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WORLD ASSOCIATION FOR SUSTAINABLE DEVELOPMENT

INTERNATIONAL JOURNAL OF GUM ARABIC (IJGA)

IJGA V1 N1/2 2025

DOI: 10.47556/J.IJGA.1.1-2.2025.5

OPEN ACCESS

IJGA ISSN
2634-2642 (Print)
2634-2650 (Online)

RESEARCH

Gum Arabic as an Organic, Prebiotic and Dietary Fibre Material

Dr Mohamed Elmustafa Osman Elsayed
University of Kordofan
Email: mustafa2274@googlemail.com
ORCID: 0009-0009-8689-4431

Dr Naglaa Abdelbasit Suliman
University of Kordofan
Email: nglaasuliman353@gmail.com
ORCID: 0009-0004-9112-5657

ABSTRACT

PURPOSE: This paper reviews organic, prebiotic and dietary fibre (DF) properties of gum arabic (GA) and highlights its major applications.

DESIGN/METHODOLOGY/APPROACH: A conceptual literature review was conducted, examining scientific publications, food standards, pharmacopoeia references and Sudanese GA sector strategies.

FINDINGS: GA has prebiotic effects through fermentation by beneficial gut microbiota, classified as a soluble DF and considered as organic material.

RESEARCH LIMITATIONS/IMPLICATIONS: More research, laboratory, clinical and industrial trials are needed to optimise GA's uses and quantify health impacts.

CITATION: Elsayed, M.E.O. and Suliman, N.A. (2025): Gum Arabic as an Organic, Prebiotic and Dietary Fibre Material. *International Journal of Gum Arabic (IJGA),* Vol. 1, No. 1/2, pp.57-73.

RECEIVED: 9 September 2025 / **REVISED:** 10 September 2025 / **ACCEPTED:** 15 September 2025 / **PUBLISHED:** 16 September 2025

PRACTICAL IMPLICATIONS: Consistent with SDGs 1, 2, 3, 9, 17. These findings support the development of functional foods and pharmaceutical formulations incorporating GA as an organic, prebiotic and DF material.

POLICY IMPLICATIONS: Sudan's sector strategies should prioritise research and development (R&D) for health claims, organic certification systems, national nutrition integration, sustainable harvesting and investment in local value addition industries.

KEYWORDS: *Gum Arabic; Organic; Prebiotic; Dietary Fibre; Health Benefits; Sudan Policy*

INTRODUCTION

Gum arabic (GA) is a dried exudate from Acacia senegal (L.) Willdenow and Acacia seyal Delile as defined by the FAO/WHO Joint Expert Committee for Food Additives (JECFA): Sudan is the leading producer and exporter of GA in the world. GA possesses a unique biochemical structure and properties that make its use in many applications a priority. It is biocompatible, biodegradable and its source is renewable. People worldwide are again seeing the necessity of using natural additives in products for human consumption due to severe adverse effects of synthetic additives. Such a shift in the human mindset has created additional demand for natural products such as GA (Prasad *et al.*, 2022). Recent advances highlight GA's organic, prebiotic and DF properties (Calame *et al.*, 2008; Phillips and Williams, 2000).

GA is a strategic export commodity for Sudan (Ali *et al.*, 2009). For centuries, GA has been traded as one of the most valuable non-timber forest products, with Sudan historically contributing between 50-80% of the world's supply.

Given its superior properties, natural origin and safety record, GA finds commercially valuable applications in many industries. In this context, GA could play a critical role in efforts to achieve the SDGs set forth in the 2030 Agenda for Sustainable Development (UNCTAD, 2018).

PROBLEM STATEMENT

Despite its potentials, the utilisation of GA as a recognised organic, prebiotic and DF remains under-developed in both scientific and industrial frameworks. The literature is rich in studies on its physicochemical properties and industrial applications, but fewer works have systematically linked its chemical functionality to health outcomes, especially in human clinical settings.

