



Vol. 12(3), Pp. 25-31, October 2024,

Author(s) retain the copyright of this article

This article is published under the terms of the
Creative Commons Attribution License 4.0.

<https://journals.directresearchpublisher.org/index.php/drjafs>

Research Article

ISSN: 2354-4147

Preparation and physicochemical characterization of magnesium glucuronate from acacia tortillis var radiana gum (*acacia tortillis savi*)

Mnahil Mohamed Gamal^{1*}, Mohamed Elmubarak Osman² and Gurashi Ahmed Mohamed³

¹Sudan University of Science and Technology, College of graduate studies.

²Sudan University of Science and Technology, College of graduate studies.

³Sudan University of Science and Technology, College of graduate studies.

Corresponding author email: manahilmohgamal@gmail.com

ABSTRACT

This study examined the physico-chemical properties of acacia radiana tortillis var. Radiana from East Nile, Khartoum North. The analysis revealed a moisture content of 9.92%, a total ash value of 2.63%, a pH value of 4.3, and an absolute viscosity of 58. The specific rotation measured was -11. Cationic composition showed sodium (711.45 mg), magnesium (4.49 mg), calcium (15.17 mg), vanadium (1.79 mg), iron (2.56 mg), nickel (1.98 mg), copper (0.64 mg), arsenic (4.08 mg), aluminum (2.29 mg), and lead (4.38 mg). Glucuronic acid was extracted from acacia radiana gum using ion exchange chromatography, followed by the production of magnesium glucuronate via the addition of magnesium bicarbonate. Magnesium glucuronate properties assessed included a moisture content of 10.3%, a total ash of 1.85%, pH of 6.41, an absolute viscosity of 16.25, and a specific rotation of -6. Elemental analysis confirmed sodium (5.49 mg), magnesium (17.19 mg), calcium (71.89 mg), vanadium (1.59 mg), iron (1.45 mg), nickel (1.79 mg), copper (0.44 mg), arsenic (3.84 mg), aluminum (1.49 mg), and lead (3.93 mg). The findings supported the formulation of an antacid tablet incorporating magnesium glucuronate, leveraging its beneficial properties. In this study magnesium glucuronate was prepared from acacia tortillis var radiana, a sample of acacia tortillis collected from sherg alnile khartoum north, and its physicochemical properties were determined. Glucuronic acid was prepared by using ion exchange chromatographic technique then magnesium glucuronate was prepared by adding magnesium bicarbonate. Physicochemical characterization of magnesium glucuronate gave moisture content was 10.3%, total ash 1.85%, pH value 6.41, absolute viscosity 16.25 Cp, specific rotation +44, and cationic composition was Na=5.49, Mg= 17.19, Ca = 71.89, V= 1.59, Fe = 1.45, Ni = 1.79, Cu = 0.44, As =3.84, Al = 1.49, Pb = 3.93 mg/l.

Keywords: Acacia tortillis, physicochemical, ion exchange chromatography, magnesium glucuronate, glucuronic acid

Article information

Received 2 August 2024;

Accepted 21 September 2024;

Published 7 October 2024

DOI: <https://doi.org/10.26765/DRJAFS7053210>

Citation: Gamal, M. M., Osman, M. E., and Mohamed, G. A. (2024). Preparation and physicochemical characterization of magnesium glucuronate from acacia tortillis var radiana gum (*acacia tortillis savi*). Direct Res. J. Agric. Food Sci. Vol. 12(3), Pp. 25-31. This article is published under the terms of the Creative Commons Attribution License 4.0.

INTRODUCTION

In truth, the word acacia comes from the Greek akis, which means a sharp point, referring to the thorns, which Australian acacia do not have. Although there are 1100

acacia species worldwide, acacia Senegal and acacia Seyal continue to be the most commercially utilized species of the entire acacia resource. Most of them grow

