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RESEARCH ARTICLE

ACACIA NILOTICA GUM: AN UNDERUTILIZED FOOD COMMODITY

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ABSTRACT

Acacia nilotica gum is an exudate obtained from stems and branches of *acacia nilotica* tree. It is a natural, water soluble hydrocolloid which has been claimed to possess several physiological, nutritional and therapeutic beneficial properties due to the presence of various bioactive phytochemicals. It has been increasingly recognized as a potential commodity having diverse pharmacological and industrial applications. Gum Acacia is a closely related gum which has commercial significance and has been used from ancient times. This extensive review aimed to study the previous literature which focuses on plant description, ethno medical claims, physicochemical properties and protective activity of *acacia nilotica* gum and other similar gums of acacia species on several organs and organ systems.

INTRODUCTION

The World Health Organization (WHO) has listed more than 21,000 plants, which are used for many medicinal purposes around the world (Kathe, 2005). They observed that about 74% of 119 plant-derived pharmaceutical medicines are used in modern medicine. It also estimates that 4 billion people (80 percent of the world population) presently use herbal medicine for health care (Mishra *et al*., 2010). The plant parts of *Acacia nilotica* linn (AN) has been widely reported to have therapeutic uses arising from its wide spread folkloric and traditional uses (Malviya *et al*., 2011). *Acacia nilotica* L. is a common, medium sized tree, locally known as 'Babul' or 'Kikar' belonging to the family Mimosaceae (Maslin *et al*., 2003). *Acacia* is the most significant genus of family Leguminosae firstly described by Linnaeus in 1773. It is estimated that there are roughly 1380 species of *Acacia* worldwide (Maslin *et al*., 2003; Orchard *et al*., 2003). The plant is considered to be antispasmodic and antidysenteric (Malviya *et al*., 2011; Said, 1969). Pods and tender leaves are reported to treat diarrhea (Malviya *et al*., 2011; Nadkarni, 1976). The plant has been shown to exhibit antibacterial (Malviya *et al*., 2011; Nabi, 1992), anti-inflammatory (Malviya *et al*., 2011; Dafallah and Mustafa,1996), antiplatelet aggregatory activity (Malviya *et al*., 2011; Shah *et al*., 1997), cestocidal activity (Malviya *et al*., 2011; Ghosh *et al*.,1996), vasoconstrictor actions (Malviya *et al*., 2011; Amos *et al*., 1999), antihypertensive (Malviya *et al*., 2011; Gilani *et al*., 1999), inhibitory effect against hepatitis C virus (Malviya *et al*., 2011; Hussein *et al*., 2000) and antioxidant activity (Malviya *et al*., 2011; Chang *et al*., 2001). Ethnobotanical studies suggested the beneficial use of *Acacia nilotica* gum for the treatment of any irritation of the skin and smoothening of the inflamed membranes of the pharynx, alimentary canal and genito urinary organs (Sonibare and Gbile, 2008; Ameh *et al*., 2010). The bark or gum of the plant *Acacia nilotica* is used in West Africa to treat cancers and/or tumours of ear, eye or testicles (Ameh *et al*., 2010). Bhils of Rajasthan uses gum of the *babool* (*Acacia nilotica*) to fill the cavity and maintenance of oral health (Bhasin, 2004).

In the project titled Biomedical Studies and IPR (Intellectual Property Rights) Documentation of Medicinal Plants Used in the Treatment of Women Diseases in Sindh, use of acacia nilotica gum for promoting health of women after parturition has been noted. Almond and pistachio were crushed and then cooked with suji (*Triticum aestivum*), asli ghee (butter oil) and gond /gum acacia (*Acacia nilotica*) were added, mixed well and taken with milk orally (Choudhary and Wahab, 2010). *Acacia nilotica* is a pioneer species, relatively high in bioactive secondary compound and are important for a variety of functions. It is economically used as a source of tannins, gums, timber, fuel and fodder (Gupta, 1970; Mahgoub, 1979). Gum obtained from the tree is pharmaceutically used as suspending and emulsifying agent and in preparation of many formulations. Its resin repel insects and water (Duke, 1983).

