J. Glob. Innov. Agric. Soc. Sci., 2017, 5(3): 114-120
ISSN (Online): 2311-3839; ISSN (Print): 2312-5225
http://www.*jgiass.com*

GUM ARABIC PROPERTIES AND USES

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A majority of gums are obtained from plant or seed materials and are regularly incorporated as food additives. One of them is Gum Arabic (GA) which is defined as the dried exudate obtained from the stems and branches of *A. senegal* and related species. The best quality gum is associated with Sudan. Its structure and emulsifying properties make it to be used in preparation different emulsions in food industry and in medicine. Gum arabic has the highest commercial value due to its widespread application in food, pharmaceutical and cosmetic industries. This review try to highlight the different properties and uses of Gum Arabic in different domains.

Abbreviations: plasma electrolyte solution (PES), water soluble yellow mustard mucilage (WSM), β-lg: β-Lactoglobulin, GA: gum arabic, XG: xanthan gum, CG: Cashew tree Gum.

Keywords: Gum Arabic, exudates, pharmaceutical, thickening.

INTRODUCTION

Gums are composed of naturally occurring polysaccharides. These materials have the ability to increase the viscosity of a solution at much lower concentrations as compared to solutions containing synthetic small molecule surfactants at the same concentration (Durham and Shipp 2015). Some of gums are natural (botanical, algal, microbial and animal) which are polysaccharides composed of sugar units linked together (Größl, Harrison *et al.* 2005), others are artificial like some fluid gels (Bradbeer, Hancocks *et al.* 2015). The plants produce natural gummy exudates which are non-woody forest product with marketable economic importance (Adam, Ballal *et al.* 2012). Some of these plants are cashew tree, acacia trees (acacia Senegal and acacia seyal). Acacia Senegal and acacia seyal are leguminous trees which have a symbiotic relation with some insect and play an important role in Nitrogen fixation (Bakhoum, Galiana *et al.* 2015).

Acacia senegal (L.) Willd is a multi-purpose tree of the Sahel arid areas of Africa. It is the main species producing the internationally traded gum Arabic (Abib, Ntoupka *et al*. 2012). The plant is native to semi-desert regions of sub-Sahara Africa and mostly found in Sudano-Sahelian zone of Africa from Sudan to Senegal (Rathore, Rai *et al.* 2012).

Gum arabic is a natural polysaccharide exuding from the trees either spontaneously or following manual tapping, it is obtained from the stems and branches of *A. senegal* and related species. More than 80% of the total gum arabic is collected from *A. senegal* which grows naturally in the gum belt of Sudan (Adam and Fadl 2011), and accounts for nearly 80 % of the worlds' gum Arabic production and controls 60 % of gum Arabic world market. Gum Arabic is also a significant source of cash income for the peasant communities occupying the gum belt (Gibreel, 2012).

Between 2003 and 2007, the European Union, which is the largest overseas market for gum arabic, imported about 200,000 tons amounting to close to US$432 million. Sixty percent of the world production came from Sudan, while 24 % came from Chad, 6 % from Nigeria, and 8 % from other minor producing Countries. Historically, Senegal used to be the second largest producer of gum arabic in Africa after Sudan until the 1960s when severe drought struck the gum belt in West Africa and an 80 % loss of gum forests was reported. At present, Senegal supplies only 1 % of the world market (Diallo, Nielsen *et al.* 2015). Gum arabic processing is a 50,000 tonnes per year industry and the processed product is widely used in the food industry as an emulsifying, stabilising, thickening and glazing agent (Manning, Chong *et al.* 2016).

***Properties of Gum Arabic*:** Gum arabic (GA) is an inexpensive, hydrophilic, nontoxic, biocompatible and totally biodegradable polymer. It is a weak polyelectrolyte that carries charged groups (carboxylate and amine groups), negatively charged above pH 2.2. When adsorbed on a particle surface, it creates steric hindrance, bridging or charge-patch depending on the pH of the particle solution (Puspendu Baric, 2015).