in dry and semi-arid environments, with an average temperature of 40-45°C in summer and less than 5°C in winter. Acacia is equipped with the majority of the traits required to withstand severe climatic conditions, hence they are considered the most effective "survivors" in the dry region (Ibrahim et al 2003). Gum Arabic is a branching hetero polysaccharide made up of Galactopyranose units and minor amounts of Glycoprotein which hydrolyses to produce Arabinose, Galactose, Rhamnose, and Glucuronic acid (Fatima, 2016; Atgie, 2018). Acacia gums are made up of polyelectrolytes that contain calcium, magnesium, and potassium salts. This hybrid polyelectrolyte contains both protein and polysaccharide subunits. It is formed of six carbohydrate moieties (galactopyranose, arabinopyranose, arabinofuranose, rhamnopyranose, glucopyranosyl uronic acid, and 4-O methyl glucopyranosyl uronic acid), as well as a minor fraction of proteins (Atgie, 2018; Nakauma, 2008). The composition of gum is influenced by location, tree age, and season of exudation, genetics, and storage conditions. The main chain consists of 1,3-linked β ,D-galactopyranosyl units, which are coupled to side chains by 1,6-linkages. Both the main chain and side chains are units of the carbohydrate moieties previously discussed. Uronic acid moieties are predominantly end units (Islam et al., 1997; Nakauma et al., 2008; Atgie, 2018). Gum Arabic is made up of 39-42% galactose units, 24-27% arabinose units, 12-16% rhamnose units, 15-16% glucuronic acid units, 1.5-2.4% protein moieties, and 12-16% moisture (Atgie, 2018).

Acacia tortilis var radiana

Botanical classification:(Elamin, 1981).

Kingdom: *Plantae*.

Division: *Mangliophyta*.

Class: *Mangoliopsida*.

Order: *Fabales*.

Family *Fabaceae*.

Subfamily *Minosoideae*.

Tribe *Acacieae*.

Genus *Acacia*.

Species *A. Tortilis*.

Binomial name *Acacia tortilis savi*.

Local name sayal.

The name *tortilis* means twisted and refers to the pod structure. It is also known as umbrella thorn due to its umbrella like structure and in India it is commonly known as Israeli baboo.

Description

The tree can occasionally reach 7-21m in height, with an uneven or round crown and one main stem from the

base. The leaves are dark green, with no alliolate margins or only at the apex pods 6-9mm wide with glabrous to pubescent hairs that cannot be seen with the human eye (Elamin, 1981). The bark is somewhat broken to fissured brown, with slashes of pinky-brown, and dark brown outer bark. Stems are reddish to blackish purple, more or less glabrous or pulberulous, with thorns that are primarily straight (5-10 cm long) and some that are more or less curled (0.5 cm long), arranged in pairs in the leaf axils, white, and alternating. Bipinnate up to 2.5 -4.5 cm long with 2 -10 pairs pinnae and 6-20 pairs of leaflets per pinna; leaflets are oblong, glabrous or more or less hairy. 3-4 cm long and 0.5-1 cm wide, petioles are 2-4 cm long, frequently with a crater-like gland above before the first pair of pinnae, and flowering occurs in the rainy season after the first leaves appear. The inflorescence in a fascicle, set in the leaf axel, is composed of 1-6 glomerules, about 2-5 cm long, whitish pedunculate, and 0.5-1 cm in diameter (FAO, 1991, 2002). Fruits are coiled pods that are 7-12 cm long and 0.5 to 0.7 cm broad when ripe, holding up to 10 seeds (FAO, 1991, 2002). The seeds are brown, convex elliptic or round, and measure 4-7 mm in diameter (Arbonnier, 2004).

Distribution

Sahil zone extends from Algeria to Senegal, Egypt, Sudan, and Kenya. From Senegal to Cameroon, as well as Somalia, topical Africa, North Africa, the Middle East, and Arabia (FAO, 1991, 2002).

Magnesium glucuronate

Glucuronic acid, with a molecular formula of $C_{12}O_{22}MgO_{14}.XH_2O$ and a molecular weight of 414.6 g/mol, is a crucial uronic acid due to its carboxylic group, which serves as a binding site for both poisonous and necessary metals (see Figure 1).

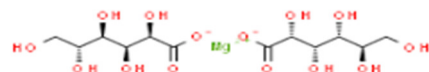


Figure 1: Structure of magnesium glucuronate

LITERATURE REVIEW

Physicochemical properties

Solubility *Acacia tortilis* var. *radiana* gum is extremely soluble in water, generating a clear solution, and is classed as soluble gum:

- Gum Arabic is a pale white, orange-brown solid that breaks with a glassy fracture (Anon., 2013).