RESEARCH QUESTION

What are the organic, prebiotic and DF properties of GA, and how can these be leveraged for food and pharmaceutical applications alongside effective policy interventions to enhance Sudan's sector?

METHODOLOGY

A conceptual literature review was conducted, analysing:

1. GA's chemical composition, functional, and physiological properties;
2. Sudan's sector strategies and policy frameworks.

RESULTS AND DISCUSSION

Chemical Composition and Functional Properties

The chemical composition of GA is a mix of complex polysaccharides, oligosaccharides, glycoproteins, arabinogalactans, and monosaccharides such as galactose (389g/kg), rhamnose (95g/kg), and arabinose (257g/kg), as well as an organic acid, mainly glucuronic acid (215g/kg) (Gashua *et al.*, 2015). There are also the amino acids hydroxyproline, serine, threonine, proline, leucine and histidine (Babiker *et al.*, 2017a), traces of phytoconstituents, e.g., flavonoids, saponins, polyphenolic tannins, others and salts of Arabic acid with calcium (Ca), magnesium (Mg), and phosphorous (P) (Ashour *et al.*, 2022). GA is a valuable source of four antioxidant minerals, copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn) (Farman *et al.*, 2020). GA is safe, odourless, tasteless, lowest in viscosity, and stable in acid solutions (Dashtdar and Kardi, 2018).

Table 1: Chemical Composition of GA

Component	*A. senegal (%)*	*A. seyal (%)*
Total polysaccharides	85-90	88-95
Arabinogalactan-protein complex	10-14	7-10
Ash	2-4	1.5-3
Moisture	10-12	12-15
Protein	2-3	1-2

Source: Randall *et al.*, 1988; Ali *et al.*, 2009; Phillips and Williams, 2000

Organic and Halal Certification

GA is classified as an organic material when it is harvested sustainably, without synthetic chemicals or pesticides, and processed minimally. Its natural origin, biodegradability and chemical-free extraction make it suitable for use in organic-certified food, a binder for seed coating, as a carrier for microbial inoculants, and cosmetic products (Ali *et al.*, 2009). Therefore, harvesting without synthetic chemicals qualifies GA for organic certification (USDA, 2020).

On 1 April 2024, the Islamic Food and Nutrition Council of America (IFANCA) certified that GA is in compliance with the halal requirements under Islamic laws (Document #: 1341.17070. II240031; Halal ID: D25370; Product certificate: HC-23INSB62) (IFANCA, 2024). As a plant derived ingredient, GA is generally recognised as halal. We will still audit another two key points to make sure that our GA is 100% halal: are there any pig products used in the manufacturing process of this ingredient? Does the ingredient contain alcohol (impure) or other haram ingredients? The manufacturing process of GA is pig-free; the raw materials (or culture medium) are Acacia senegal and no other haram ingredients will be used in the manufacturing process of GA. As a top food ingredients supplier, Foodchem has been supplying halal certified GA to customers all over the world for many years (Foodchem, 2025).

PREBIOTIC EFFECTS

GA, traditionally a food ingredient, exhibits potential as a health-promoting prebiotic in the human gut. Prebiotics, distinct from probiotics, are DFs selectively fermented by beneficial gut bacteria, enhancing their growth and activity (Vu *et al.*, 2023). As a result, short-chain fatty acids (SCFAs) are produced in the large intestine instead of being digested in the small intestine. A combination of these SCFAs improves gut barrier function, reduces inflammation, and improves immune response (Li *et al.*, 2023). Beneficial gut bacteria such as Bifidobacterium and Lactobacillus are encouraged, and harmful bacteria such as clostridium are inhibited (Calame *et al.*, 2008). As a prebiotic, GA has potential applications and challenges in various sectors, including food, beverage, pharmaceuticals, and nutraceuticals, as well as solutions to these challenges (Talib *et al.*, 2018). Since GA does not break down in the large intestine, it is a non-digestible carbohydrate or fibre (Bejeshk, 2022). It ferments slowly into SCFAs, particularly propionic acid, by intestinal bacteria. GA, a DF with a bifidogenic effect, increases the proportion of lactic acid bacteria and bifidobacteria in healthy subjects (Yousefi *et al.*, 2023). Acacia gum has shown prebiotic potential at a 10g/day dose (Cherbut *et al.*, 2003). Studies have investigated the fermentability of Acacia senegal, identifying Prevotella ruminicola as a predominant bacterium in the fermentation process (Phillips and Phillips, 2011). By providing energy for intestinal bacteria to uptake ammonia as a nitrogen source, this bacterium, an ordinary member of the human intestinal microbiota, suggests that GA can reduce luminal ammonia concentrations in large intestine. This may benefit patients with renal and hepatic diseases (Abd Aziz, 2020).