It is known as a natural and harmless polysaccharide derived from acacia trees. Due to its well steric stabilization effect as adsorbing on the surfaces of colloids and its numerous functional groups such as carboxylate and amine groups (Chen, 2010). Odourless, tasteless and translucent, it is an excellent natural emulsifier widely used in the food, pharmaceutical and cosmetic industries (Abib, Ntoupka *et al.* 2012), it has been used as capping agents (Chen, 2010). Its emulsifying properties make it to be used in preparation of carotenoids, water and oil emulsions (Liu, Hou *et al.* 2015). Gum arabic has shown an impeccable stability in the flavour oil system, both at the ‘‘concentrated’’ stage and after the final dilution of the beverage. These effective emulsifying properties are due to its solubility and affinity for the oil phase over a wide pH range (Ma, Bell *et al.* 2015).

Gum Arabic is a highly branched and complex polysaccharide, composed of carbohydrate moieties (Sarika, Cinthya *et al.* 2014), it is a natural mixture of hydrophilic carbohydrate and hydrophobic protein components, the hydrophilic part being the dominant one (Binsi, Nayak *et al.* 2015).

Its chemical structure consists of a 1, 3-linked β-D-galactopyranose backbone with branches of 1, 6-linked galactopyranose units. Both the main and the side chains contain units of α-larabinofuranosyl, α-L-rhamnopyranosyl, β-D-glucuronopyranosyl and 4-O-methylb-Dglucuronopyranosyl (Dhenadhayalan, Mythily *et al.* 2014, Sarika, Cinthya *et al.* 2014, Ma, Bell *et al.* 2015).

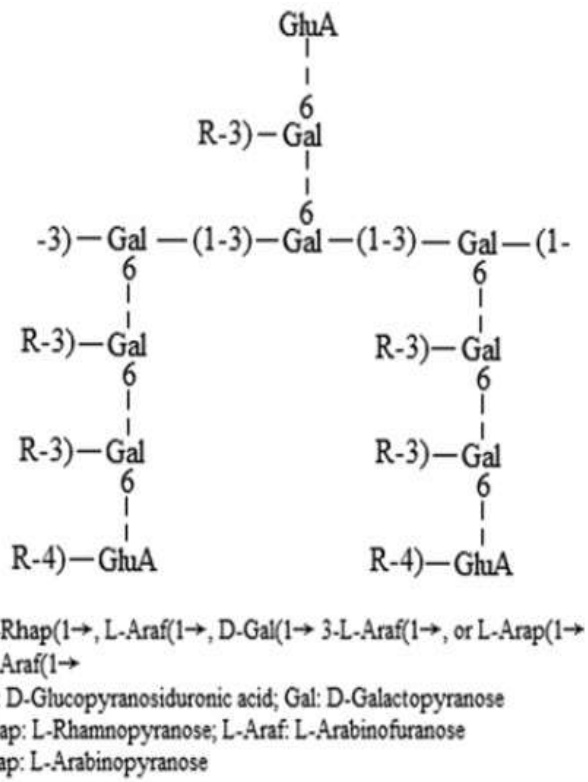

Figure 1: Structure of Arabic gum.
Source: (Li, Gan *et al.* 2014)

The protein moieties render the gum surface active and drive the adsorption at oil droplets in an oil-in-water emulsion. The emulsion is stabilized against coalescence and flocculation through steric hindrance arising from the protruding hydrophilic carbohydrate chains. A low molar mass protein-poor arabinogalactan (AG) and a high molar mass protein-rich arabinogalactaneprotein complex (AGP) has been reported to be responsible for the emulsifying and stabilizing properties of GA as no stabilizing power was observed with proteolytically degraded GA (Alftrén, Peñarrieta *et al.* 2012, Hosseini, Jafari *et al.* 2015).