- Highly soluble in water, with solutions reaching up to 55% (Anon., 2013).
- It is not soluble in oils or most organic solvents (Anon., 2013).
- It is considered 95% soluble fibre (Anon., 2013).

Moisture content

The moisture content is the weight lost as a result of water evaporation (Benjamin and Laterite, 1970). It increases the solubility of hydrophilic carbohydrates and hydrophobic proteins in gum Arabic (Thomas et al., 2003). The moisture level of good grade gum should not exceed 15 and 10% for granular and spray dried materials, respectively (FAO, 1999). Daoub et al. (2016) has revealed that A. Raddiana gum has a moisture content of approximately 8.49%.

Total ash

Ash content is a measure of the inorganic residue that remains after organic matter has been burned; it is used to assess critical levels of foreign matter, acid in soluble mater, and calcium, potassium, and magnesium salts. Inorganic residues exist as elements. According to Daoub et al. (2016), A. Raddiana has an ash content of approximately 2.05%.

Optical rotation

Natural gum, such as A.raddiana gum, can rotate the plane of polarised light. The amount and direction of rotation are regarded diagnostic parameters (Biswas et al., 2000).The optical activity of organic molecules (saccharides and carbohydrates) is determined by their structure and a characteristic quality of the material (Eugene & Banlacorek, 1987). According to Daoub et al. (2016), A. Raddiana has an optical rotation of around (+86.75).

Nitrogen content

Dickinson (1988) investigated the emulsifying behaviour of gum Arabic and concluded that there is a substantial relationship between the percentage of protein in the gum and its emulsifying stability. Idris (1989) demonstrated that the protein content of new samples remained relatively constant (2%) regardless of the age of the tree. Intensive research (Anderson et al., 1985; Gammon et al., 1968) demonstrates the importance of nitrogen and nitrogenous components in the structure, physicochemical characteristics, and functionality of gum Arabic. A. Raddiana's nitrogen content is approximately 1.549%, while its protein content is approximately 10.375% (Daoub et al., 2016).

Viscosity

The viscosity of a liquid is defined as its resistance to shearing, stirring, or passing through a capillary tube (Bancraft, 1932). It was regarded as one of the most important analytical and commercial parameters (Anderson et al., 1969) because the study of gum solution flow is critical in the identification and characterization of their molecular structure, as it involves the size and shape of the macromolecule. The viscosity of a solution can vary greatly depending on its composition, due to the possibility of hydrogen bonding between the solute and solvent molecules (Pimental & MC cellen, 1960). For example, more hydroxyl groups result in higher viscosities because a network of hydrogen bonds forms between the molecules, which extends throughout the liquid, making flow difficult.They also discovered that the viscosity of gum Arabic solutions varies with pH, although it reaches a maximum at pH 6-7 and is inversely related to temperature.

Acidity and pH measurement

The concentration of hydrogen ions is particularly essential in gum chemistry and industry; pH value affects functional qualities such as viscosity and emulsifying power. Arabic acid is a prominent component of commercial gum arabic; it decomposes to produce arabinose, which makes the gum solution somewhat acidic (Ahmed, 2007). Daoub et al. (2016) reported that A. Raddiana has a pH of 4.45.

Uronic acids

Uronic acids are widely dispersed in animal and plant tissues and comprise a significant component of several natural polysaccharides (Ahmed, 2007). A variety of methods have been developed for determining uronic acids. They include colorimetric, decarboxylation, and acid-base titimetric techniques. Gums vary greatly in their equivalent weight and uronic acid concentration (Karamalla, 1965).

Molecular weight

The molecular weight of polymers can be determined using physical measurements or chemical methods. Physical methods commonly used for determining polymer molecular weight include osmometry, polymer viscosity, coefficient of diffusion measurement, ultra centrifugation, and light scattering (Fatima, 2016). On-line multi-angle laser light scattering (MALLS) has been shown to be a very powerful tool for characterization. The molecular weight of A. Raddiana was calculated by Daoub et al. (2016) and found to be 2.06×10^6 .

Applications

Gum Arabic is widely used due to its emulsification, microencapsulation, thickening, and stabilising qualities.