GA is used as a natural prebiotic, due to its resistance to digestion. GA is fermented by the anaerobic microbiota to short-chain fatty acids (SCFs) that have an important role in maintaining homeostasis, structure, and function in the gastrointestinal tract (GIT). They also control the whole luminal microbial ecology and inhibition of pathogenic where cecum harbour the most microbiota in the GIT; the fermentation is mainly done at this part. GA is a natural supplement that plays an important role in intestinal and liver metabolism and has other potential health benefits.

GA holds excellent promise as a natural prebiotic, potentially offering numerous health benefits. Further research is required to comprehensively understand its prebiotic mechanisms and optimise its applications across various industries. GA could be essential in promoting gut health and preventing disease as we continue to learn more about the human gut microbiome (Elnour *et al.*, 2023).

DIETARY FIBRE ASPECTS

The term "dietary fibre" was first introduced in 1950s, referring to plant cell wall materials; it was later used to describe a class of plant-originated polysaccharides that cannot be digested and absorbed in the gastrointestinal tract (van der Kamp *et al.*, 2004). Dietary fibre is the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine, with complete or partial fermentation in the large intestine (AACC, 2001).

Table 2: Conventional Classification of DF

	Chemical constituents from plant cell walls	*Major physiological effects and mechanisms*
Soluble fibre	Non-cellulosic polysaccharides, oligosaccharides, pectins, β-glucans, gums	Delay gastric emptying, regulate blood glucose levels, lower serum cholesterol levels, due mainly to its effects of increasing viscosity of gut content and colonic fermentation
Insoluble fibre	Cellulose, hemicellulose, lignin	Shorten bowel transit time, improve laxation due to its bulking capacity; support growth of intestinal microflora (esp. probiotic species) due to its fermentation in large intestine

Source: Cho and Dreher, 2001; Chawla and Patil, 2010; Dai and Chau, 2016

GA is classified as soluble DF for its indigestibility and physiological benefits (CAC, 2009). It has been considered as a safe additive since the 1970s, approved by the US Food and Drug Administration (FDA) and the Joint FAO/WHO Expert Committee on Food Additives (JECFA) (Cox *et al.*, 2021). GA is a natural DF, considered as the best of all soluble fibres and a direct additive to liquid foods (Satti *et al.*, 2020). The soluble DF content is 85-90% (Dashtdar and Kardi, 2018).

DFs can be categorised into three groups: insoluble DF, soluble DF and resistant starch. Soluble DF has been widely used as thickener, emulsifier, stabiliser, fat replacer, suspending and gelling agents, etc., in food and the pharmaceutical industry. DFs are becoming one of the most important food ingredients for their irreplaceable roles of techno-functional as well as biofunctional purposes in food products (Delcour and Poutanen, 2013). Acacia fibre is a non-viscous, fermentable DF that is obtained from the branches of Acacia senegal and Acacia seyal trees as a water-soluble exudate (Al-Jubori *et al.*, 2023). Acacia fibre is non-digestible in the human body but fermentable by the large intestine's microbiota, consequently modulating resident taxa, specifically bifidobacteria and lactobacilli and producing short-chain fatty acids (SCFAs) (Calame *et al.*, 2008). Acacia fibre is among the oldest and most well-known natural gums, with its usage dating back 5,000 years (Patel and Goyal, 2015).