GA is an anionic arabinogalactan polysaccharide-protein complex comprised of three fractions (Niu, Dong *et al.* 2015). The major faction (*89% of the total; *250 kDa) consists of a 1, 3 β-galactopyranose (galactan) polysaccharide backbone that is highly branched with 1, 6 β-galactopyranose residues terminating in arabinose and glucuronic acid and/or 4-O-methyl glucuronic acid units. The combination of these two materials produces an encapsulating material (Liu, Low *et al*. 2010).

***Uses of Gum Arabic*:** Gums have been found in Ancient Egypt art, used in decoration of funerary masks and others cellulosic substrates. In the Middle Age, gums were used as binders for inks and colours, particularly in the manufacture of illuminated manuscripts (Riedo, Scalarone *et al.* 2010), and sizing agents or mummification materials since antiquity (Anna Lluveras-Tenorio, Joy Mazurek *et al.* 2012).

Arabic Gum mixtures are used as encapsulating Agents of freeze-dried fennel Oleoresin products in the food and flavor industries by virtue of its ability to protect sensitive food components against degradation reactions and loss of volatiles (Chranioti and Tzia, 2013). Gum Arabic is used in iron microencapsulation for milk fortification to protect iron from oxidation by forming an impermeable membrane as barrier to oxygen diffusion, to mask the unacceptable flavour caused by iron salt and to increase bioavailability (Gupta, Chawla *et al.* 2015). And americans use it for grape skin microencapsulation (Kuck and Norena, 2016), and in other nanoparticles as both support and reducing agent (Khazaei, Rahmati *et al.* 2013). Gum Arabic (GA) is a widely used additive in the production of foods. The best quality gum is associated with Sudan (Sprenger, Meylahn *et al.* 2014).

Gum Arabic (GA) is a widely used additive in the production of foods, pharmaceuticals and cosmetics. GA has an effect when added to total colloid content and monosaccharide composition in wine production as shown by Sprenger et.al in their result (Fig2).

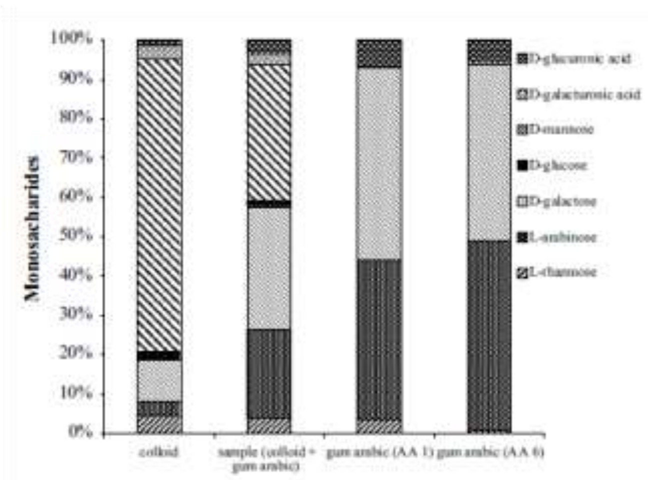

Figure 2: Monosaccharide composition of colloids isolated from a German white wine, the same sample after the addition of 300 mg l^{-1} GA and two GA samples obtained from Kordofan province in Sudan. Values given in mol %, means of duplicates.
Source: (Sprenger, Meylahn *et al.* 2014)