In food industrial

Gum Arabic is extensively utilized in the food industry due to its biocompatibility, low cost, low toxicity and relatively wide spread availability (Nep & Conway, 2010)

Confectionery

Gum Arabic is the preferred natural element for the creation of high-quality soft candies. In this case, the gum is mostly employed in its raw form, allowing for the production of soft, chewy candy (Anon., 2013). Gum Arabic is a great taste transporter that formulators employ to add a clean, long-lasting freshness test (Anon., 2013). Gum Arabic can be used to emulsify flavour oils or fats in confections or to prevent crystallization in high sucrose confections (Anon., 2013). Gum Arabic's film-forming property makes it a suitable ingredient for coatings, such as pan-coating fruits and nuts (Anon., 2013). Furthermore, specialized anti cariogenic (anti tooth decay) candies contain Gum Arabic, which is resistant to degradation by microorganisms in the human mouth that cause such effects (Anon., 2013).

Miscellaneous bakery applications

Gum Arabic is an ingredient that needs to be taken into consideration if film-forming and emulsifying qualities are required without compromising product taste or rheology.

Encapsulation flavours

It is used to emulsify essential oils in soft beverages, prevent sugar crystallization in confectionary items, and as a taste encapsulator in dry mix products such puddings, desserts, cake, and soup mixes (CNI, 2005). Gum Arabic can be used to make "off-the-shelf" spray-dried tastes (Anon., 2013). It has an impact on food's viscosity, body, and texture; it is harmless, fully soluble in water, and has no effect on the taste, colour, or aroma of the food it is added to (Tewari, 2010). Due to its emulsifying and surface-active qualities, gum Arabic is a perfect material for flavour encapsulation. It has been demonstrated to meet the requirements for microencapsulation, which is the process of forming active ingredient particles and covering them with a thin layer of another material to provide protection and controlled release. In spray drying applications, it serves as a fixative to shield the flavour ingredient from oxidation and volatilization (Kanakdande et al., 2005).

Gum Arabic has several benefits, including long shelf life, desired taste release, high dispersibility, and flavour protection (Anon., 2013).

Pharmaceutical, vitamins and cosmetics

Due to its physiological innocuousness, gum arabic is utilised as a medication carrier. It also serves as a diluent, binder, disintegrant in tablets, thickening in oral liquids, protective colloids in suspensions, gelling agent in gels, and base in suppository (Zatz & Kushla, 1989). According to various studies (Trommer & Neubert, 2005; Hinson et al., 2004; Ali & AL Moundhri, 2006); Evans et al., 1992; Tiss et al., 2001); it has some biological properties as an antioxidant and can be used to treat a variety of illnesses, including kidney (Ali et al., 2008; Matsumoto et al., 2006); cardiovascular (Glover et al., 2009); and gastrointestinal (Wapnir et al., 2008). Gum Arabic has the ability to positively alter human physiological state, decrease the absorption of glucose, and increase faecal bulk and bile acids (Adiotomre et al., 1990). Cough syrups have been one of its most traditional and well-known use (Anon., 2013). It is used in cosmetics as an adhesive in face powders and masks, as well as a smoothener in lotions and protective creams (Verbeke et al., 2003). It is also utilised in products like hair creams and face masks (Anon., 2013).

High fiber formulations

When used creatively by food technologists, gum Arabic can be included in natural nutritional supplements that aid in adding soluble fibre in a form that is palatable (Anon., 2013). The official classification of dietary fibre by the European Union and Codex Alimentarius is as follows (Phillips et al., 2008; Phillips & Phillips, 2011).

Miscellaneous industrial applications

Gum arabic's capacity to generate extremely uniform films and "carry numerous ingredients through co-spraydrying" has made it a renowned alternative in sprayed glazes, as well as high technology ceramics and as a flocculating agent in the refinement of specific minerals (Anon., 2013). Gum Arabic is used in textiles, lithography, paints, and paper production (Verbeke et al., 2003; Elmanan et al., 2008). Gums are frequently used in textile industries to impart lustre to specific materials (silk), as colour thickeners, and as a mordant in calico printing (Omer, 2004). Because of its adhesive characteristics, gum has been employed in the production of postage stamp adhesives as well as paint and ink formulations (Ahmed, 2007).