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Origin and distribution

Acacia is multipurpose nitrogen fixing tree legume. It occurs from sea level to over 2000m and withstand at extreme temperature (>50°C) and air dryness but sensitive to frost when it is young (Bargal and Bargali, 2009). It is widely spread in subtropical and tropical Africa from Egypt to Mauritania southwards to South Africa, and in Asia eastwards to Pakistan and India (Bennison and Paterson, 1994; The Ayurvedic Pharmacopoeia of India, 2007).

The species is widespread in Africa and Asia, and occurs in Australia and Kenya. Indian gum Arabic tree is found in well watered Sahelian and Sudanian savannas to the southern Arabian Peninsula, East Africa and in the Gambia, the Sudan, Togo, Ghana, and Nigeria. It is widely cultivated in the Indian subcontinent, and also found on lateritic soil in the Himalayan foothills in India (Iman *et al*., 2007).

Table 1. Taxonomical classification

Kingdom	Plantae
Subkingdom	Tracheobionta
Super division	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Rosidae
Order	Fabales
Family	Fabaceae
subfamily	Mimosoideae
Genus	*Acacia*
Species	*Nilotica*

(www.ncbi.nlm.nih.gov/taxonomy*;* Malviya *et al.*, 2011)

Table 2. Subspecies of *Acacia nilotica*

subsp. Nilotica
subsp. Indica
subsp. Cupressiformis
subsp. Tomentosa
subsp. Adstringens
subsp. Subalta
subsp. Leiocarpa
subsp. Hemispherica
subsp. Kraussiana

(*www.ncbi.nlm.nih.gov/taxonomy*)

Plant description

Acacia nilotica is a single stemmed plant, grows to 15-18 m in height and 2-3 m in diameter. Pods are 7-15 cm long, green and tomentose (when immature) or greenish black (when mature), indehiscent, deeply constricted between the seed giving a necklace appearance. Seeds are 8-12 per pod, compressed, ovoid, dark brown shining with hard testa (Iman *et al*., 2007). The leaves are bipinnate, pinnate 3-10 pairs, 1.3-3.8 cm long, leaflets 10-20 pairs, and 2-5mm long (Beniwal *et al*., 1992). Flowers are globular heads, 1.2-1.5 cm in diameter of a bright golden yellow colour, develop either in axillary or whorly pattern on peduncles 2-3 cm long located at the end of branches (Bargal and Bargali, 2009). Stems are usually dark to black coloured, deep longitudinal fissured, grey-pinkish slash, exuding a reddish low quality gum (Brenan, 1983). The bark has a tinge of orange and/or green (young tree), but older trees have dark, rough bark and tend to lose their thorns (Khan *et al*., 2009). Thorns are thin, straight, light grey exist in axillary pairs (usually 3-12), 5-7.5 cm long in young trees. Root is generally of brown colour in older and whitish in younger regions. The gum varies in colour from very pale yellowish brown to dark reddish brown depending on the quantity of tannins in the sample. The lighter, more highly valued gums are soluble in water and very viscous; the tannins in the darker gum reduces the solubility (New,1984).

Growth pattern and germination

Acacia nilotica is a tropical species found throughout India and occurs from sea-level to over 2000 m altitude. Prickly Acacia germinates in rainfall in the wet season. But some seeds may still germinate up to 15 years after seed drop. Seedlings grow rapidly near water but more slowly in open grasslands. It grows in average annual temperatures range from 15–28°C, being frost sensitive when young and withstanding daily maximum temperatures of 50°C (Ali, 1980). The mean maximum temperature of the hottest month is 25–42ºC and the mean minimum temperature of the coldest month 6–23°C. Babul plant prefers dry conditions. This subspecies is commonly found on soils with high clay content, but may grow on deep sandy loam in areas of higher rainfall. It commonly grows close to waterways on seasonally flooded river flats and tolerates salinity well (Ali and Faruqi, 1969). Trees can flower and fruit two to three years after germination, but after high rainfall it is more quickly, usually between March and June (Mann *et al*., 2003). Pods are formed between July and December. Most leaf fall between June and November and seed pods drop during October to January (Champion and Seth, 1968). Seeds are very simple. Inner integument degenerates completely and the testa is formed by the outer integument (Sinha, 1973; Puri and Khybri, 1975). It has observed that *A. nilotica* is more productive than *A. tortilis* after slat treatment. It grows well in two types of soils i.e. riverian alluvial soil and black cotton soil (Abdulrazak and Orskov, 2000).

