Acacia gum *Senegalia senegal*
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Acacia Gum

Senegalia senegal (syn. *Acacia senegal*, *A. verek*)
Vachellia seyal (syn. *A. seyal*)

Family: Fabaceae

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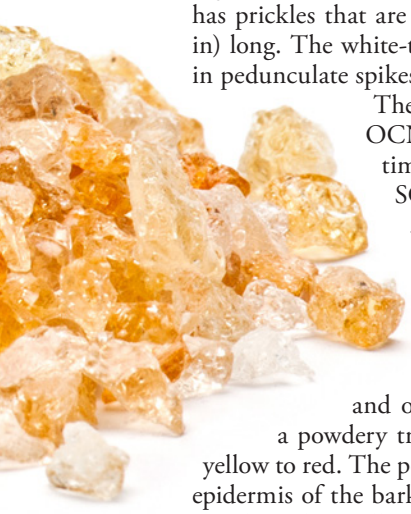
INTRODUCTION

Acacia gum, more commonly known as gum arabic, is the dried sap of various species of trees in the legume family (Fabaceae or Leguminosae), although no universally adopted definition specifies the species from which the gum must originate. The properties of this natural, edible, and polysaccharide-rich thickening agent have made it important for many applications across multiple industries, including food, beverage, cosmetic, and pharmaceutical.[1-3] For at least 4,000 to 5,000 years,[2,4] this gummy exudate has been hand-collected from the branches of various wild trees native to arid deserts or dry shrubland biome regions of North and East Africa, South Asia, and the Middle East,[5-7] but the name gum arabic is most commonly associated with two species: *Senegalia senegal* and *Vachellia seyal*.[2,8,9]

The names acacia gum and gum arabic are often used interchangeably, but the name gum arabic takes historical precedence over acacia gum and reportedly was used at an earlier date.[2,3] Gum arabic is the more widely and commonly used name referring to the gums of *S. senegal*, *V. seyal*, and other Fabaceae species.[1,2,4] Gum arabic is the preferred name in the United States[10] and is used by the United Nations and other organizations,[2] but the name acacia gum appears to be preferred in some other places, perhaps used more in the European Union (EU) than elsewhere.[8] The fact that *S. senegal* and *V. seyal* are no longer classified within the genus *Acacia*[11,12] adds to the confusion from referring to the gummy exudate of either species as acacia gum, and this perhaps lends credence to the use of the more widely adopted term gum arabic. The American Botanical Council's HerbMedPro database lists both gum arabic and gum acacia as common names,[13] and acacia gum will be used hereafter to refer to the gums of both species. When referred to as gum arabic in early and primary literature, that name will be used to maintain accuracy and preserve historical narrative.

The Standardized Common Name (SCN) for *S. senegal* is gum arabic tree according to the *American Herbal Product Association's Herbs of Commerce*, 3rd ed. (2023),[10] while the SCN for the dried gummy exudate of *S. senegal* is gum arabic. The Other Common Name (OCN) for this species is thorny acacia, and OCNs for the dried gummy exudate are acacia gum, gum acacia, and Senegal gum.[10] The Royal Botanic Gardens, Kew reports that their Survey of Economic Plants for Arid and Semi-Arid Lands database contains 196 local names for *S. senegal*. Common names include *tur*, *tulh*, *harheyr* (Jibbali), *temmar* (Dhofari Arabic), Sudan gum, *gommier*, *gomme* (French), *khor* (Punjab region), *kumta* (Rajputana region), and Somali gum.[6]

Senegalia senegal grows in thickets and stands, ecologically prefers arid semi-deserts and dry savannas, and has a native distribution across sub-Saharan Africa and from East Africa to South Africa. The species is also native across the Arabian Peninsula to India and has been introduced in Australia and elsewhere.[6] It is a shrub or tree that grows up to 12 m (40 ft) tall with bark that is gray, rough, and scaly. Botanical iden-



tity is based on several morphological characteristics including its "thorns": its stipules are not spinescent, but instead it has prickles that are very sharp and grow up to 7 mm (0.3 in) long. The white-to-cream flowers are fragrant and grow in pedunculate spikes 2–10 cm (0.8–4 in) long.[14]

