Chemical Composition, Physical Properties, Nutritional Value, Bioactive Compounds Content and Biological Activities of Gum Arabic (Acacia seyal)

By

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Abstract:

The present study aims to determine the chemical composition, physical properties, nutritional value, bioactive compounds content and biological activities of the gum arabic (*Acacia seyal*) collected from Sudan Republic. The extractive value for gum arabic (GA) in different organic solvents was very low (0.065-1.942%) while very high in water (16.052-16.921%). The contents of moisture, total protein, crude fat, crude fiber, ash and carbohydrates content of GA were 10.32, 2.87, 0.15, 81.45, 2.63 and 2.85%, respectively. Also, the total energy (Kcal/100g), the daily requirement of adult man for protein (GDR/protein) and energy (GDR/energy) , percent satisfaction of the daily requirements of adult man in protein (P.S./protein) and energy (P.S./energy) which recorded 23.15, 2195, 12527, 4.56 and 0.80, respectively. Furhermore, bioactive compounds content of GA powder indicated that polysaccharides were the most largest compound (211.53± 10.43mg starch equvalent. g^{-1}) followed by phenolics (43.98 ± 1.76 mg gallic acid equvalent. g^{-1}),_and flavonoids (10.23 ±

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0.34 mg catechin equivalent. g^{-1}). Also, GA was e richen in dietary fiber (74.45± 3.21g/100g). The samples also recorded several very high biological activities which include antioxidant and radicals scavenging activities. Such important bioactive compounds content and biological effects of GA could play important roles in strategies to combat/treat many diseases, especially those for which oxidative stress is one of the mechanisms for its occurrence i.e. obesity, diabetes, cancer, atherosclerosis etc. Therefore, the present study recommended like of that GA powder and/or extracts to be included in our daily diets, drinks, food supplementation and pharmacological formulae.

Keywords: Gum arabic, antioxidant activity, radicals scavenging activity**,** extractive value**.**

Introduction

Gum arabic (GA) also known as gum sudani, gum acacia, acacia, Senegal gum, Indian gum, and by other names, was defined In the thirty first Codex Committee for Food Additives, The dried exudate from the trunks and branches of Acacia senegal or Vachellia (Acacia seyal) in the family Fabaceae was on display at The Hague from March 19 to 23, 1999 (*Leguminosae*) *(***Muller and Okoro, 2004).** According to a 2017 safety re-evaluation by the European Food Safety Authority's Panel on Food Additives and Nutrient Sources, the word "gum arabic" does not imply a specific botanical source; in certain situations, so-called "gum arabic" may not have even been harvested from Acacia species. (Mortensen et al., 2017). As reported by MSN (2008) there are approximately 900 species of acacia capable of producing mucilage. These are located mainly in tropical climates, with about 130 of them

located specifically on the African continent. As a result, Africa quickly became the primary source of GA. This is why it's also known as "Senegalese gum." The mucilage is essentially the secretion of many acacia (leguminous) trees. The species of Acacia Gum, numbering as many as seventeen, produce acacia Gum of varying type and quantity. Interestingly, approximately 80% of GA is produced by *Acacia Senegal* in Sudan Republic. The remaining gum is generated by Acacia laeta or Acacia seyal, with each species accounting for 10% of the overall supply. The chewing gum produced by *Acacia Senegal* is commonly referred to as "hard chewing gum" and the gum from *Acacia seyal*, "flaky gum". Europe and the United States are major GA markets that import an average of 40 kilotons per year, while Japan, the largest Asian consumer, imports about 2 kilotons per year.

Related to the chemical structure, GA is a neutral or slightly acidic salt of a complex polysaccharide composed of galactose, arabinose, rhamnose, glucuronic acid, 4-*O*-methylglucuronic acid, calcium, magnesium, and potassium. The molecular weight has been reported to be 600,000 (Anderson and Dea, 1971). Gum arabic is distinguished from other gums by its high solubility in water; 50% solutions can be prepared, compared with maximum concentrations of 5% or less for most other gums (Furia, 1972). In the last two decades, several investigations have been conducted in order to reveal the molecular structure of GA and relate it to its exceptional emulsifying and rheological properties. The chemical composition of GA is complex and consists of a group of macromolecules characterized by a high proportion of carbohydrates (~ 97%), which are predominantly composed of *D*-galactose and *L*-arabinose units and a low proportion of

proteins (<3%) (Islam *et al.*, 1997 and Mohamed, 2013). The chemical composition of GA may vary slightly depending on its origin, climate, harvest season, tree age and processing conditions, such as spray dying (Al-Assaf *et al.,* 2005a-b; Flindt *et al.,* 2005; Hassan *et al.,* 2005; Siddig *et al.,* 2005; Elhassaneen, 2020; ElSamoty, 2021).