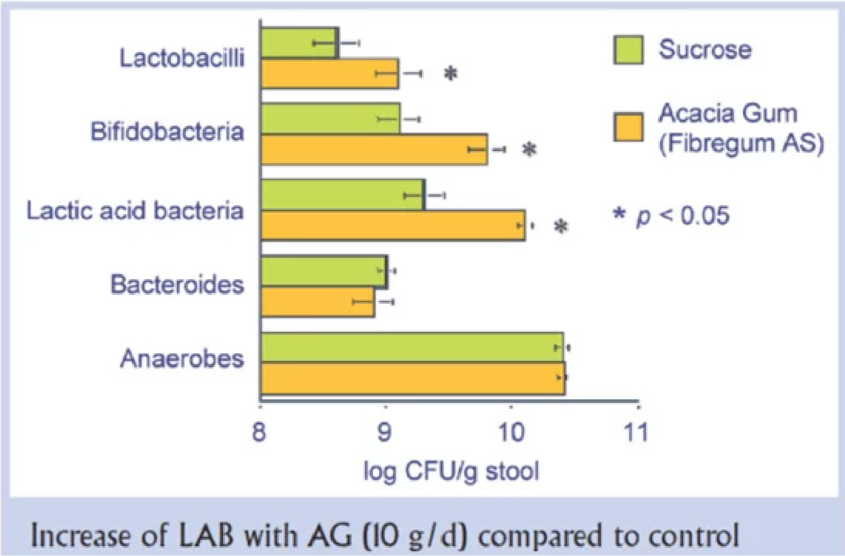

Figure 1: Sucrose and GA as Feed for Bacteria

Source: https://www.nexira.com/wp-content/uploads/2020/12/increase-of-lab-with-ag.png

Sperber *et al.* (2021) found that across 33 countries on 6 continents, more than 40% of persons worldwide suffer with Functional Gastrointestinal Disorders (FGIDs), such as Irritable Bowel Syndrome (IBS); these dramatically affect their quality of life and healthcare use. Across Europe, consumer spending on over-the-counter medicines (OTC) and supplements is considerable. Diets and supplements have crucial roles in managing these disorders and brands can play a part.

Acacia fibre is commonly found in powder form, with prebiotic efficacy demonstrated at 10g/day (Calame *et al.*, 2008; Cherbut *et al.*, 2003). Most published studies report a daily dose of acacia fibre between 5g and 30g used for up to 3 months with no safety or tolerability concerns (Al-Jubori *et al.*, 2023; Cherbut *et al.*, 2003; Larson *et al.*, 2021). With thousands of years of traditional use and over 15 years of research into its prebiotic potential, acacia fibre has demonstrated various health benefits (Table 3).