Beverages

Gum Arabic is frequently employed in a variety of beverages as the preferred emulsifying agent due to the complete stability of the emulsifying created even in ordinarily problematic low acid settings (Anon., 2013). It is appropriate for application in flavour oil emulsions in the manufacture of soft drinks, where it avoids flocculation and coalescence and inhibits creaming-induced destabilization (Tadesse et al., 2007) (Wyasu & Okereke, 2012). It can also be used to clarify alcoholic beverages, such as high-quality wines (Anon., 2013).

Structure of gum arabic

Acacia gum is made up of a polyelectrolyte combination that contains calcium, magnesium, and potassium salts. This hybrid polyelectrolyte combines protein and carbohydrate subunits. It is made up of six carbohydrate moieties (galactopyranose, arabinopyranose, arabinofuranose, rhamnopyranose, glucopyranosyl uronic acid, and 4-O methyl glucopyranosyl uronic acid) and has a minor amount of protein (Figure 2).

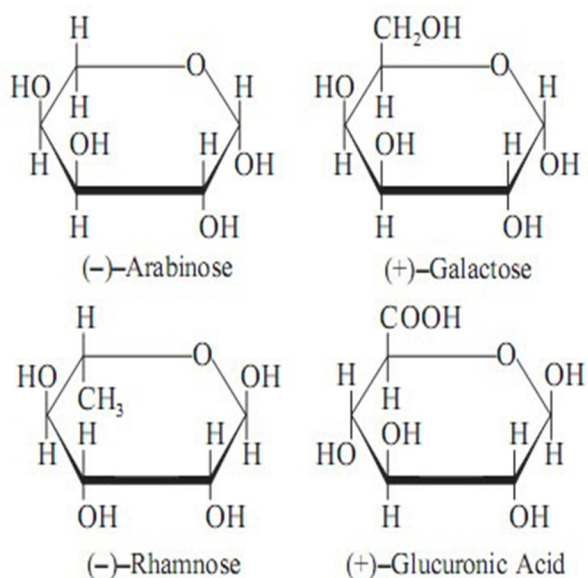


Figure 2: Structure of some sugars in gum Arabic

The primary chain consists of 1,3-linked β -D-glucopyranosyl units. These 1,3-linked β -D-glucopyranosyl units consist of side chains connected to the main chain via 1,6-linkages. Both the main chain and side chains contain units of the carbohydrates moieties discussed previously, with the uronic acid moieties being predominantly end units (Islam et al., 1997; Yadav et al., 2006; Caslettani et al., 2010; Nakauma, 2008; Atgie, 2018). Gum Arabic is made up of 39 to 42% galactose

units, 24 to 27% arabinose units, 12 to 16% rhamnose units, 15 to 16% glucuronic acid units, 1.5 to 2.4% protein moieties, and 12 to 16 moisture (Atgie, 2018). These percentages differ from gums in terms of acacia tree age and location (Willims and Phillips, 2000; Mariana et al., 2012).

Chemical structure

Gum Arabic is a complex mixture of macromolecules of varying sizes and compositions, with a high carbohydrate content (97%) and a low protein content (Islam et al., 1997). The most recent study was undertaken by Daoub, Elmubarak, Misran, Hassan, and Osman (2016). Chemical differences between numerous acacia gums (*A. senegal* var *senegal* (ASG), *A. mellifera* (AMF), *A. seyal* var *seyal* (ASY), and *A. tortilis* var *raddiana* (ATR)) were discovered, with (ATR) having a high amount of nitrogen and, consequently, protein levels and (ASY) having the lowest level (Figure 3).

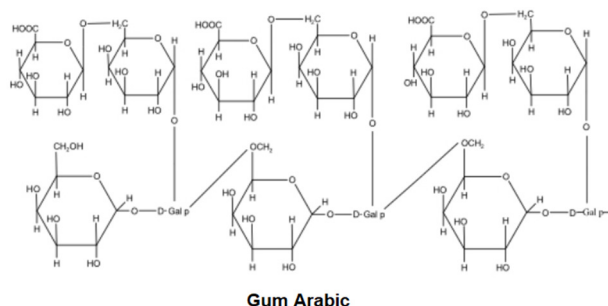


Figure 3: Chemical structure of gum Arabic

MATERIALS AND METHODS

Acacia gum (*tortilis* var *radiana*) provided by prof Mohamed Elmubark was collected from Sherg Al Nile Khartoum North, Amberlite resin IR 120H⁺ (a strong cation exchange resin) was provided by prof Elfatih, magnesium bicarbonate was obtained from Dr Gurashi, deionized water was used throughout this work.