The uses of GA have been known since ancient times back to the year 2000 BC when the Egyptians used it as a called "Gum arabic" because was exported from Arabian ports (Abdul, 2002). Today, the properties and features of GA have been widely explored and developed and it is being used in a wide range of industrial sectors such as textiles, ceramics, lithography, cosmetics, pharmaceuticals and food. Regarding food industry, GA 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). In this context, Mohamed, (2013) and Elhassaneen *et al.,* (2013) were fortified the flour with different levels of GA and produced high-dietary fiber bakery products. Also, the addition of GA to the flour leads to enhance the rheological properties of the dough subsequently the quality of the manufactured breads. Also, GA is used as a stabilizer, a flavor fixative, a thickener, an adhesive and/or an emulsifier agent (Verbeken *et al.,* 2003). The following products may contain GA 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 Sciences Research Office, 1973).

Regarding the biological role of GA has confirmed in the last four decades including reduction in plasma cholesterol level in animals and humans (Sharma, 1985 and Tiss *et al.*, 2001), anticarcinogenic effect (Nasir *et al.*, 2010; Elhassaneen,. 2020) and antioxidant effect (Al-Majed *et al.*, 2002; Ali *et al.*, 2003; Trommer and Neubert, 2005; Ali and AlMoundhri, 2006; **Rdwan et al., 2016;** ElSamoty, 2021**)** with a protective role against hepatic and cardiac toxicities (Elhassaneen,2020). In addition to that, it has been claimed that GA alleviates effects of chronic renal failure in humans (Ali *et al.*, 2008; Glover *et al.*, 2009 and Ali *et al.*, 2010; Abd El-Khader, 2018). Also, GA 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 (Phillips and Philips, 2011). One of these benefits is its prebiotic effect (Phillips *et al.*, 2008). For example, Calame *et al.*, (2008) reported that four week supplementation with Gum Arabic (10 g/day) led to significant increases in Bifidobacteria, Lactobacteria, and Bacteriodes indicating a prebiotic effect. Several epidemiological studies suggest that a high intake of dietary fiber, including GA (dietary fiber > 80%), is associated with beneficial effects on fat metabolism (Slavin, 2003 and Ali *et al.*, 2009). It can serve to reduce obesity and therefore prevent associated complications in humans (Lear *et al.*, 200; Hedley *et al.*, 2004; Abd El-Khader, 2018; Elhaet al., 2018; Elhassaneen, 2020). It's been tested in individuals with chronic renal failure, and it's said to help lower urea and creatinine plasma concentrations, as well as reduce the need for dialysis from

three to two times per week (Suliman et al., 2000 and Abd El-Kafee, 2012). GA is also used to treat inflammation of the intestinal mucosa and to cover inflammatory regions both internally and externally (Gamal el-din *et al.*, 2003). Despite the fact that GA is commonly utilised as a drug delivery vehicle in physiological and pharmacological trials and is thought to be a "inert" chemical, several new reports indicate that GA has antioxidant, nephroprotectant, and other properties (Rehman *et al.*, 2001; Gamal el-din *et al.*, 2003 and Ali *et al.*, 2008). All of the previous studies with the others led to widely use GA around the world in folk and modern medicine.

In recent history, the use of plants such gum trees and their exudates (GA) as medicines has involved the preparation of extracts and isolation of bioactive compounds. Using bioactivity-directed fractionation and separation, several essential bioactive chemicals have been found from natural sources, according to numerous research. The majority of these bioactive substances are secondary plant metabolites, and many naturally occurring pure molecules have been developed into medication, dietary supplements, and other commercially useful items (**Mohammed, 2013; Hegazy, 2014; Elhassaneen et al., 2014 a-b; Rdwan et al., 2016; Elhassaneen, 2020)**. Therefore, the present study was designed to study the chemical composition, physical properties, nutritional value, bioactive compounds content and biological activities of gum arabic.

Materials and Methods

Materials

SAVANNA Companies Group (Processing Gums, Juices, and Confectionery Chemical Co. (St. Louis, MO, USA) provided the 1,1-

diphenyl-2-picrylhydrazyl (DPPH), potassium ferricyanide, catechin (CA), ferrous ammonium sulphate, butylated hydroxytoluene (BHT), gallic acid (GA), ascorbic acid (AA), AlCl3, trichloro acetic acid (TCA), sodium phosphate, sodium nitrate, am (Dam-stadt, Germany).