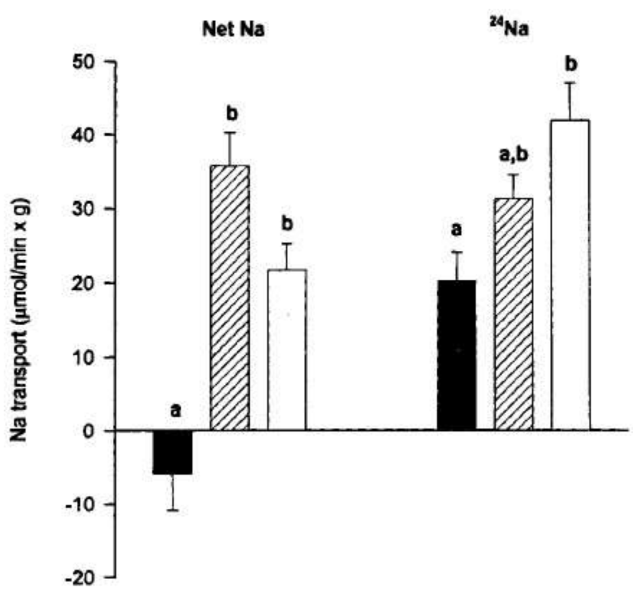

Figure 3: Net sodium movement and unidirectional 24Na movement in rats perfused with PES, with or without GA and their controls. Closed bars: cholera toxin-treated, PES-perfused (N = 7); stippled bars: same treatment, perfused with PES + 5.0 g/liter GA (N = 6), open bars: controls not exposed to cholera toxin (N = 5). In each set of values, bars not sharing the same letter are different at the P < 0.05 level
Source: (J.L. Turvill and S. TEICHBERG 2000)

Gum arabic (GA) also known as gum acacia is well dissolved in water with emulsifying, suspending and mild viscosity increasing properties. These properties make them appropriate candidate compounds for retaining the whey within cheese curd during whey expulsion stage (Lashkari, Khosrowshahi Asl et al. 2014). GA promotes lumen to blood intestinal transport of water and sodium despite cholera toxin activation. These observations support a potential role for GA in enhancing the efficacy of oral rehydration solutions (ORS) in the treatment of diarrheal disease of various etiologies, including cholera.

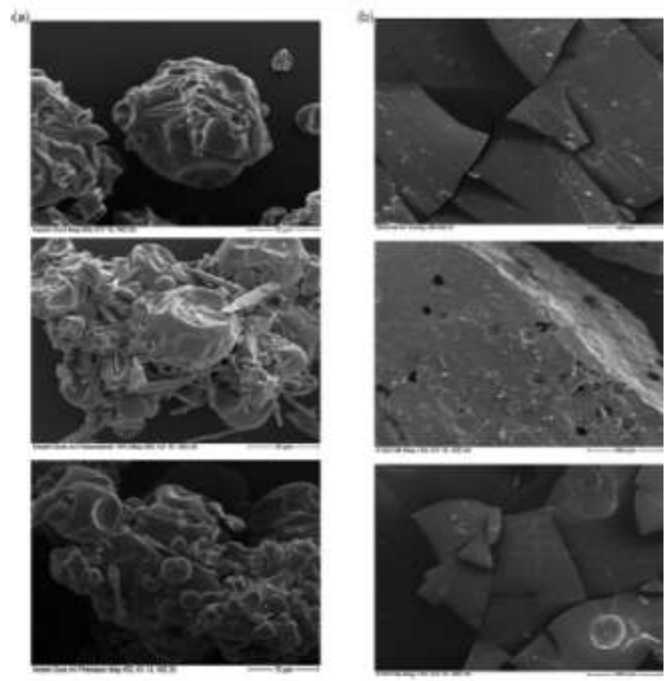

Figure 4: (a) Pre-mixtures of gum arabic and 10% paracetamol (top) and 10% phenazone (bottom). (b) SEM images of the extrudate surfaces (from top to bottom: placebo, paracetamol 10%, phenazone 10%).
Source: (Kipping and Rein 2015)

Gum arabic (GA) is a nontoxic, hydrophilic, phytochemical glycoprotein polymer widely used as a stabilizer in the food and pharmaceutical industries. It is a heterogeneous polymer comprising three main components: low-protein content arabinogalactan (90%); high-protein content arabinogalactan (10%); and high-protein content glycoproteins (Zhang, Yu *et al.* 2009). GA is indigestible for both human and animals; its fermentation by colonic intestinal bacteria leads to formation of various degradation products, such as short-chain fatty acids *(Kaddam, FdleAlmula et al.* 2015). Gum arabic (GA) has been used in different purposes as in food, pharmaceutical, cosmetics and medical purposes. Therefore,

Figure 5: Images of various drug loaded gum arabic matrices (direct comparison between paracetamol and phenazone).