Aims and Objectives

a) To study the scientific literature of acacia nilotica gum and also other closely related gums of Acacia species.
b) To map out the information regarding ethnomedicinal and traditional claims on gum of Acacia species.
c) To compile the physiological and therapeutic benefits of the gum in a systematic manner.
d) To study the nutritional components and bioactive phytochemicals present in these gums.
e) To list out its pharmacological and industrial uses.

Review of Literature

A. Major Chemical Constituents in *Acacia nilotica* Linn

Acacia species contain secondary metabolites including amine, alkaloids, cyanogenic glycosides, cyclitols, fatty acids, fluoroacetate, gums, nonprotein amino acids, terpenes (including essential oils, diterpenes, phytosterol, triterpene, genins and saponins), hydrolyzable tannins, flavonoids and condensed tannins (Seigler, 2003). The plant is richer source of cystine, methionine, threonine, lysine, tryptophan, potassium,

phosphorus, magnesium, iron and manganese (Singh *et al*., 2008). The plant chemical compounds like diester, pentacosanedioic acid, dihexadecyl ester and its alcohol, heptacosane 1, 2, 3-triol (Banso, 2009). Seeds contain high percentage of phenolic constituents consisting of m-digallic acid, gallic acid, protocatechuic and ellagic acids, leucocyanidin, m-digallic dimer, 3,4,5,7-tetrahydroxy flavan-3-ol, oligomer 3,4,7- trihydroxyflavan 3,4-diol and 3,4,5,7-tetrahydroxy flavan-3-ol and (-) epicatechol. The mature seed also contains crude protein, crude fibre, crude fat, carbohydrates, potassium, phosphorus, magnesium, iron and manganese occurred in high concentrations and it is richer source of cystine, methionine, threonine, lysine and tryptophan. Fruit also contains mucilage and saponins (Pande, 1981; Siddhuraju, 1996). Pods contain gallic acid, digallic acid and condensed tannins. Leaves contain apigenin, 6-8-bis-D-glucoside, rutin, 8% digestive protein (12.4% crude protein). Relative levels of tannin in different parts of plant is, deseeded pods (50%), pods (5.4%), leaves (7.6%), bark (13.5%) and twigs (15.8%) (Wassel, 1990).

B. Physical characteristic of *acacia nilotica* gum

Acacia nilotica gum exudates collected from Batagarawa, Katsina State were in form of tasteless and odourless nodules or lumps, with their colour varying from off-white to orange-brown. The acacia nilotica gum samples were found to be water soluble at 30°C to form viscous solutions, indicating that they are natural gums of the hydrophilic colloid group. Samples were however found to be insoluble in common organic solvents (ethanol, acetone, ether, chloroform, benzene etc) and in oils, with which they form emulsions in aqueous suspension (Yusuf, 2011). The solubility of the gum is indicative of the absence of cross linking between polymeric chains. This is because gums having cross linked polymeric chains only swell in water, without dissolving (Remington, 2000).