Methods

Preparation of Extracts

GA powders were utilised for their various forms of extracts, as described by Amin et al., (2004), with some changes. In the aqueous extraction, 20 g of GA + 180 ml deionized water were homogenised and transferred to a beaker, where they were agitated at 200 rpm for 1 hour at room temperature in an orbital shaker (Unimax 1010, Heidolph Instruments GmbH & Co. KG, Germany). Filtration via Whatman No. 1 filter paper separated the extract from the residue. The leftover residue was extracted twice more, and the two extracts were then mixed. The filtrates were concentrated using a rotary evaporator (Laborata 4000; Heidolph Instruments GmbH & Co. KG, Germany) under reduced pressure at 55°C. In organic solvents extraction, the same previous extraction procedure was carried out by using different organic solvent separately including petroleum ether, hexane, dimethyle sulfoxide, diethyl ether, benzene, chloroform, ethanol and methanol as an extraction medium.

Determination of GA chemical properties

GA samples were analyzed for proximate chemical composition including moisture, protein (T.N. × 6.25, micro - kjeldahl method using semiautomatic apparatus, Velp company, Italy), fat (soxhelt miautomatic apparatus Velp company, Italy, petroleum ether solvent), ash, fiber and The AOAC recommended techniques for determining dietary fibre

levels were used (1995). Carbohydrates calculated by differences: Carbohydrates (%) = 100 - (% moisture + % protein + % fat + % Ash + % fiber). Total energy (Kcal/100 g) was calculated according to **Insel *et al,* (2002)** using the following equation: Total energy value (Kcal/100 g) = 4 (Protein % + carbohydrates %) + 9 (Fat %).

Determination of GA nutritional value

Satisfaction of the daily needs of adult man (25-50 year old) in protein

The RDA (1989) values were used to calculate the grammes consumed (G.D.R. g) of food (wet weight basis) to meet the daily protein needs of an adult man (63 g). Percent satisfaction of the daily requirement of adult man in protein (P.S.%) when consuming the possibly commonly used portions in Egypt i.e. three loves (one loave, 80 g weight), was also calculated.

Satisfaction of the daily requirements of adult man (25-50 year old) in energy

Grams consumed of food (wet weight basis) to cover the daily requirements of man in energy (G.D.R. g) were calculated using the RDA (Recommended dietary allowances) which are 2900 Kcal /day for man as given by RDA (1989) .

The percent satisfaction (P.S. %) of the daily needs of adult man (25 -50 year old , 79 Kg weight and 176 cm height) in energy upon consumption the commonly used portion at homes in Egypt, i.e. three loves (one loave, 80 g weight)), was also calculated.

Determination of GA physical properties

Specific rotation of gum samples was measured using a polarimeter (Bellingham and Stanley) equipped with a sodium

light and a 20 cm path length cell in a filtered 1 percent aqueous solution (Abu Baker, 1996).

The relative viscosity of gum Arabic samples was determined using a U-shaped viscometer in a filtered 1 percent aqueous solution (AOAC, 1990).

The refractive index of gum samples was determined using an Abbe refractometer in a filtered 1 percent aqueous solution, as described by Karamalla et al (1998).

Determination of bioactive compounds in GA

Determination of total phenolics

Total phenolic contents in ***GA*** extracts were estimated by the method described by Wolfe *et al.,* (2003). Total phenolic contents were expressed as gallic acid equivalent, GAE (standard curve equation: $y = 0.0851x + 0.2995$, $R^2 = 0.9873$), mg of GA/g of dry extract. The experiment was carried out three times at each concentration.

Determination of total flavonoids

Total flavonoids contents in **GA** extracts were estimated using colorimetric assay described by Zhisen et al. (1999). Total flavonoid contents were expressed as catechin equivalent, CAE (standard curve equation: $y = 0.0003x - 0.0117$, $R^2 = 0.9827$), mg of CA/g of dry extract. The experiment was carried out three times at each concentration.

Total polysaccharides

Total polysaccharides were determined by spectroscopic analysis technique using a UV- visible-light spectrophotometer. Samples were extracted and measured according to the method of **Vazirian *et al.*, (2014).** Starch was used as a standard and the results were expressed as mg of starch equivalents per g of dw.

