The viscosity results of the *Acacia senegal* gum shows an increase in viscosity following the increase in concentration, and a decrease in viscosity when the gum solution is subjected to an increase in temperature. At concentrations above 40%, *Acacia senegal* gum produced solutions with a considerably higher viscosity, which indicates that gum acacia molecules at these concentrations effectively overlap, and steric interactions result in a much higher solution viscosity (Williams et al., 1990).
- *Compatibility*: gum acacia has a broad range of compatibilities and is compatible with most gums, starches, carbohydrates and proteins. It is incompatible with sodium alginate and gelatine. With gelatine, gum acacia forms a well-known coacervate utilised in the preparation of encapsulated oils. A synergistic viscosity decrease was reported with a mixture of gum tragacanth and gum acacia, which reached minimum viscosity at 80% gum tragacanth and 20% gum acacia (Imeson, 1992).
- *Effect of heat*: prolonged heating causes the thermal destruction of gum acacia. It results in the denaturation and precipitation of the proteins from the high molecular weight AGP and GP complexes, and this causes a reduction in the emulsification capacity and solution viscosity (Randall et al., 1989).
- *Sensory properties*: *Acacia senegal* gum is generally odourless, colourless and tasteless, while *Acacia seyal* gum is slightly dark in colour.
- *Nutraceutical properties*: gum acacia is a complex, non-starch polysaccharide, indigestible to both humans and animals but fermented in the colon to give short-chain fatty acids, leading to a wide range of potential health benefits (Phillips and Phillips, 2010). It thus meets dietary fibre definitions that are adopted by the European Union and Codex Alimentarius. The typical fibre content of gum acacia is in excess of 85% (AOAC method). Due to the complex, highly branched molecular structure of gum acacia, its fermentation is very slow and this reduces the bloating side effect.

Gum acacia is a prebiotic, soluble fibre that feeds and stimulates the growth and activity of the beneficial bacteria (Probiotic) in the colon, that is, lactobacilli (Cherbut et al., 2003). Probiotic bacteria strengthens the immune system to combat allergies, stress, exposure to toxic substances and other diseases.

It has been reported that studies *in vivo* and *in vitro* with gum acacia shows compatibility in the diet of patients suffering with diabetes mellitus, and a reduction in systolic blood pressure; this may translate into an improved cardiovascular outcome and a reduction in the progression of renal disease (Phillips and Phillips, 2010). A calorific value of 1.7 Kcal/g for gum acacia has been confirmed by the Food and Drug Administration (FDA), and can be used for the calculation of gum acacia energy contribution.

GUM ACACIA APPLICATIONS

Gum acacia enjoys a remarkable diversity of applications; this is mainly due to its desirable physico-chemical properties and functions as reported earlier. The functions of gum acacia include emulsifier, formulation aid, stabiliser, thickener, surface finishing agent, processing aid, firming agent, texturiser, adhesive, plasticiser, soluble fibre and prebiotic source and many others.

- *CONFECTIONERY*: gum acacia has been widely used in the confectionery industry for many centuries. This is due to its ability to prevent sugar crystallisation, modify texture, emulsify and keep fatty components evenly distributed. It also acts as a boundary film in glazing systems (Adamson and Bell, 1974; Langwill, 1939).
- *High Sugar Confectionery (pastilles, candies, gum drops)*: in pastilles and candies, gum acacia is used in concentrations up to 45% to inhibit sugar crystallisation, and as a binder. The traditional wine gums and gum drops (or fruit gums) were originally prepared exclusively with gum acacia (Voelker and Thieme, 1972) as a higher clarity could be achieved compared to other hydrocolloids. The resistance to melt-away, shape retention, bland taste and odour, pliable texture, and low adhesion when chewed, are all major benefits of this gum (Imeson, 1992). Other properties of providing slow, controlled flavour release, protecting flavours from oxidation and controlling sugar crystallisation are also valuable.
- *Reduced sugar and no-sugar confectionery*: gum acacia performs very well in replacing the bulk and texture of sugars in combination with artificial sweeteners, for example, Sorbitol, as well as providing binding and fibre in low calorie confections. Reduced calorie nougat candies have been made by incorporating up to 27% each of gum acacia and Microcrystalline Cellulose (MCC) in the standard nougat composition (Brucker et al., 1974). Calorie reductions of over 50% have been achieved in toffee by using higher levels of gum acacia with MCC (Glicksman, 1983).
- *Compressed Sugar Confectionery (tablets, lozenges, extruded paste)*: gum acacia is used as the binding agent and paste base for forming the stiff dough that is rolled in sheets and stamped into lozenges (Williams, 1961). Depending on the concentration of gum acacia, the sugar types and proportions, and the residual moisture in the confectionery, textures ranging from soft lozenges and pastilles to hard gums can be produced (Wolff and Manhke, 1982).
- *Caramels and toffees*: gum acacia keeps the fat uniformly distributed throughout the caramel and toffee confection, and this prevents the fat from rising to the surface where it causes problems as an easily oxidised, greasy film (Williams, 1961).
- *Coated Products (dragees, chewing gum, chocolate centres, nut centres, coated almonds, chocolate coated peanuts and raisins)*: in making sugar-coated confections such as sugared almonds, a planning process is employed where gum acacia solutions are used to coat the nut before the final sugar coating is applied. With chocolate-coated products, the gum solution is applied as the final coating. In all such applications, gum acacia functions as a film forming or a glazing/coating agent.
- *Chewing gum*: gum acacia performs a variety of roles associated with chewing gum manufacture, including flavour carrier, control of flavour release and texture improver. Gum acacia is also used to glaze and coat finished chewing gum pieces to seal and protect the flavour, improve resistance to humidity and give a pleasing, shiny appearance to the product (Huzinec and Graff, 1987).
- *Snacks (dry roasted peanuts, spicy nuts)*: a concentration of up to 25% gum acacia solution is used in this application as an adhesive coating to apply seasoning to products such as dry roasted peanuts.
- *Chewy candies*: gum acacia is used in the manufacture of chewy sweets at low levels (1–2%) as the gelatine is the main texturising agent. Gum acacia is used to give additional adhesion, to reduce elasticity, and to give extra fine sugar crystallisation with a smooth texture. However, with the concerns over BSE in cattle and the use of their by-products, gelatine is being completely replaced with gum acacia in combination with other hydrocolloids.
- *Bakery products*: in the baking industry, gum acacia is used for its comparatively low water-absorption, viscoelastic properties and high soluble fibre. In addition, it has favourable adhesive properties for use in glazes and toppings, and imparts smoothness when used as an emulsion stabiliser (Glicksman, 1983).