Source: (Kipping and Rein, 2015) Spray drying hydrolysed casein uses gum Arabic as the carrier agent, in order to decrease the bitter taste. Three formulations with differing proportions of hydrolysed casein: gum Arabic (10:90, 20:80 and 30:70) are prepared and characterized (Subtil, Rocha-Selmi et al. 2014).

Viscosities (η) of the different solutions and emulsions at a shear rate of 150 s^{-1}.

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	Solutions			Emulsions						
Biopolymers	β-lg	GA	XG	β-lg		GA		XG	β-lg:GA	β-lg:X
Concentrations (w/w%)	2.5	2.5	1	1	2.5	1	2.5	1	2.5	1
η (mPa.s)	2.0±0.1	4.0±0.4	11±2	2.0±0.2	2.0±0.2	2.0±0.1	5±2	28±3	7.0±0.1	35±4

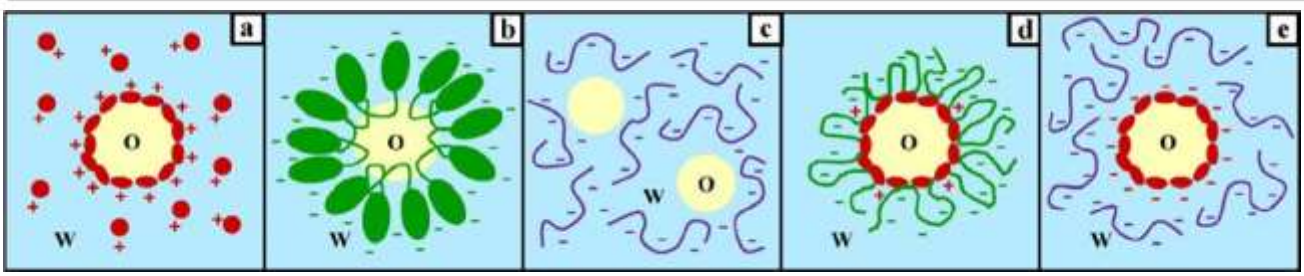

Figure 6: Schematic depiction of the different obtained stabilization mechanisms with (a) β-lg at pH 4.2, (b) GA at pH 4.2, (c) XG at pH 7, (d) β-lg:GA at pH 4.2, and (e) β-lg:XG at pH 7.

Source: (Bouyer $_E$ et.al) The solubility of guar and xanthan gums at 30, 60, 70 and 90°C, and observed values lower than those of the present study for Arabic Gum (AG) and Cashew tree Gum (CG) at all temperatures. Although guar and xanthan gums have presented the same solubility at 30 °C (65 and 60 %, respectively), the temperature increase did not improve the solubility of guar gum.

the necessity of using safe GA in food processing and medical purposes becomes more important.

Gam Arabic capped with Silver nanoparticles have an inhibitory effect on glycation end products that are major contributors to the pathology of diabetes, Alzheimer's disease, and atherosclerosis (Ashraf, Ansari *et al.* 2014).

In pharmaceutical applications gum arabic is mainly used in oral or topical application due to its suspending and emulsifying properties. Also the application for the production of pastilles, lozenges or as a binder in tablet manufacturing is possible, here it can also be used as a release modifier.

It is indigestible to both humans and animals, not degraded in the intestine, but fermented in the colon to give short-chain fatty acids, leading to a large range of possible health benefits. One of these benefits is its prebiotic effect. It has been claimed that four week supplementation with Gum Arabic (10 g/day) led to significant increases in Bifidobacteria, Lactobacteria, and Bacteriodes indicating a prebiotic effect. Other effects include reduction in plasma cholesterol level in animals and humans, anticarcinogenic effect and anti-oxidant effect with a protective role against hepatic and cardiac toxicities (Rasha Babiker, 2012).