Biological activities of GA

Antioxidant activity

Antioxidant activity (AA) of GA extracts and standards (α-tocopherol, and BHT) was determined by β-carotene bleaching (BCB) assay such as mentioned by Marco, (1968). BHT and α-tocopherol by various concentrations in 80% methanol were used as the standard. AA was calculated as percent inhibition relative to control was expressed as antioxidant activity (AA) using the equation of Al-Saikhan *et al.,* (1995).

DPPH radical scavenging assay

The ability of GA extracts to scavenge free radicals was determined using the DPPH radical scavenging assay established by Desmarchelier et al (1997). 2.4 mL of 2,2-diphenyl-1-picrylhydrazyl (DPPH) (0.1 mM in methanol) was combined with 1.6 mL of G. lucidum extract at various concentrations (12.5–150 g/mL) to make a solution. The reaction mixture was completely vortexed and kept at room temperature for 30 minutes. The absorbance of the mixture was measured spectrophotometrically at 517 nm (UV-160A; Shimadzu Corporation, Kyoto, Japan). BHT was used as reference. Percentage DPPH radical scavenging activity was calculated by the following equation: DPPH radical scavenging activity (%) =[(A0− A1)/A0]×100, where A_0, absorbance of the control, and A_1, absorbance of the *G. lucidum* / BHT. Then inhibition (%) was plotted against concentration, and IC_{50} was calculated from the graph.

Statistical Analysis

All measurements were done in triplicate and recorded as mean ± standard deviations (SD). After data arranged in Excel sheet, All statistical analysis was performed with the Student *t*-

test and MINITAB 12 computer program (Minitab Inc., State College, PA).

Results and Discussion

Chemical and nutritional properties of GA

Data in Table 1 shows the proximate chemical composition of GA samples. The contents of moisture, total protein, crude fat, crude fiber, ash and carbohydrates content of GA collected from Sudan Republic *were* 10.32, 2.87, 0.15, 81.45, 2.63 and 2.85%, respectively. Such data are partially corresponding with that observed by Hegazy, (2014) and ElSamoty, (2021). Also, Elhassaneen, (2020) found that the contents of moisture, total protein, crude fat, crude fiber, ash and carbohydrates content of GA collected from Sudan Republic were 11.98, 3.15, 0.18, 78.16, 2.61 and 3.92%, respectively. Furthermore, data indicated that the moisture content of Sudanese gum is lower than the value reported by FAO (1990) while the total protein and ash values are falls within the range reported by the same source. GA's chemical makeup varies slightly according on the country of origin, climate, harvest season, tree age, and processing circumstances. (Flindt *et al.,* 2005; Hassan *et al.,* 2005; Siddig *et al.,* 2005; Al- Assaf, *et al.,* 2005 (a,b); Elhassaneen, (2020). Therefore, Sabah El-Kheir *et al.,* (2008) reported that there are some differences between the chemical composition of the GA taken from *Acacia senegal* and *Acacia seya*. As well as, Karamalla *et al.,* (1998) and Sabah El-Kheir *et al.,* (2008) found that the protein and total soluble fiber content in gum samples collected from kordofan and Damazin regions in Sudan Republic are significantly ($p \leq 0.05$) different. Finally, Abd El-Khader, (2019) and Elhassaneen, (2020) recorded partially different in gross chemical composition of GA

samples collected from different sources/zones of Sudan Republic.

Table 1. Proximate chemical composition of GA samples

Factor	Value
Moisture (%)	10.32 ± 1.56
Total protein (%)	2.87 ± 0.54
Crude fat (%)	0.15 ± 0.03
Crude fiber (%)	81.45 ± 3.21
Ash (%)	2.63 ± 0.45
Carbohydrates (%)*	2.58 ± 0.23

* Carbohydrates were determined by calculation (by the difference)

Nutritional evaluation values of GA samples were illustrated in Table (2). Fom such data it could be noticed that these properties include the total energy (Kcal/100g), the daily requirement of adult man for protein (GDR/protein) and energy (GDR/energy) , percent satisfaction of the daily requirements of adult man in protein (P.S./protein) and energy (P.S./energy) which recorded 23.15, 2195, 12527, 4.56 and 0.80, respectively. Data of this study are in partially accordance with that reviewed by many authors (Hegazy, 2014; Elhassaneen, 2020 and ElSamoty, 2021). All the previous data indicated that the characteristics of GA and consequently the nutritional value may vary significantly, depending on the geographical origin and age of the trees, climatic conditions, soil environment, the place of exudation on the tree and the agriculture management.