Sample pretreatment

Dry samples were hand cleaned to remove sand, dust, and bark contaminants, then pulverised with pestle and mortar and stored in labelled (polyethylene) bags.

Preparation of Glucuronic acid

Ion exchange chromatography was used to manufacture glucuronic acid. A class column containing amberlite resin IR 120H⁺ (a strong cation exchange resin). 0.2 M sulphuric acid was run through the column several times

Table 1: Physicochemical properties of gum sample.

Moisture(%)	Ash(%)	pH	Specific optical rotation	Colour	Viscosity Cp
9.92	2.63	4.3	+79	9.1	58

Analysis of sample was carried out in triplicate and then averaged.

Table 2: Physicochemical properties of magnesium glucuronate.

Moisture(%)	Ash(%)	pH	Specific optical rotation	Viscosity Cp
10.3	1.85	6.41	+44	16.25

Table 3: Minerals content (mg/l) of gum sample and magnesium glucuronate.

Element	Na	Mg	Ca	V	Fe	Ni	Cu	As	Al	Pb
Acacia tortilis	711.45	4.49	15.7	1.79	2.56	1.98	0.64	4.08	2.29	4.38
Magnesium glucuronate	5.49	17.19	71.89	1.59	1.45	1.79	0.44	3.84	1.49	3.93

before being rinsed with deionized water until no white precipitate of BaSO₄ appeared after adding Barium chloride. After weighing and dissolving 27.48g of sample in 500ml of deionized water, the solution was slowly passed through the column to replace its cations with hydrogen bonded to the resin, and the acidity of the resulting eluate was measured. The eluate was Arabic acid.

Preparation of magnesium glucuronate

18.5g of magnesium bicarbonate were weighed and put to 200ml of glucuronic acid solution in a beaker, which was then agitated until bubbles formed. The precipitate was collected, placed to a Petri dish, and allowed to dry for three days at room temperature before being pulverized to powder.

Physicochemical properties of gum and magnesium glucuronate

Moisture, ash, viscosity, pH, and specific optical rotation were determined for a gum sample and magnesium glucuronate using the AOAC, 1990 method.

Colour test

After preparing a 25% gum solution, the device was turned on and the solution was placed in a sample cell. The cell was then inserted, and the light that was transmitted through the sample was compared to that transmitted through a series of glass colours in primer colours red, blue, and yellow. The slide was adjusted until a visual colour match was found for the light from the sample, and the colour was expressed in lovibond RYBN colour units.

RESULTS AND DISCUSSION

Physicochemical properties of gum sample

The study examines the physicochemical features of acacia gum (*tortilis* var *radiana*) (Table 1), as well as analytical data from the sample under consideration. The physicochemical parameters of acacia gum are consistent with those described by Karamella et al. (1998), FAO (1999), Al-Assaf et al. (2005), Hassan et al. (2005), Elmanan et al. (2008), Abdelrahman (2011), and Daoub et al. (2016).

Acacia *tortilis* var *radiana* displayed positive optical rotation of polarized light, as reported by Daoub et al. (2016). Karamella et al. (1998) found that the presence of free carboxyl groups of D-glucuronic acid and 4-O-methyl D-glucuronic acid residues resulted in a slightly acidic pH value.

The acidity value of the eluate produced by ion exchange is 2.4, which is higher than the acidity of the sample due to the exchange of cations by hydrogen and the formation of additional glucuronic acid. The physicochemical parameters of magnesium glucuronate (Table 2) revealed positive optical rotation and a pH value of semi neutral due to the synthesis of gluconate magnesium salt from glucuronic acid. The analysis of the mineral composition of the gum sample and magnesium glucuronate as shown in (Table 3) indicates that the primary cations present are Na, Mg, and Ca, at concentrations of 711.45, 4.49, and 15.17 mg/l, respectively. It is noteworthy that all mineral values in magnesium glucuronate were found to be lower than those in the gum sample, with the exception of Mg and Ca, which showed an increase. This discrepancy may be attributed to the utilization of ion-exchange chromatography during the preparation of glucuronic acid in the preceding stage of magnesium gluconate production.