***Comparison between Gum Arabic and other Emulsifiers*:** AG displays good emulsifying properties and has low viscosity compared to other polysaccharides of similar molar mass and has very good volatile retention properties (Chranioti and Tzia 2013, de Oliveira, Dos Reis Coimbra *et al.* 2015).

Among all gum exudates, gum arabic has the highest commercial value due to its widespread application in food, pharmaceutical and cosmetic industries. During the homogenization process, gum arabic adsorbs at the surface of the freshly formed fine droplets and forms a relatively thick and negatively charged interfacial layer around them, preventing their aggregation due to steric hindrance and electrostatic repulsion.

Bouyer $_{E}$ et.al compared viscosities of the different emulsions at a shear rate of 150 s^{-1}. The viscosities for the various emulsions can be classified in the order: $_{\beta}$-lg < GA < $_{\beta}$- lg:GA < XG < β-lg:XG. These values explain the better stability of emulsions containing XG compared to $_{\beta}$-lg alone, even if the droplets formed in the $_{\beta}$-lg stabilized emulsions were smaller than those in XG stabilized ones. XG clearly enhanced the viscosity of the continuous phase of the emulsions and conferred them a shear thinning behavior as it is shown in next table and Fig. 6.

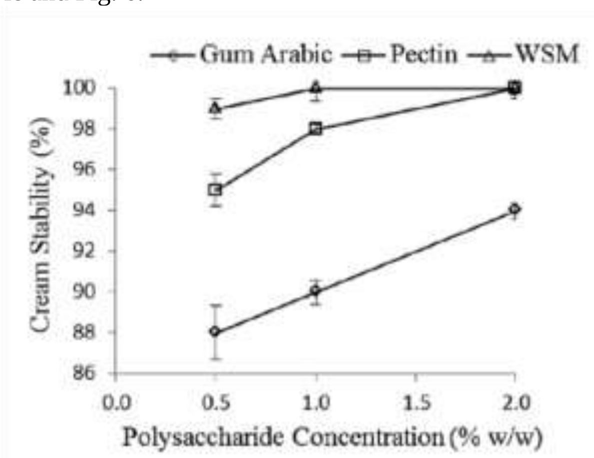

Figure 7: Freezee - Thaw stability of emulsions with various polysaccharide types and concentrations.
Source: (Binsi, Nayak *et al.* 2015).

For xanthan gum, it was observed a similar behavior from AG, i.e., an increase of 33.3 % in the solubility at 60 °C and a reduction of 12.5 % at 90 °C. A possible explanation for the reduced solubility of xanthan gum is due to gelation, which also may have occurred with AG and CG (Zhang, Yu *et al.* 2009, Kuck and Norena, 2016). Wu $_{Y}$ et.al compared emulsifying properties of water soluble yellow mustard mucilage (WSM) with two commercial emulsifier-gum Arabic and citrus pectin.

The results presented in Fig. 7 show a higher concentration was related to a better emulsion stability for all polysaccharides, with the exception that 1.0% and 2.0% WSM showed no difference. When comparing the emulsions with the same polysaccharide concentrations, emulsions prepared with WSM showed the best stability, followed by pectin and gum Arabic. At 2.0%, pectin and WSM showed similar stability and both were more stable than gum Arabic emulsion.

The 0.5% WSM emulsion exhibited superior stability to 2.0% gum Arabic emulsion and 1.0% pectin emulsions suggesting that WSM has greater potential as an ingredient in frozen food products (Binsi, Nayak *et al.* 2015).

***Conclusion*:** Gum Arabic is a very much needed product from recent years until now, because of its good and desirable properties and it has a significant source of income to the high population. These properties make it to be used in different domains, like in agriculture, medicine, food industry etc. It is an excellent natural emulsifier widely used in the food, pharmaceutical and cosmetic industries that is why Gum Arabic source must be well managed for sustainable production.

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