The SCN for *V. seyal* is *talh*, while the OCNs for this species are red acacia, shittim wood, *talca*, and whistling tree. The SCN for the dried gummy exudate of *V. seyal* is gum talha, and the OCN is gum arabic.[10] *Vachellia seyal* has a range and distribution across sub-Saharan Africa (the Sahel) and East Africa.[7,15] It is a tree that is more or less flat-topped and grows from 3–9 m (10–30 ft) tall, and occasionally up to 12 m (40 ft),[16] with a powdery trunk that varies in color from white to yellow to red. The powdery nature of the flakes is due to the epidermis of the bark flaking off as the plant grows, revealing the red to yellow powdery inner bark. In contrast to *S. senegal*, the "thorns" of *V. seyal* are spinescent stipules that grow up to 8 cm (3 in) long.[14] *Vachellia seyal* has two subspecies, one of which is known for having stipules that swell into large galls that then become home to colonies of ants that are thought to provide protective benefits to the tree.[17] The sound of wind blowing through these large, hollow galls is thought to give rise to the common name whistling tree. The flowers are bright yellow and grow in axillary pedunculate heads 10–13 mm (0.4–0.5 in) long.[14]

While both *S. senegal* and *V. seyal* had been placed within the genus *Acacia* since the early 19th century,[18,19] a narrower taxonomic definition of the genus was proposed in 2005,[11,12] and *S. senegal* and *V. seyal* were placed in other genera. While these changes were debated for years,[20] they have been upheld and now are widely accepted based on morphology and molecular phylogenetic analyses.[21-23] *Senegalia* has widespread tropical and subtropical distribution, with 220 accepted species that range across all continents except Europe and Antarctica.[24] *Vachellia* has a similar range and distribution and contains 157 accepted species.[25]

While multiple parts of these species are used medicinally, including roots, bark, leaves, and seeds,[26,27] the gum, a dried exudate of scarified stems and branches, is the most important medicinal part and the primary item of commerce. The gum of *S. senegal* is considered to have superior properties compared with the gum of other related species (including *V. seyal*), and *S. senegal* is the primary species in international trade.[6] Prices for *S. senegal* gum are generally substantially higher than for *V. seyal* gum.[2] However, *S. senegal* gum is itself of varying quality and can be grouped into three grades.[27] The Kordofan region of Sudan is known for producing the highest quality acacia gum, and the Kordofan Hashab grade commands the highest price and is the standard against which other gums are compared.[2]

The three biggest markets for acacia gum are the EU, United States, and India.[6] In 2014–2016, it was reported that 47% of processed acacia gum was imported by European countries, 15% by the United States, and 35% by other countries.[2] The three largest producers of acacia gum are Sudan, Nigeria, and Chad,[6] with up to 80% being produced in Sudan. In the first half of 2013, Sudan's exports reportedly reached 33,000 metric tons, and the export volume was expected to increase.[28] Revenues for global exports of acacia gum were estimated at $337 million annually from 2014 to 2016.[2] Of the acacia gum harvesting and production nations reporting annual exports, in 2022, Senegal reported the most at 3,909,599 kg (estimated trade value of $20,060,095), followed by Nigeria at 3,655,230 kg ($3,332,030). Notably, Sudan and Chad did not report exports.[29] In 2022, the United States imported 12,039,420 kg of acacia gum from Sudan (valued at $36,524,000) and 3,194,710 kg from Chad (valued at $4,282,000).[30]

HISTORY AND CULTURAL SIGNIFICANCE

Use of acacia gum dates back to Ancient Egypt, where it was used as an adhesive component in paints and for the mummification of bodies.[31-33] Acacia trees were described in several important ancient traditional herbal writings. The Greek philosopher Theophrastus (ca. 371–ca. 287 BCE) described *akantha* (acacia) in his *Historia Plantarum*. The English translation, *Theophrastus: Enquiry into Plants and Minor Works on Odours and Weather Signs*, describes acacia tree uses and physical characteristics and mentions the tree's gum.[34] Greek physician, botanist, and pharmacologist Dioscorides (ca. 40–90 CE) also described acacia (as *akakia*). The English translation of his work, *De Materia Medica*[35] (original text ca. 64 CE), describes the color, aroma, and herbal applications of some of acacia's plant parts. Acacia gum is described as "astringent and cooling."[35]

Exodus 25-26 (King James Version) states that after their Exodus from Egypt, the Israelites used shittim wood to construct the Tabernacle and the Ark of the Covenant, which housed the stone tablets on which the Ten Commandments were written.[36] The shittim (or shittah) tree is historically identified as *V. seyal*; however, other related species may have been used.[37] This is one example of the sacredness ascribed to acacia, and the many unique properties of acacia gum found concomitant religious usage that continued into the Middle Ages.