Conclusion

The results obtained strongly support the suggestion that the binding of free carboxylic groups with metal ions leads to a decrease in acidity. The decrease in cation values observed when increasing magnesium and calcium levels may be attributed to the use of ion-exchange, possibly related to the presence of magnesium bicarbonate salt.

REFERENCES

- Adiotomre, J., Eastweed, M. A., Edward, C. A. & Brydon, W. G., (1990). Dierty fiber.
- Ahmed, A. H., (2007). Fractionation , physicochemical and functional properties of acacia polyacantha.
- Ali, A. A., Ali, K. E., Fadlalla, A. & Khalid, K. E., (2008). The effect of GA oral treatment on the metabolic profile of chronic renal failure patient under regular haemodialysis in central sudan.
- Ali, B. H. & AL Moundhri, M. S., 2006. Agent ameliorating or augmenting the nephrotoxicity of cisplatin and other platinum compound.
- Ali. A, Rokiah. H, Sabar. B, Sivamany. K, and Ehsan. T (2004), Fabrication and characterization of gum Arabic bonded Rhizophora suparticle boards, *Material and Design*, 60:108-115.
- Anderson, D. M., Whowleet, J. F. & MC Nab, G. A., (1985). The amino acid composition of the proteinacaus component of gum arabic A. senegal.
- Anon., (2013). Gum Arabic in sudan. s.l.:s.n.
- Atgie, M.M. (2004). Composition and structure of gum Arabic in solution and at oil-water interface, *food hydrocolloids*, Elsevier. 91:319-330.
- Benjamin, P. S. & Laterite, G., (1970). Spacific relationship between the optical rotation and carbohydrate composition.
- Caslettani, O, Al-Asaaf. S, Axelos. M, Phillips. G.O and Anton. M,(2010). Hydrocolloids with emulsifying capacity, part1 – emuss.
- Christian. S, Denis. R, Paul. R, Christophe. S, and Jacques. L, (2001) structure and rheological properties of acacia gum dispersion.Elsevier, *food hydrocolloids*, 16:257-267.
- CNI, (2005). Carbohydrate Polymer. CNI.
- Daoub. R, M. Elmubarak, A. H. Misran, M. Hassan.E. A and Osman. M. E,(2016). Characterization and functional properties of some natural acacia gums, *journal of Saudi Society of Agricultural sciences*.
- Dickinson, E., (1988). Emulsifying behaviour of gum arabic.
- Elamin. H.M. (1981), *Trees and Shrubs of the Sudan*, khatroum.
- Elmanan, M., Al-Assaf, S., Phillips, G. O. & Williams, P. A., (2008). Studies on Acacia exudate gums.
- Elmanan. M, Al-Assaf. S, Phillips G. O and Williams. P. A, (2008), Studies on acacia exudate gums, part VI, interfacial heologe of acacia sengal and acacia seyal. *Food hydrocolloids*, 22(4), 682-689.
- Eugene, S. S. & Banlacorek, S., (1987). A simiemirical Theory of the optical activity of saccharides.
- Evans, A. J., Hood, R. L., Oaken, F. D. G. & Sidhu, G. S., (1992). Relationship between structure and function of dietary fiber.
- FAO (1999). Compendium of food additive specifications, s.l.: s.n.
- Fatima, O. S., (2016). Preparation and Characterization of Glucuronic Acid and Magnesium Glucuronate from Acacia Senegal var Senegal.
- Fatima, O.S (2016), preparation and characterization of glucuronic acid and magnesium glucuronate from acacia Senegal var Senegal.
- Gammon, D., Churm, S. & Stephen, A., (1968). Arabino Glactan Protein Components of Acacia tortilis Gum Carbohydrate.
- Gammon, D., Churm, S., and Stephen, A.(1968). Arabino Glactan Protein components of of acacia tortilis gum Carbohydrate. *Res*. 151:135-146.
- Glover, D. A., Ushida, K., Phillips, A. O. & Riley, S. G., (2009). Acacia sengal SUPERGUMMT.