Gum Arabic is used in bread manufacturing as a rich fibre source, and because of its functional properties such as increasing water absorption, dough height and bread volume. The incorporation of 0.1–0.5% of gum acacia to flour from Punjab wheat during bread making has improved the volume of bread by all the levels of gum addition (Sidhu and Bawa, 2004). Extended storage of frozen dough resulted in changes in rheological properties, which cause increased proofing time and ultimately a lower loaf volume of bread. The main causes of these changes are ice crystallisation, which damages the gluten network. Incorporation of Carboxymethylcellulose (CMC), and Gum Arabic at different levels reduced the ice crystallisation in frozen dough. The loaf volume increased significantly compared to control after each storage period (Asghar et al., 2005). Gluten-free bread requires polymeric substances that mimic the viscoelastic properties of gluten in bread dough. Research studies have successfully formulated gluten-free bread by incorporating gum acacia (Gum Arabic), CMC, Guar gum and egg albumen into non-wheat flours (Toufeili et al., 1994).

- *FLAVOURS AND BEVERAGES*: gum acacia has been used extensively for many years in the flavour and beverage industry due to its unique emulsifying, stabilising, encapsulating, low viscosity and acid stability properties.
- *Liquid flavour emulsions*: gum acacia is extensively used to prepare and stabilise essential oil emulsions (orange, lemon, lime, cherry and cola), which are supplied to the soft drinks industry. A high concentration of gum acacia is required to stabilise a beverage emulsion, as the oil droplet surface should be fully covered to prevent flocculation and coalescence. In general, as much as 20% gum acacia may be needed to stabilise a 12% beverage emulsion (D'Angelo, 2006; Matthias, 2010).
- *Spray dried flavour encapsulation*: gum acacia is universally known as an excellent encapsulating material for flavours. This is due to its emulsification properties, low viscosity, bland flavour, and for its protective action against flavour oxidation during processing and storage. Several dry-food products, including desserts, pudding mixes, soups and beverage powders, contain encapsulated flavours for flavour stability and a longer shelf life. A pre-spray drying liquid emulsion is first formed, with a formulation that might contain 7% oil-based flavour and 28% gum acacia (Thevenet, 1988).
- *Flavoured beverage with added cloudiness and pulps*: as well as the encapsulation of flavours and juices, gum acacia can act as a clouding agent in dry beverage mixes. A spray dried emulsion of gum acacia and vegetable oil gives a stable, encapsulated, free flowing powder, that when dispersed in water, gives cloudiness or turbidity imitating the effect of added pulps of citrus and other fruit juices (Eng and Mackenzie, 1984).
- *Nutritional drinks*: gum acacia is used increasingly as a source of soluble fibre in low calorie and dietetic beverages (Phillips, 1998). The FDA Daily Recommended Value (DRV) for fibre is 25 grams, with formulation requirements based on serving sizes. Products labelled 'Good Source' or 'Fibre Fortified' must contain 2.5 g (10% of DRV) per serving, while products labelled 'High Fibre' must contain 5 g (20% of DRV) per serving.