Table 2. Nutritional evaluation of GA samples

Factor	Value
Energy (Kcal/100g)	23.15± 2.21

G.D.R. (g) for protein (63 g)	2195± 134
G.D.R. (g) for energy (2900 Kcal)	12527± 1121
P.S./100 g For protein (63g), [% Recommended protein/day (RDA, 63g)]	4.56± 1.09
P.S./100 g For energy (2900 kcal), [% Recommended energy/day (RDA, 2900 Kcal)]	0.80± 0.11

* G.D.R. (g): Grams consumed to cover the recommended daily allowance of adult man according to RDA (1989), P.S./100 (g): Percent of satisfaction of 100 g for adult man according to RDA (1989).

Physical properties

The Physical properties of GA samples were showed in Table (3). From such data it could be noticed that the physical properties of GA samples. had specific rotation (-27.95± 1.22) and relative viscosity (16.01± 0.98). Such physical properties of GA were accordance with that recorded by Abd El-Khader, (2019) and ElSamoty, (2021). Also, Elhassaneen, (2020) reported that GA (*Acacia senega*l) had specific rotation (-27.11) and relative viscosity (14.10). Furthermore, Also, the present data are found within the range reported previously by FAO, (1998), Sabah El-Kheir *et al.,* (2008). The Refractive index (1.37 ± 0.21), pH (4.46 ± 0.14) and average molecular mass (388 kDa) which are agree with those obtained by Montenegro *et al.,* (2012), Abd El-Khader, (2019) and Elhassaneen (2020) . In similar study, Montenegro *et al.*, (2012) reported that GA functional/physical properties are closely related to its structure, which determines, for example, viscosity, degree of interaction with water and oil in an

emulsion, solubility and microencapsulation ability. By other meaning, the highly branched structure of the gum arabic molecules leads to compact relatively small hydrodynamic volume and, consequently gum arabic will only become a viscous solution at high concentrations. Also, Williams *et al.*, (1990); Williams and Phillips, (2000) and Hegazy, (2014) reviewed that Because acids and bases modify the electrostatic charge on the macromolecule, they can change the viscosity of gum arabic solutions. For example, in very acidic solutions, acid groups neutralize so inducing a more compact conformation of the polymer which leads to a decreased viscosity; while a higher pH results in maximum viscosity around pH 5.0-5.5. On the other side, in very basic solutions, the ionic strength increment reduces the electrostatic repulsion between gum arabic molecules producing a more compact conformation of the biopolymer and thus reducing the viscosity of the final solution. Such physical properties are playing very important roles during food technological applications (Elhassaneen et al., 2014 a-b; Hegazy, 2014 and Rdwan et al., 2016)

Table 3. Physical properties of GA samples

Property	Value
Specific rotation (degree)	-27.95± 1.22
Relative viscosity	16.01± 0.98
Solubility (Percentage, w/v)	25.93 ± 1.67
Refractive index	1.37 ± 0.21
pH	4.46 ± 0.14
Average molecular mass (kDa)	388.00

Extractive value

Extractive value of GA samples using different organic solvents and water were shown in Table (4). From such data it could be noticed that the extractive value for GA in different organic solvents was very low (0.065-1.942%) while very high in water (16.052-16.921%). In similar study, Elhassaneen, (2020) found that the extractive value for gum arabic in different organic solvents was 0.028 ± 0.004 -2.011 ± 0.210 % while in water was 16.023 ± 1.210 - 17.734 ± 2.102 %. Also, similar results were obtained by Hegazy (2014) and ElSamoty, (2021). In general, the extractive values of materials in different organic solvents are based on the their quantity, which are soluble in solvents. It makes a valuable test to check the quality of drug and any variation in the chemical constituents may cause a change in the extractive values. Thus, it is an index of the purity of drug. Such data confirmed that gum arabic constituents were found in hydrophilic/aquatic phase in line with the rule the "like dissolve like i.e. Polar dissolve polar and non-polar dissolve non-polar". The existence of a specific component, as well as the solubility, soil condition, ambient condition, and water content of the sample, may cause variance in the extractive values (Jahan *et al.,* 2008; Elhassaneen et al., 2014 a-b; Hegazy, 2014; Abd Elalal et al., 2021).