Table 3: Health Benefits and Mechanisms of GA as a Prebiotic DF

Health Benefit	*Mechanism of Action*	*Source*
Gut microbiota modulation	Fermentation by *Bifidobacteria* and *Lactobacilli* producing SCFAs that improve gut health	Calame *et al.* (2008)
Improved bowel function	Increases stool bulk and moisture due to its soluble fibre nature, aiding regularity	CAC (2009)
Cholesterol reduction	Binds bile acids in intestine, increasing excretion and reducing serum cholesterol levels	Ali *et al.* (2009)
Glycaemic control	Slows gastric emptying and reduces postprandial glucose absorption	Babiker *et al.* (2017b)
Enhanced mineral absorption	SCFAs production enhances solubility and absorption of Ca, Mg, and Zn	Phillips and Williams (2000)
Anti-inflammatory properties	SCFAs and bioactive components reduce gut and systemic inflammation	Calame *et al.* (2008); Ali *et al.* (2009)
Potential weight management	Increases satiety and reduces calorie intake due to fibre's bulking effect	Calame *et al.* (2011)
Heart health	Improving cardiovascular and metabolic syndrome risk factors, including high blood pressure, high blood glucose and dyslipidemia	Mohamed *et al.* (2015); Jarrar *et al.* (2021); Larson *et al.* (2021); Al-Jubori *et al.* (2023)
Malnutrition control	Managing malnutrition in children aged 6-59 months	Omer and Hilali, (2016)
Dental health	Improving plaque and gingivitis	Gafar *et al.* (2022).
Treatment of sickle cell anaemia	Exhibiting anti-inflammatory effects in sickle cell anaemia	Kaddam and Kaddam, (2020); Al-Jubori *et al.* (2023)
Protective effect and enzyme reduction	Conferring hepatic and renal protective effects, including uric acid and liver enzyme reduction	Hasheim *et al.* (2021); Kamal *et al.* (2021); Al-Jubori *et al.* (2023)

Source: Given in table

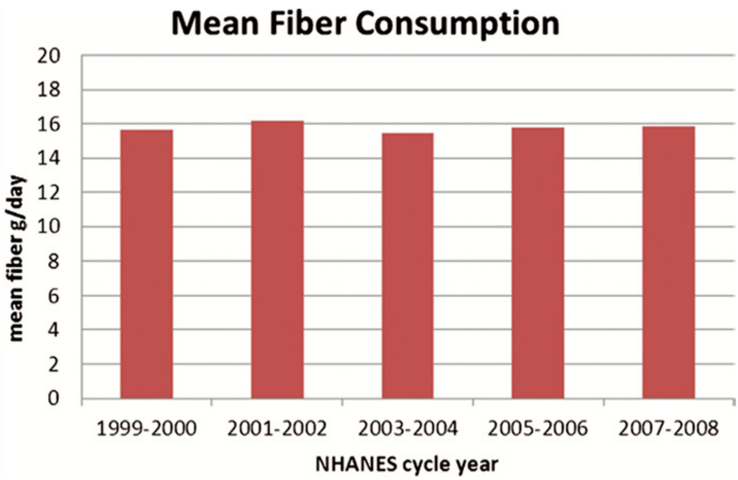

Figure 2: Mean Fibre Consumption in the US (1999-2008)

Source: King *et al.*, 2012

Health effects of dietary fibre

Health benefits of DF have been well documented in literature over the past two decades. Diets, deficient in DF, lead to a number of diseases, i.e., constipation, hiatus hernia, appendicitis, diabetes, obesity, coronary heart diseases, gallstones, etc. (Sudha *et al.*, 2012). Consumption of adequate amounts of DF reduces risk of the above-mentioned diseases (Dahl and Stewart, 2015); specifically, studies have shown that individuals with an adequate intake of DF appear to be at lower risk for developing stroke (Zhang *et al.*, 2013), colorectal cancer (WCRF/AICR, 2011), cardiovascular diseases (Threapleton *et al.*, 2013), and type-2 diabetes (Yao *et al.*, 2014). Increased intake of DF is also associated with lower blood pressure and lower serum cholesterol levels (Brown *et al.*, 1999). In addition, an adequate intake of fibre is suggested to aid in weight loss or prevent weight gain, mainly through satiety or fullness regulation (Li *et al.*, 2014), and appears to improve immune function through gut health and fibre-microbiota interactions (Dong *et al.*, 2016). In children, increased fibre intake has been found to be associated with lower risk of being overweight or obese (Quick *et al.*, 2013). Fermentation by gut microbiota produces SCFAs beneficial to gut health (Calame *et al.*, 2008).