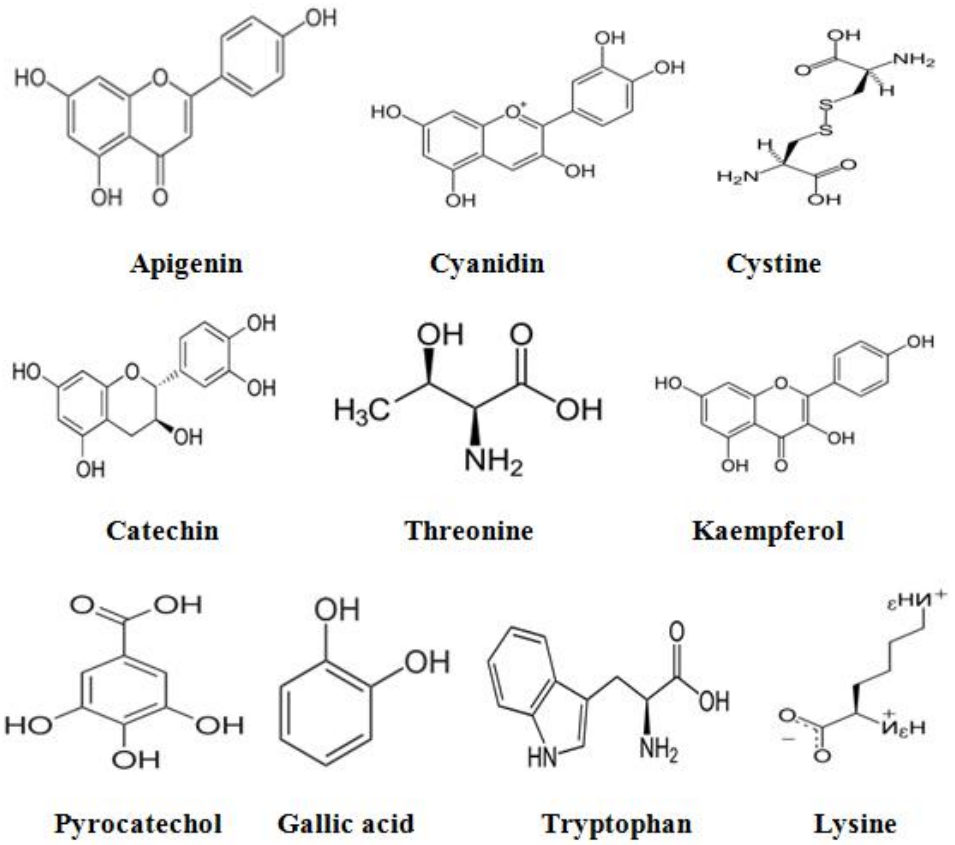

Fig.1. Phytochemicals in *Acacia nilotica* Linn. (Malviya *et al*., 2011)

Bark contains tannin (12-20%), terpenoids, saponins and glycosides, Phlobetannin, gallic acid, protocatechuic acid pyrocatechol, catechin, epigallocatechin-5,7-digallate (Chaubal and Tambe, 2006). Its extract contains total phenolic content ranging from 9.2 to 16.5 g/100 g (Bushra *et al*., 2007). Root contains octaconsanol, betulin, β-amyrin and β-sitosterol. Gum is composed of galactoaraban which gives on hydrolysis L-arabinose, D-galactose, L-rhamnose, D-glucuronic acid and 4-O-methyl- D-glucuronic acid (Malviya *et al*., 2011).

Cationic composition of gum samples was also determined and results showed that calcium has the highest value followed by magnesium, sodium, potassium, iron and zinc. Sugar composition was estimated using HPLC technique where galactose and arabinose content were found to be 15.5% and 81.9% respectively (Yusuf, 2011).

C. Physicochemical properties *A. nilotica* gum exudates:

Table 3. Physicochemical properties *A. nilotica* gum exudates (Yusuf, 2011)

Physicochemical parameter	ACACIA NILOTICA GUM
Moisture (%)	15.60
Solubility (30°C) (%)	38
Melting temperature (°C)	300-320
Relative density of 20% solution (35°C)	1.32
Relative viscosity of 1% solution (30°C)	24.80
pH (25% solution)	4.50
Ash (%)	3.54
Tannin	0
Nitrogen (% w/w)	0.40
Protein (% Nx6.6)	2.71
Total soluble fibre (%)	78.15
Calcium (g/100g)	0.70
Magnesium (g/100g)	0.30
Iron (g/100g)	0.004
Sodium (g/100g)	0.016
Potassium (g/100g)	0.78

D. Constituent sugar analysis of acacia gum exudates

Table 4. Protein and Constituent sugar analysis of different samples of acacia gum exudates

Sample	Protein (%)	Constituent sugar(%)			
		Rhamnose	Arabinose	Galactose	Uronic acid
i.	1.8	2.0	53.5	36.6	7.9
ii.	2.1	2.4	45.9	30.6	14.1
iii.	2.5	3.4	49.4	33.7	12.4
iv.	2.2	Trace	65.7	24.2	8.2
v.	1.6	Trace	62.6	23.1	13.2
vi.	1.3	Trace	53.6	32.7	11.9
vii.	2.0	13.5	33.0	37.0	16.0
viii.	1.9	2.7	44.5	34.1	14.3