Table 4. Extractive value of GA samples using organic solvents and water

Solvents	Mean extract (%) ±SD
Petroleum ether	1.694 ± 0.009 [b]

Hexane	1.432 ± 0.013 [b]
Dimethyle sulfoxide	1.942± 0.010 [b]
Diethyl ether	0.831 ± 0.005 [bc]
Benzene	0.028 ± 0.003 [d]
Chloroform	0.065 ± 0.004 [d]
Methanol	1.061 ± 0.011 [bc]
Ethanol	0.918 ± 0.009 [bc]
Water (Distilled water, DW)	16.052. ± 0.853 [a]
Water (Tap water)	16.921 ± 0.972[a]

Each value represents the mean of three replicates ±SD. Means under the same column with different superscript letter were significantly different at $p \leq 0.05$.

Bioactive compounds and dietary fiber content in GA powder

Bioactive compounds in GA powder were shown in Table (5). From such data it could be noticed that polysaccharides were the most largest compound (211.53± 10.43mg starch equvalent. g^{-1}) followed by phenolics (43.98 ± 1.76 mg gallic acid equvalent. g^{-1}),_and flavonoids (10.23 ± 0.34 mg catechin equivalent. g^{-1}). Also, GA was e richen in dietary fiber (74.45± 3.21g/100g). In similar study, ElSamoty, (2021) found that the total phenolics in GA was 40.67 mg gallic acid equvalent. g^{-1}. In a nutritional point of view, several biological activities for polysaccharides including anticoagulant, antithrombotic, anti- inflammatory, anti-obese, antiviral, immune system-boosting properties and anti-osteoporosis (Fitton *et al.*, 2008; Nagaoka *et al.*, 2000; Elhassaneen *et al.*, 2020-2021). Polysaccharides also serve to guard against potential carcinogens, empty the digestive

system, and protect the stomach and intestine's surface membranes. They absorb cholesterol, which is then excreted from the digestive system, resulting in hypocholesterolemic and hypolipidemic reactions (Ito and Tsuchida, 1972; Burtin, 2003). This is frequently accompanied with a rise in faecal cholesterol and a hypoglycaemic reaction (Dumelod et al., 1999). Other bioactive substances discovered in GA, such as phenolics and flavonoids, may play key biological roles in the prevention and/or treatment of a variety of disorders, including diabetes, atherosclerosis, cancer, obesity, bone, anaemia, and ageing (Elhassaneen *et al.*, 2016 a-c, 2019, 2020, 2021). These chemicals' prior benefits are primarily due to their magical biological/antioxidant actions.

On the other side, GA samples rich in dietary fiber (DF). Carbohydrates is available as polysaccharide, which is not taken up by the human body and are regarded as DF. They are good for human health as they make an excellent intestinal environment by favoring the growth of intestinal microflora, including probiotic species so they can be considered as prebiotic (Tosh and Yada, 2010). The value of consuming reasonable levels of dietary fibre for human health has been addressed by several authors (Forsythe et al., 1976 and Ballesteros et al., 2001). Fibers are primarily insoluble and can bind bile acids, according to Camire et al. (1993) and Elbasouny et al. (2019). One of the processes through which certain forms of dietary fibre lower plasma cholesterol is thought to be bile acid binding. Furthermore, El-Sadany (2001) studied the hypocholesterolemic effect of dietary fiber and found that after four weeks of feeding on potato peels, rats showed 40 % reduction in plasma cholesterol content and 30% of hepatic fat cholesterol levels were reduced as compared with

animals fed only with cellulose supplemented diet. Moreover, the effect of GF on serum glucose and insulin response has been demonstrated by many other authors. For example, Chandalia *et al.*, (2000), Al-Weshahy and Rao, (2012) and According to Elhassaneen et al., (2021), a high DF intake has a favourable effect on serum glucose profile and related health issues in both healthy and diabetic people. DF can affect the absorption of other simple sugars by changing the stomach emptying time.

Table 5. Total content of bioactive compounds and dietary fiber in GA

Component	Mean ±SD
Dietary fiber (g/100g)	74.45± 3.21
Phenolics (mg gallic acid equivalent. g^{-1})	43.98 ± 1.76
Flavonoids (mg catechin equivalent. g^{-1})	10.23 ± 0.34
Polysaccharides (mg starch. g^{-1})	211.53± 10.43

*Each value represents the mean of three replicates ±SD.