FDA Grants Citizen Petition on Acacia (GA) as a DF

In the 1970s, the US Food and Drug Administration (FDA) labelled acacia fibre as Generally Recognised as Safe (GRAS) and more recently as DF (FDA, 2021). The FDA later reported that:

> "based on our consideration of scientific evidence and other information submitted with the petition, and other pertinent scientific evidence and information; we conclude that strength of the evidence shows that gum acacia has a physiological effect that is beneficial to human health. Therefore, in accordance with 21 CFR § 10.30(e) (3), we are granting your request and will propose to amend the list of non-digestible carbohydrates that meet the definition of DF to include "acacia (GA)." We intend to exercise enforcement discretion for declaring "acacia (GA)" in the amount of DF declared on Nutrition and Supplement Facts labels until we can complete a rulemaking to amend 21 CFR § 01.9(c)(6)(i) to include additional DFs in the list of non-digestible carbohydrates that meet our definition of DF" (FDA, 2021).

EFSA OPINION ON ACACIA FIBRE

The European Food Safety Authority (EFSA) released an opinion letter on acacia fibre's safe use as a feed and food additive for animals and humans, respectively, including its use in food for infants below 16 weeks of age (Younes *et al.*, 2019; Bampidis *et al.*, 2022).

GLOBAL FIBRE MARKET

The global acacia fibre market was recorded at a compound annual growth rate (CAGR) of 5.9% from 2016-2021, reaching almost US$900 million in 2022; it is expected to grow at a rate of 7.2% CAGR within 2022-2023 to reach US$1.797 billion (Future Market Insights, 2022).

APPLICATIONS IN FOOD AND PHARMACEUTICALS

GA is a natural polysaccharide extensively employed as a food additive (Le Van *et al.*, 2023). GA applications are wide and versatile, spanning the food, pharmaceutical, cosmetics, paint, textile and printing industries (Patel and Goyal, 2015). In the food industry, GA is used as a carrier, stabiliser, texturiser, emulsifier and binder, demulcent and thickener in various food formulations, including ice creams, jellies, candies, soft drinks, beverages, syrups, and chewing gums to increase their fibre content (Patel and Goyal, 2015; Larson *et al.*, 2021).

In baked goods, GA is used to regulate the moisture content for its water regulation properties, helping with the preservation of these products and extending their shelf-life (Ashour *et al.*, 2022). In the pharmaceutical and cosmetic industries, it is used to coat pills and lozenges and formulate creams and lotions, respectively. Due to its binding properties, it is used in lithography, printing, and watercolour paints (Patel and Goyal, 2015). Lastly, acacia fibre is showing promise in nanotechnology and nanoformulation-based drug delivery (Al-Jubori *et al.*, 2023).

Types and Grades of GA

As shown in Table 4, conventionally, the raw GA is graded into different size. Moreover, it is processed mechanically into kibbled gum (small particles) or mechanical powder (by milling) and spray-dried into microbiologically stable, food-grade powder. These specifications are shown in Table 5.

Table 4: General Specifications of GA Grades

Hashab *(Acacia senegal)*		**Talha** *(Acacia seyal)*	
Grade	*Size (mm)*	*Grade*	*Size (mm)*
Hand Picked Selected	16 and above	-	-
Cleaned and Sifted	5-16	Cleaned	4 and above
Granules	0.5-5	Sifting	0.5-4
Dust	0.5	Dust	0-0.5

Source: https://bayrony.com/product-enquiry/products/gum-arabic/

Table 5: Specifications of Raw, Powder and Spray Dried Acacia Gum

Property	*Raw*	*Powder*	*Spray dried*
Appearance	Off-white to yellowish granular or powder	White to off-white powder	White to off-white powder
Odour	Own inherent smell, no odor		
Viscosity	60-100	60-100	60-100
pH	3.5-6.5	3.5-6.5	3.5-6.5
Moisture	15% Max	≤10%	≤10%
Total ash	4% Max	≤4%	≤4%
Acid insoluble ash	0.5% Max	≤0.5%	≤0.5%
Acid insoluble matter	-	≤1%	≤1%
Solubility	Soluble in water, insoluble in ethanol		
Nitrogen	0.24-0.41%	0.24-0.41%	0.24-0.41%
Starch or dextrin	Negative		
Tannin	Negative		
Arsenic (As)	3 ppm Max	≤2 mg/kg	≤2 mg/kg
Lead (Pb)	10 ppm Max	≤3 mg/kg	≤3 mg/kg
Mercury (Hg)	-	≤1 mg/kg	-
Cadmium (Cd)	-	≤1 mg/kg	-
Heavy Metals	40 ppm Max	≤20 mg/kg	≤20 mg/kg
E. coli/5g	Negative		
Salmonella/10g	Negative		
Total Plate Count	1000 cfu/g Max	≤5000 cfu/g	≤5000 cfu/g