(i) ***Acacia nilotica*** gum exudate from Maharashtra;
(ii) ***A. nilotica*** gum exudate from Andhra Pradesh;
(iii) ***A. nilotica*** gum exudate from Madhya Pradesh;
(iv) ***A. nilotica*** gum exudate from Uttar Pradesh I (Banthra Research Station);
(v) ***A. nilotica*** gum exudate from Uttar Pradesh II (Kukrail Forest during winter);
(vi) ***A. nilotica* gum** exudate from Uttar Pradesh III (Kukrail Forest during summer);
(vii) Gum arabic from ***Acacia senegal*** (Sudan);
(viii) Gum arabic from ***Acacia seyal*** (Nigeria); (Kapoor *et al*., 1991).

E. Chemopreventive and antimutagenic activity

The chemopreventive activity of Acacia nilotica (Linn.) gum, flower and leaf aqueous extracts, on 7,12-dimethylbenz (a) anthracene (DMBA) induced skin papillomagenesis in male Swiss albino mice was reported. Animals were divided into 4 groups. Group I (Controls)were given DMBA and croton oil, with no extract ; Group II (treatment) animals were treated with *Acacia nilotica* gum (Group II-a) (800 mg/kg body weight), flowers (Group II-b) (800 mg/kg body weight), or leaves (Group II-c) (800 mg/kg body weight) during the peri- and post initiation periods of DMBA and croton oil application. A significant reduction in the values of tumor burden, tumor incidence and cumulative number of papillomas was observed in mice treated by oral gavage with the *Acacia nilotica* gum, flower and leaf extracts as compared with the control group. The chemopreventive and antimutagenic activity of the leaf extract of *Acacia nilotica* was most significant followed by the flower extract and then by gum (Meena *et al*., 2006).

F. Acacia Gum or Gum acacia - a gum similar and closely related to *Acacia nilotica* gum

Gum arabic or gum *Acacia* is a tree gum exudate and has been an important article of commerce since ancient times. It was used by the Egyptians for embalming mummies and also for paints for hieroglyphic inscriptions. Traditionally the gum has been obtained mainly from the *Acacia Senegal* species. The gum oozes from the stems and branches of trees (usually five years of age or more) when subjected to stress conditions such as drought, poor soilor wounding. Production is stimulated by 'tapping', which involves removing sections of the bark with an axe taking care not to damage the tree. The sticky gummy substance dries on the branches to form hard nodules which are picked by hand and are sorted according to colour and size (Fig. 2).

Fig.2. Collecting gum arabic from *Acacia Senegal* trees

Commercial samples commonly contain *Acacia* species other than *Acacia Senegal* notably *Acacia seyal*. In Sudan the gum from *Acaciasenegal* and *seyal* are referred to as hashab and talh arespectively. Gum Arabic is a dried exudate obtained from the stems and branches of *Acacia Senegal* (L) Willdenow or closely related species of Acacia (fam. Leguminosae). *Acacia seyal* is a closely related species. Gum arabic consists mainly of high molecular weight polysaccharides and their calcium, magnesium and potassium salts which on hydrolysis yield, arabinose, galactose, rhamnose and glucuronic acid (Williams and Phillips, 2000).

Gum acacia is a potent drug having diverse pharmacological effects and wide therapeutic potential. It is used in diarrhoea and dysentery, irritations and ulcers of the stomach and intestine. It is also used in haemoptysis, bleeding piles, menorrhagia, leucorrhoea, spermatorrhoea. It is also known as Babool gum and in Unani System of medicine it is known as samagh-e- arabi (Jahan *et al*., 2008).

Safety of Gum acacia

Acute studies of toxicity of gum Arabic report oral LD50 values of 16, 18, 16, and 8 g/kg/day for mice, rats, hamsters, and rabbits, respectively (as cited in JECFA, 1982a) (WHO,1982; JECFA,1982).

The National Toxicology Program (NTP) conducted carcinogenicity studies of gum arabic in both rats and mice. Groups of fifty male and fifty female F344 rats and B6C3F1 mice were fed diets containing 0, 25000 (2.5%) or 50000 ppm (5.0%) gum arabic for 103 weeks. No significant differences were observed in survival between any of the dosed groups of rats or mice and their control groups. Decreased body weight gain (>5%) was observed in female rats fed diets containing gum arabic. No histopathological effects were noted and therefore, under the conditions of the assays, gum arabic was considered non-carcinogenic to rats or mice (Melnick *et al*., 1983). Gum arabic is approved for use as a food additive by the U. S. Food and Drug Administration and is on the list of substances "generally recognized as safe" (CFR,1974).