The genus *Acacia* was first described in 1754 by English botanist and gardener Philip Miller (1691–1771) in his publication *The Gardeners Dictionary* (4th edition).[38] The name acacia is borrowed from the Greek word ἀκακία (or akakia), meaning "sharp," "point," or "thorn."[39] As early as 1623, Dioscorides' ἀκακία is credited as the source of the Latin word acacia, and he is credited as being the first to use akakia in reference to acacia.[40]

Senegalia senegal was first described as *Mimosa senegal* in 1753 by Swedish botanist Carl Linnaeus (1707–1778) in his work *Species Plantarum*.[41] The species was later placed in the genus *Acacia*[18] and later moved into the genus *Senegalia*.[42] The name mimosa is derived from the Greek μῖμος (or *mimos*), meaning "mime" or "actor," and the suffix *-osa*, meaning "resembling."[43] This probably refers to the leaves of

some *Mimosa* species (e.g., the "sensitive plant," *M. pudica*) that quickly roll up when touched, quietly moving on their own and thus "resembling a mime." Both the genus name *Senegalia* and epithet *senegal* refer to Senegal in West Africa, one of the first regions to supply acacia gum to Europe and a region previously known as the "gum coast."

Vachellia seyal was first described as *Acacia seyal* in 1813 in *Flore d'Egypte* by French botanist Alire Raffeneau Delile (1778–1850).[44] With the reclassification of the genus *Acacia sensu lato*, the species was then placed within the newly created genus *Vachellia*.[45] *Vachellia* is named in honor of English plant collector Reverend George Harvey Vachell (1799–1839), who collected widely in China,[12] and the epithet *seyal* is derived from the Arabic word لايس (or *sayāl*), meaning "prone to flow" or "flowing a lot."[46] The word is used in reference to the sap or gum that flows or is exuded from the stems and trunk of *V. seyal* and related species.

In the 18th century, acacia gum (gum arabic) became an important ingredient in textile printing for European linens.[47-49] As industrialization increased, so did the demand for this botanical ingredient. Export amounts doubled from the early 17th century into the 1780s due to European traders.[47] In fact, European traders made such a significant profit from gum arabic that it became a highly traded commodity, and competition between European powers for control of trade led to the "Gum Wars" of the 18th century.[48,49]

Some of the earliest proto-pharmacopeias such as Nuremberg (1546),[50] Augsburg (1564),[51] and the *Dispensatorium Brandenburgicum* (1698)[52] listed gum arabic (gummi arabici) without mention of source species. Historically, both species were listed in international official compendia since the late 18th century.[53-55] In the United States, acacia gum has a long history of use and was valued early on for its physical properties of enhancing consistency and stabilizing formulations. For example, "gum arabic mucilage" is listed throughout *The Pharmacopoeia of the Massachusetts Medical Society* (1808)[56] as an ingredient in preparations of infusions, emulsions, and troche formulations (lozenges). The mucilage of acacia gum is also a listed ingredient in *The Pharmacopoeia of the New York Hospital* (1816).[57]

The first edition of the *United States Pharmacopeia* (USP), published in 1820, listed Acaciae gummi (acacia gum, called gum arabic).[58] Today, the monograph in the *National Formulary* (USP-NF) is titled "Acacia" and defined as the "dried gummy exudate from the stems and branches of *Acacia senegal* or of other related African species of Acacia."[59] During the Civil War era in the 1860s, imported gum arabic (*S. senegal*) reportedly was not readily available in the supply chain, and slippery elm (*Ulmus rubra*, Ulmaceae) inner bark was an alternative for physicians and pharmacists.[60]

The value of the genus *Acacia sensu lato* is highlighted in several ethnobotanical surveys of African traditional and medicinal uses.[61] In the Nuba mountains of Sudan, an ethnobotanical survey found that approximately 40% of surveyed farmers maintain *hashab* (*S. senegal*) gardens in the local forest to support their household income.[62] In the remote area of southeastern Sudan, the gum powder from *S. senegal* has been used for kidney conditions.[63] A stem bark decoction of *V. seyal* has been given orally for dysentery and diarrhea.[63] In Benin, an ethnobotanical survey recorded 16 species of *Acacia* used in traditional medicines.[64] Based on field interviews, *S. senegal* was grouped with plants used for infectious diseases with a high fidelity level.[64] While the gum was not specifically described in the interviews, *S. senegal* (vernacular name: *gommier blanc*) is used for "pains of heart," the leaves for sore throats and abdominal pains, and the root for wounds.[64]