Biological Activities of GA extracts

Antioxidant activities

Antioxidant activity of GA is tabulated in Table (6). From such data it could be noticed that GA sample showed high antioxidant activity (AA, 84.85%) for aqueous extract while very low (AA, 11.21-14.32%) for organic solvent extracts (ethanol and methanol, respectively. The AA in GA is correlated with the reasonable content of different bioactive compounds such as phenolics, flavonoids and polysaccharides. Such data confirmed that gum arabic constituents were found

in hydrophilic/aquatic phase in line with the rule the "like dissolve like i.e. Polar dissolve polar and non-polar dissolve non-polar". The variation in the antioxidant activity values may be possible due to the presence of specific compound according to the solubility water content of the sample (Elhassaneen et al., 2014 a-b; Hegazy, 2014; ElSamoty, 2021).

DPPH radical scavenging activity

The free radical scavenging activity (%) of GA different extracts and standard (BHT) are shown in Figure (1) and Table (7). Such data indicated that water extract (AqE) only possessed the highest scavenging activity while organic solvents (EtE and MeE) don't exhibit activity. At a concentration of 100 µg/mL, the radicals scavenging activity of water, ethanol and methanol extracts were 65.78, 29.39 and 25.35%, respectively, whereas at the same concentration, the standard BHT was 92.13%. For the IC50, the water extract was recorded 35.02 ± 1.02 µg/mL while ethanol and methanol

Table (6). Antioxidant activity of GA extracts and standards

Factor	Value (Mean ±SD)
Antioxidant activity (AA, water/aqueous extract)	84.45 ± 2.87
Antioxidant activity (AA, ethanol extract)	14.32 ± 1.14
Antioxidant activity (AA, methanol extract)	11.21 ± 1.70
α-tocopherol (Standard, 50 mg/L)	97.89 ± 0.74
Butalyted hydroxyl toluene (BHT,Standard, 50mg/L)	86.11 ± 0.69

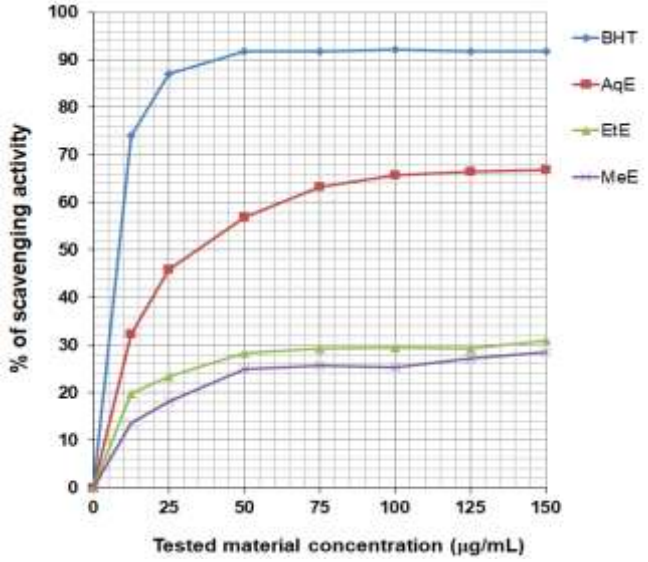

Figure 1. DPPH radical scavenging activity (%) of GA extracts and standard (BHT)*

* Each value represents the mean value of three replicates. BHT, Butylated hydroxytoluene, WE, Water extract, EtE, Ethanol extract, MeE, Methanol extract,

Table 7. IC_{50} (DPPH) of GA extracts and BHT (Standard)

Tested extract	BHT	AqE	EtE	MeE
IC_{50} (µg/mL)	9.2 ± 0.20^{b}	35.02 ± 1.02^{a}	ND	ND

* Each value represents the mean value of three replicates ±SD. Values with different superscript letters in the same raw are significantly did different at $p \leq 0.05$. BHT, Butylated hydroxytoluene, AqE, Water/aqueous extract**,** EtE, Ethanol extract, MeE, Methanol extract. ND. Not detected.

extracts not detected. The IC_{50} of BHT (standard) was 9.2 ± 0.20 µg/mL. The free radical scavenging activity of different tested extracts and standard was in the following order: standard (BHT) > water extract > ethanol extract > methanol extract**.** The theory of the DPPH radicals scavenging activity test is based on measurement of the diene conjugation ( ) by absorption at 234 nm in the presence of DDPH (2,2-diphenyl-1-picrylhydrazyl) substrate is commonly used for determining the oxidative stability of the GA sample (Antolovich and others 2002). Several studies indicated that DPPH methodology has been used successfully to evaluate the antioxidant activity/ oxidative stability of different parts including different plant parts (Kahkonen *et al.*,1999; Abd Elalal et al. 2021). Also, many studies reviewed that the free radical scavenging activity are very important to prevent the adverse role of free radicals in different diseases including obesity, cancer, cardiovascular, diabetes, neurological, pulmonary diseases (Lien *et al*., 2008; Elbasouny et al., 2019; Abd Elalal et al. 202; Elhassaneen *et al.*, 2021). The results of this study suggest that GA water extract showed free radical scavenging activity which due to their high content of different categories of bioactive compounds (antioxidants) including polysaccharides, phenolics, flavonoids etc.