Gum acacia is used as a flavor fixative in dry packaged food mixes, a foam stabilizer in soft drinks and beer, an adhesive for icings and toppings, and an emulsifier and stabilizer in confectionaries (Furia, 1972). Gum arabic is used in the preparation of the products at approximately the concentrations indicated: candy (28%); chewing gum (2.8%); imitation dairy products, frostings, fats and oils, and grain products (1%); sugar substitutes, fruit ices, nut products, and gelatin puddings (0.5% - 0.06%); baked goods, meat products, and alcoholic beverages (0.15% - 0.06%); instant coffee and tea (0.08% - 0.01%); nonalcoholic beverages (0.06% - 0.04%), processed fruit, frozen dairy products and breakfast cereals (0.02% - 0.007%) (Life Science Research Office,1973).

In an experiment 25g gum arabic was administered once a day for 3 weeks to human subjects. The effect of dietary gum arabic on glucose absorption, cecal and colonic function, and hematologic and clinical chemistry parameters was studied. Decreases in serum cholesterol were observed but dietary gum arabic had no effect on glucose tolerance, stool weight, or fecal bile acids and neutral sterols. Gum arabic was not recovered in stool samples, suggestive of metabolism of gum arabic bacteria in the colon (Ross *et al*.,1983)

Physiological Significance of Acacia Gum

i. Acacia Gum as Galactogogue

In a study, the quantity and quality of milk was assessed in nine lactating cows reared in Khartoum University fann at Shambat. They were divided into three separate groups, each group having three. They were provided with three dietary regimens containing 0% or 5% or 10% Arabic Gum from *Acacia Senegal.* The duration of the experiment was four weeks. Results obtained indicated that the milk production was increased in the three groups by 7.7%, 18.1% and 19% respectively. Moisture content of the milk was increased by 3%, 0.6% and 0.2%, respectively. Protein is decreased by 11% in the first group and increased by 12% and 10% for the other two groups respectively. Ash of the milk is increased by 50% in the first group and decreased by 5% and 10% for the other treated groups. Fat is increased by 42% in the first group and decreased by 46% for both treated groups. Lactose of the milk is decreased by 2%, 3% and 2% for the three groups respectively. Total solids increased by 5% for the three groups. Bulk density of the milk is decreased by 0.3% for the first group and increased by 0.2% and 0.1 % for the other two groups respectively. Calcium content in the three groups is increased three times while phosphorous content is increased two times. No health problems or adverse effects were reported in experimental animals following consumption of gum Arabic (Idris *et al*., 2007).

ii. Acacia Gum as an antioxidant

The purported action of GA (Gum Arabica) as an antioxidant has led to the publication of a series of articles by the same group claiming a protective effect of GA against experimental gentamicin and cisplatin nephrotoxicity (Al-Majed *et al*.,2002; Al-Majed *et al*.,2003), doxorubicin cardiotoxicity(Abd-Allah *et al*.,2002) in rats, and acetaminophen hepatotoxicity (Gamal el din *et al*., 2003) in mice. All of these studies were based on the assumption that GA has strong anti-oxidant properties, and a major mechanism for the induction of these toxicities is the generation of free radicals (Ali and Moundhri, 2006; Hinson *et al*., 2004). Using a lipid model system, eight different polysaccharidic compounds (including GA) were studied for their antioxidant and lipid peroxidation lowering effects in vitro. It was found that GA protected against lipid peroxidation in skin in a dose-dependent manner (Trommer and Neubert, 2005).

iii. Influence of Acacia Gum on Lipid Profile (Hypocholesterolemic effect)

The effects of the low-viscosity fibre acacia gum at doses of 15 g/day to a mixture of high viscosity water-soluble fibre (psyllium, pectin, guar and locust bean gum) on blood lipids in hypercholesterolemic males and females was compared. The fibre mixture reduced serum total cholesterol concentrations by about 10 % and LDL-cholesterol by 14 %, whereas the acacia gum alone showed no effect on either total or LDL-cholesterol in both studies (Haskell *et al*., 1992; Jensen *et al*., 1993). In a study the effects of a mixture of apple fibre and acacia gum (10 g/day , approximately half apple fibre and half acacia gum) in a crossover study in 27 men and found a significant 10 % reduction in serum cholesterol and a significant 14 % reduction in LDL-cholesterol concentrations with the fibre mixture as compared to the non-fibre control (Mee and Gee, 1997).