Source: https://www.foodchemadditives.com/halal/1554#sthash.Fb7g3MR1.dpuf

Policy Strategies, Targets and Responsible Institutions for GA Sector

As shown in Table 6, the paper suggests some policy strategies, targets and responsible institutions for Sudan's GA sector. This may lead to the improvement and development of all actors and stakeholders of the GA sectors, especially the producers.

Table 6: Policy Strategies, Targets and Responsible Institutions for GA Sector

Strategy	*Specific Target*	*Responsible Institution(s)*
Research and Development (R&D)	Validate health claims and develop functional products	ARC; Universities
Organic certification facilitation	Increase certified GA exports by 30% within 5 years	Ministry of Trade; SSMO

Strategy	*Specific Target*	*Responsible Institution(s)*
Nutrition policy integration	Include GA as recognised DF in national guidelines	Ministry of Health; National Nutrition Programme
Sustainable harvesting and reforestation	Increase gum belt area under managed production by 20% within 10 years	FNC; Ministry of Agriculture
Value addition and industrial investment	Establish at least 3 new gum-based processing industries	Ministry of Industry; SMEDA; Private Sector
Market development and branding	Develop Sudanese GA international branding strategy	GA Board; Ministry of Trade
Capacity building for producers	Train 10,000 producers on sustainable tapping and handling	FNC; Universities; NGOs; Producer Associations

Source: Constructed by authors

RECOMMENDATIONS

1. Conduct interdisciplinary research on health, market, and environmental impacts.
2. Establish GA research and innovation centres.
3. Facilitate international collaborations for certification and product development.
4. Promote national DF and prebiotic awareness campaigns.
5. Incentivise private sector investments in value addition and sustainable forestry.

CONCLUSIONS

GA's scientifically validated prebiotic and DF properties make it a strategic health-promoting and economic resource. Integrated research, innovation and enabling policies are essential to maximise its benefits sustainably.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge Dr Idris Musa Adam, Agricultural Research Corporation Sudan, Elobeid Research Station for his significant contributions, critical review and dedicated efforts that enriched the quality of this work.

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BIOGRAPHY

Dr Mohamed Elmustafa Osman Elsayed is an associate professor at the Department of Food Science and Technology, Faculty of Natural Resources and Environmental Studies, Kordofan University in Sudan. In 2008, he obtained his PhD in Chemistry of Plant Products from Georg-August University of Gottingen in Germany, and he holds both an MSc and a BSc from the Department of Biochemistry of Food Science, Faculty of Agriculture, University of Khartoum (1991 and 1994). Since 1994, he has taught, conducted research and consulted for various institutions in food science, biochemistry and nutrition. He worked as Deputy Director and then Director of the Institute of Gum Arabic Research & Desertification Studies (IGARDS) (2008-2014), and, since 2014, is Principal of the College of Developmental and Technological Studies.

Dr Naglaa Abdelbasit Suliman graduated from the Faculty of Pharmacy University of Khartoum. Dr Suliman obtained her MSc and PhD in Medical Biochemistry, Faculty of Medicine, Department of Medical Biochemistry and Molecular Biology, University of Khartoum. She is currently assistant professor at the Department of Medical Biochemistry, Faculty of Medicine, University of Kordofan. She has participated in teaching, research activities and community services.