Conclusion

Data of the present study supported our hypothesis that GA contains several categories of bioactive compounds including dietary fiber, phenolics, flavonoids and polysaccharides with other compounds that are responsible for different biological activities. The biological activities studied here including antioxidant activities and radicals scavenging activities. Such major bioactive chemicals and biological

effects in GA could play a key role in methods to combat/treat a variety of disorders, particularly those in which oxidative stress is one of the underlying processes. As a result, we advise include GA powder and/or extracts in our everyday diets, drinks, food supplementation, and pharmaceutical formulations.

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التركيب الكيميائى والخواص الطبيعية والقيمة الغذائية ومحتوى المركبات النشطة حيويا والأنشطة الحيوية للصمغ العربي

الملخص العربي :

تهدف الدراسة الحالية إلى تحديد التركيب الكيميائي والخصائص الفيزيائية والقيمة الغذائية ومحتوى المركبات النشطة بيولوجيا والأنشطة البيولوجية للصمغ العربي (أكاسيا سيال) الذي تم جمعه من جمهورية السودان. كانت القيمة الاستخلاصية للصمغ العربي (GA) في المذيبات العضوية المختلفة منخفضة جدًا (٠.٠٦٥-١.٩٤٢٪) بينما كانت عالية جدًا في الماء (١٦.٠٥٢-١٦.٩٢١٪). كانت محتويات الرطوبة، البروتين الكلي، الدهون الخام، الألياف الخام، محتوى الرماد والكربوهيدرات في الصمغ العربى ١٠.٣٢، ٢.٨٧، ٠.١٥، ٨١.٤٥، ٢.٦٣ و ٢.٨٥٪ على التوالي. أيضًا، إجمالي الطاقة(Kcal / 100g) ، والاحتياجات اليومية للإنسان البالغ من البروتين (GDR /بروتين) والطاقة (GDR/ الطاقة)، ونسبة إشباع الاحتياجات اليومية للإنسان البالغ من البروتين (نسبة الاشباع/ البروتين) والطاقة (نسبة الاشباع/ الطاقة) التي سجلت ٢٣.١٥ و ٢١٩٥ و ١٢٥٢٧ و ٤.٥٦ و ٠.٨٠ على التوالي. أشار محتوى المركبات النشطة بيولوجيًا في مسحوق الصمغ العربى إلى أن السكريات العديدة كان أكبر مركب (٢١١.٥٣ ± ١٠.٤٣ مجم مكافئ النشا/ جرام يليه الفينولات (٤٣.٩٨ ± ١.٧٦ مجم مكافئ حمض الجاليك/جرام، والفلافونويد (١٠.٢٣ ±) مكافئ كاتشين ٠.٣٤ / مجم . أيضا، كان الصمغ العربى غنيا بالألياف الغذائية (٧٤.٤٥ ± ٣.٢١ جم / ١٠٠ جم). كما سجلت العينات أيضًا العديد من الأنشطة البيولوجية عالية جدًا والتي تشمل مضادات الأكسدة وأنشطة إزالة الشقوق الحرة . لذلك، يمكن لمحتوى المركبات النشطة بيولوجيًا والتأثيرات البيولوجية للصمغ العربى أن تلعب أدوارًا مهمة في استراتيجيات مكافحة / علاج العديد من الأمراض، خاصة تلك التي يكون الإجهاد التأكسدي أحد آليات حدوثها مثل السمنة والسكري والسرطان وتصلب الشرايين وما إلى ذلك. لذك توصى الدراسة الحالية بإدراج مثل مسحوق الصمغ العربى أو مقتطفات في وجباتنا الغذائية اليومية والمشروبات والمكملات الغذائية والمستحضرات الدوائية.

الكلمات المفتاحية: الصمغ العربي، النشاط المضاد للأكسدة، نشاط كسح اللشقوق الحرة، القيمة الاستخلاصية.