- Hassan, H. M, Abdelkareem, A. A, and Taha, H. M. (2018). Chemistry, Biological, and Pharmacological properties of gum Arabic.
- Hinson, J. A., Reid, A. B., Mc Cullough, S. S. & James, L. P., (2004). Acetaminophen-induced hepatotoxicity.
- Ibrahim, B. G. (2016). An Investigation of the Molecular Structure, Composition and Biophysical Properties. PhD thesis, University of wolverhampton.
- Ibrahim, M. Kamal, F. and Loutfi, I. (2017). Adendrological key for Identification of acacia species growing in Saudi Arabia and Northern Sudan.
- Idris, O. H., (1989). Physicochemical and microbiology and characterization of ACacia Senegal willed gum.
- Jamal, A. I., Malik, A. A., and Mohammed, E. O., (2014). Physicochemical Characteristics if the Albiziz Amara gum. SUST, ARPN.
- Kanakdande, D., Bhosale, R. & Singhal, R. S., (2005). Cheracterization of starch and gum Arabic-maltodextrin.
- Karamalla, K. A. (1965). Analytical and structural studies in poly saccharide group. PhD. Thesis University of Edinburgh.
- Karamalla, K. A., (1965). Analytical and structural studies in poly saccharide group.
- Kauther, S. A., and Hussien, M. D. (2018). Physicochemical and Functional Properties of the Gum Arabic from Acacia Senegal. *Annal. Food Science and technology*. Khartoum Sudan.
- Lelon, J. K., Jumber, I. O., Keter, J. K., Chemuku, W., and Odour, F. D.(2010). Assessment of physical properties of gum Arabic from Acacia Senegal varieties in Boringo District, Kenya. *African journal of plant science*, 4(4) 95-98.
- Mariana, A. M., Maria, L. B., Lorena, V. & Claudio, D. B., (2012). Gum Arabic : More than an Edible Emulsifier.
- Matsumoto, N. et al., (2006). Butyrate modulates TGF-beta1 generation and function : potential renal benefit for Acacia (sen) super gum (GA).
- Nakauma, M.(2008). Comparison of sugar beet pectin soy been soluble polysaccharide and gum arabic as food emulsifiers.
- Nep, E. I. & Conway, B. R., (2010). Characterization of Grewia Gum , a potential Pharmaceutical Excipient.
- Omer, E. A. (2004). Characterization and Analysis studies of a Polycantha gum. Ph.D Thesis SUST, Khartoum Sudan.
- Omer, E. A., (2004). Characterization and analysis studies of A polycantha Gum.
- Samar, A. A. (n.d). preparation and Characterization of Physicochemical and Functional Properties of potassium Glucuronate from Acacia Senegal var Senegal gum. Msc thesis Sudan university of science and technology.
- Somsubhra, G., V.Laxmi,P., Sowjanya, B., Srivani, P., Alagaraja, M., and Dr. Dived, B. (2013). Inductive Coupled Plasma-Optical Emission Spectroscopy. *Asian J. Pharma*.
- Tadesse, W., Desalegn, G. & Alia, R., (2007). Natural gum and resin bearing species of Ethiopia and thair potential application.
- Trommer, H. & Neubert, R. H., (2005). The examination of polysaccharides as potential antioxidative compounds for topical adminisrtation using a lipid model system.
- Verbeken, D., Dierckx, S. & Dewettinck, K., 2003. Exudeate gum : occurrence , production and application.
- Wapnir, R. A. et al., (2008). Modulation of rat intestinal nuclear factor NF-kappa B by gum arabic.
- Willims and Phillips. (2000). Characterization and functional Properties of son natural Acacia Gums. *Hand Book of hydrocolloids*.
- Wyasu, G. & Okereke, N. Z., (2012). Improving the film formation ability of gum arabic.
- Yadav, P., Kant, R. & Kothiyal, P., (2013). A review on Acacia Tortilis.
- Zatz, J. L. & Kushla, G. P., (1989). Pharmaceutical dosage forms.