OTHER FOOD APPLICATIONS

- *Food colours*: gum acacia is used as a base for the preparation of spray dried colour oleoresins such as annatto, paprika and turmeric (Idris and Haddad, 2012). It can also be used to prepare and stabilise liquid colour emulsions.
- *Nutritional foods*: gum acacia is designed as a convenient means of adding soluble fibre to high fibre/low fat food products ranging from yoghurts to cakes. It delivers in excess of 85% total dietary fibre. Hence, the use of gum acacia affords all the benefits associated with soluble fibre without the adverse effects on the textural properties of the food.

- *Fruit post-harvest*: edible coatings of 10% Gum Arabic significantly delayed changes in firmness, weight, soluble solids, ascorbic acid, titratable acidity, percentage decay and colour development of tomato during 20 days storage (Asgar et al., 2013). Gum Arabic in aqueous solution of 10% combined with silver nanoparticles significantly hindered the growth of microorganisms and physicochemical losses, and showed the best performance for enhancing the shelf life of green bell peppers (Hedayati and Niakousari, 2015). Application of GA 10% coating combined with CA 3% might be a simple and effective technique for preserving mango fruit quality during low temperature storage (Ghulam et al., 2015).
- *Protective coatings*: oil-soluble vitamins, such as vitamin A, are stabilised by spray drying them in an emulsion containing antioxidant, fat, lactose and gum acacia to give an encapsulated powder retaining 85% of its vitamin activity after 12 months storage at room temperature. A coating of gum acacia will help protect unstable oils and flavours from the development of rancidity and off-tastes (Glicksman, 1983).

PHARMACEUTICAL

Gum acacia has been used successfully in a variety of pharmaceutical products because of its many functional properties such as binder, adhesive and glaze for pharmaceutical tablets (Tame-Said, 1997). In demulcent syrups, it is used for its soothing and protective action, as a suspending agent and as an emulsifying agent. Gum acacia is also used as one of the main ingredients in medicated cough drops and lozenges.

COSMETICS

In cosmetics, gum acacia has a variety of roles because of its excellent functions such as a stabiliser. It also imparts spreading properties, gives a protecting coating and a smooth feel. It is used as a binding agent for cake material and an adhesive in facial masks. Gum acacia is used in the formulation of mascara, facial moisturiser, moisturiser, anti-aging, body wash/cleaner, liquid hand soap, hair spray, eyeliner, lipstick (Whistler, 1993) and others.

PRINTING AND PAINTS

- *Lithography*: in lithography, gum acacia is used as a sensitiser for lithographic plates (FAO, 1995), as it confers good viscosity control and generates uniform layers of adsorbed film, producing a uniform coverage of material on the plates used. Gum acacia solutions are also used to generate a protective film for storage of the printing plate, and to emulsify solvents in the preparation of cleaning solutions (Idris and Haddad, 2012).
- *Inks*: gum acacia has been used as an emulsifier or suspending agent in a variety of different types of inks because of its protective colloid properties.
- *Water colours*: gum acacia is traditionally used in water colours as a binder because it is highly soluble in water, low in viscosity and, when it dries, forms a thin layer that binds pigments to the paper surface. Gum acacia increases the water colour brilliancy, gloss, transparency and gives colours greater depth.

INDUSTRIAL

- *Adhesive*: gum acacia is used as an adhesive for postage stamps and to make liquid glues, and although these traditional applications have largely died out, it is still used as a specialist paper adhesive. A 50% gum acacia solution is prepared and then applied to the paper either directly from an applicator nozzle or by roller, followed by drying.

- *Ceramics*: the functions of gum acacia in ceramics' manufacture include as a plasticiser for the moulding of delicate shapes, providing green strength prior to firing in a kiln, and as an adhesive for the application of cup and bowl handles prior to firing.
- *Pumpable and fluid cement mixes*: in liquid cement mixes, gum acacia is used as a suspension and plasticiser agent.
- *Fireworks/pyrotechnics*: gum acacia is mixed with fireclay to seal the base of the containment tube of fireworks.

MISCELLANEOUS

Gum acacia has been used to inhibit metal corrosion in batteries. It is also used in gunpowder mixture/cartridge powders, flotation in phosphate mining/refinement, insecticide sprays and as a detergent for removing oil.

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BIOGRAPHICAL NOTES

Osama H.M. Idris obtained Master (University of Khartoum) and PhD (University of Wales) on the Physico-Chemical, Microbiological and Functional Properties of Gum Arabic. He has been working with the Gum Arabic manufacturing and business for over 30 years (9 years with the Gum Arabic Company in the Sudan, and 21 years with the Spray Drying Gum Arabic Factory in UK). He has published several well-received papers on Gum Arabic, and currently works as Technical Sales Director with Agrigum International Limited – UK.