The cholesterol-lowering effect of water-soluble fibre depends on increased viscosity that reduces the reabsorption of bile acids, increases the synthesis of bile acids from cholesterol, and reduces circulating (LDL) cholesterol concentrations. Acacia gum has a relatively low viscosity, and its effects on blood cholesterol have been weak or non-detectable in the small, and often uncontrolled, clinical trials presented despite the relatively high doses used (EFSA, 2009). Fifteen grams of gum acacia administered twice daily to seven hypocholesterolemic subjects for 30 days, reduced their serum cholesterol by

approximately 10.4% but had little effect on HDL cholesterol and triglycerides, LDL+VLDL cholesterol was decreased significantly ($p<0.05$) (Sharma,1985). In a study reduction of total serum cholesterol by 6% and 10.4%, respectively when subjects received 25 g/day and 30 g/day of GA for periods of 21 and 30 days was reported. The decrease was confined to LDL and VLDL cholesterol only, with no effect on HDL and triglycerides (Ross *et al*., 1983; Sharma, 1985).

iv. Protective role against Hepatotoxicity

Overdose of acetaminophen, a widely used analgesic drug, can result in severe hepatotoxicity and is often fatal. This study was undertaken to examine the effects of arabic gum (AG), which is commonly used in processed foods, on acetaminophen-induced hepatotoxicity in mice. Arabic gum administration dramatically reduced acetaminophen-induced hepatotoxicity as evidenced by reduced serum alanine (ALT) and aspartate aminotransferase (AST) activities. Acetaminophen-induced hepatic lipid peroxidation was reduced significantly by arabic gum pretreatment. The protection offered by arabic gum does not appear to be caused by a decrease in the formation of toxic acetaminophen metabolites, which consumes glutathione, because arabic gum did not alter acetaminophen-induced hepatic glutathione depletion. Acetaminophen increased nitric oxide synthesis as measured by serum nitrate plus nitrite at 4 and 6 h after administration and arabic gum pretreatment significantly reduced their formation (Ayman *et al*, 2003).

v. Gum Acacia as Prebiotic

Gum Arabic is a fermentable soluble substance with mechanical and metabolic effects, delaying gastric emptying, increasing faecal bulk and frequency of bowel movements, regulating colonic transit time, slowing glucose absorption from the small intestine with reduction of postprandial blood, serum total cholesterol and low density lipoproteins (Luca *et al*., 2009).

vi. Effect of Gum Acacia on the gastrointestinal tract

It has been shown that GA improves small intestinal absorption of sodium in normal rats (Codipilly and Wapnir, 2004; Wapnir and Teichberg, 1996) and of sodium and water in two animal models of diarrheal disease (Wapnir and Wingertzahn, 1997). In normal male juvenile rats, addition of 5 and 10 g/L of GA increased the rates of sodium removal from the intestinal lumen perfused with oral rehydration solutions (ORS) containing either 60 mM or 90 mM sodium. Although GA tended to facilitate bidirectional fluid movement in these experiments, net water absorption was unaffected (Wapnir and Teichberg, 1996). The higher concentration of GA was also associated with expansion of the basolateral intercellular space. Experimental diarrhea was induced in rats by either one week of drinking a cathartic (magnesium citrate-phenolphthalein) solution to produce chronic osmotic-secretory effects or by jejunal perfusion of theophylline to induce jejunal secretion. Addition of GA to the jejunal ORS-perfusate resulted in roughly a twofold increase in absorption of sodium, potassium and water in the chronic osmotic- secretory diarrhea model, and neutralized theophylline induced abolition of net sodium and potassium absorption, in addition to reversing water and glucose malabsorption (Wapnir and Wingertzahn, 1997).

vii. Effect on Renal Function

One of the unexplained findings is that GA treatment was associated with an increased 24 h-creatinine clearance in healthy mice (Nasir, 2007). In a recent study, serum butyrate concentrations were increased following treatment with GA in healthy subjects and this may have a role in the claimed salutatory effect on creatinine clearance and Glomerular Filtration Rate(Matsumoto *et al*., 2006). Recently, a report from Sudan assessed the effect of GA on the concentration of certain metabolites in the sera of patients with Chronic Renal Failure (CRF) on a low-protein diet. GA was given at an oral dose of 50 g/day for 3 months, with or without supplementing the diet with ferrous sulfate (200 mg/day) and folic acid (5 mg/day). Serum creatinine, urea, phosphate and uric acid concentrations were reported to be significantly reduced by GA, while the treatment significantly increased that of serum calcium. No explanations for these results have been offered, and the inclusion of iron and folic acid supplements has not been justified, although it was concluded that GA could alleviate ‘‘adverse effects of CRF” (Ali *et al*., 2008).

Applications and Industrial use

i. Confectionery

The major application of gum arabic is in the confectionery industry where it is used in a variety of products including gums, pastilles, marshmallows and toffees.

Table 7. Typical formulation for marshmallows

Constituents	Percentages
Water	39.0%
Sugar	37.0%
Dextrose	19.0%
Albumen	1.8%
Gum arabic	2.4%
Gelatin	0.5%
Salt	0.3%

Table 8. Typical formulation for caramel-type products

Constituents	Percentages
Corn syrup	38.4%
Sweet condensed whole milk	34.4%
Granulated sugar	9.6%
Invert sugar	9.6%
Hydrogenated vegetable oil	3.8%
Salt	0.2%
Gum Arabic	4.0%

ii. Beverages

Gum arabic is stable in acid conditions and is widely used as an emulsifier in the production of concentrated citrus and cola flavour oils for application in soft drinks. The gum is able to inhibit flocculation and coalescence of the oil droplets over several months and further more the emulsions remain stable for up to a year when diluted up to~500 times with sweetened carbonated water prior to bottling. In the preparation of the

emulsion a weighting agent is normally added to the oil in order to increase the density to match that of the final beverage and thus inhibit creaming.

iii. Flavour encapsulation

Microencapsulation is commonly used to transform food flavours from volatile liquids to flowable powders that can be readily incorporated into dry food products such as soups and dessert mixes. The process also renders the flavour stable to oxidation. Encapsulation involves spray-drying an emulsion of the flavour oil which is produced using gum Arabic as emulsifier. Now adays maltodextrin is commonly mixed with the gum in order to reduce costs.

Table 9. Typical formulations for flavour encapsulation

Flavour	7%	10%
Gum arabic	28%	15%
Maltodextrin	nil	25%

(Williams and Phillips, 2000)

Gum arabic is used as an excipient for pills and tablets, a syrup for the suspension of insoluble drugs, an emulsion stabilizer for lotions and protective creams, and a pigment binder in face powders and rouges. Gum arabic may be added to various glues, pastes, and binding cements, to paint and pigment formulations, and to inks. This gum is also used as a sizing and finishing agent in the textile industry, a corrosion inhibitor in storage batteries, and a binder for insecticides (Kirk and Othmer,1966).

Conclusion

Acacia trees of different varieties found in India produce gum exudates that are of potential economic interest. In the present comprehensive review, data are collected and compiled to obtain information based on taxonomy, origin, distribution, description, phytoconstituents, traditional and pharmacological claims on *Acacia nilotica* gum as well as the closely related gums. Traditionally the plant used widely for the treatment of various ailments, but scientifically few of them was screened out. Thus the scientific studies should be conducted to investigate the unexploited potential of *Acacia nilotica* (L.). This gum is very beneficial but is an underutilized food commodity. Awareness should be created about its significance and wide spectrum of medicinal activities. The gum of *Acacia nilotica* is odourless and tasteless but it enhances the texture, appearance and stability of the product. So, the gum should also be incorporated in simple recipes which can be prepared at home and its acceptability among people should be assessed. Further studies are needed to identify active moieties and understand the mechanism of action. These studies will be highly beneficial as the demands of natural alternatives are increasing constantly.

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