Vachellia seyal (vernacular names: *menèn*, *puwituani*) also is mentioned in the survey, with uses for stomach aches, edema (swelling), peritonitis (infection of the abdominal tissue layer called the peritoneum), bacterial infections, and rheumatism.[64] In Burkina Faso, an ethnobotanical study focusing on the Seno and Nayala provinces reported that consumption of the gum of *S. senegal* (vernacular name: *gommier*) suppressed appetite and helped with thirst.[65] A bark decoction of *V. seyal* (vernacular name: *gon-miougou*) supported weight loss.[65]

The *African Herbal Pharmacopoeia* (2010) mentions other ethnopharmacological uses of *S. senegal* bark, leaves, and gum to support coughs, sore throats, eye infections, diarrhea, gonorrhea, dysentery, and urinary tract infections.[66] The *West African Herbal Pharmacopoeia* (2013) describes topical uses of the gummy exudate for dressing burns, inflammation of tissues (mucous membranes), and irritated nipples.[67] Decoctions of the gum also may be used for wounds, conjunctivitis (inflammation of the eyes), and dermatitis (inflammation of the skin).[67] Plant material is also used for wood fuel, fence building, and livestock food during drought when other vegetation is limited.[68]

The widespread distribution and use of *S. senegal*, *V. seyal*, and other related gum-producing species throughout their native ranges across sub-Saharan Africa have prompted the name "gum belt," which refers to this region and is indicative of the economic importance and cultural significance of the gums.[4] Across this "gum belt" and in other gum-producing regions, acacia gum is wild collected from natural stands or forests of gum-producing trees, which may be managed with various agroforestry methodologies, or it is collected from trees that are cultivated on large, highly controlled plantations.[4,6] In either case, the crude gum exudes through the bark either naturally due to injury, disease, or environmental stress, or due to tapping (i.e., human-induced incisions on the trunk and branches of the tree). The tree exudes sap that dries upon contact with air, becoming gummy and gradually hardening.[4] This crude acacia gum ranges in color from light tan to red-orange, depending on factors including tree health and environmental conditions at time of harvest.[2] Darker colors of crude gum reflect a higher tannin content.[69] The color also generally indicates the species from which the gum originates. For example, gum derived from *V. seyal* and other species is darker compared to the pale white to amber gum from *S. senegal*.[70]

The gummy exudate, or crude acacia gum, is then hand-collected, facilitated by the use of hand-held tools including small axes and traditional tools such as *Sunki* and *Makmak*,[71] typically during the dry season, because the higher temperatures and environmental pressures result in greater yield and better quality.[72] Once the globose or spherical lumps of crude gum are collected, they are cleaned, then sorted and graded based on size, color, and amount of impurities in the gum.[4] These impurities are naturally occurring and can include sand, bark, and other organic materials.[73] The various grades of crude acacia gum are prepared for export or undergo additional processing. Some gum-producing countries and regions have facilities that are capable of converting crude acacia gum into more highly processed, refined products. However, in many other instances, processing occurs in more industrialized countries working as intermediaries between producing countries and those importing processed acacia gum. Processed acacia gum may take the form of powdered, flaked, spray-dried, and other more specialized final products for various industries and global markets.[2]

The unique properties of acacia gum have inspired innovation in many contexts, and its broad utility and versatility can be seen across many sectors, including medicine, food, art, and cosmetics.

CURRENT AUTHORIZED USES IN COSMETICS, FOODS, AND MEDICINES

Monographs for acacia gum (gum arabic) quality standards are published in official compendia of the United States such as the USP-NF[74] and in legally binding compendia such as the *Food Chemicals Codex* (FCC). The Gum Arabic FCC monograph is incorporated by reference in Title 21 of the US Code of Federal Regulations (CFR).[75] The US Food and Drug Administration (FDA) specifies "acacia (gum arabic)," in its regulation 21CFR § 172.780, as the dried gummy exudate from stems and branches of trees of various species of the genus *Acacia* that must meet the specifications of the FCC monograph for use as a generally recognized as safe (GRAS) food additive with maximum usage levels in certain foods, including alcoholic beverages, breakfast cereals, cakes and cookies, grain-based bars, soups and soup mixes, among others (for dietary fiber, emulsifier, stabilizer, and thickener functions).[76]

As per FDA regulation 21CFR § 184.1330, FCC-quality acacia is permitted as a GRAS direct food substance with maximum usage levels established for beverages and beverage bases, chewing gum, confections and frosting, dairy product analogs, fats and oils, gelatins, fillings, puddings, hard candy and cough drops, nut products, quiescently frozen confection products, snack foods, and soft candy, among other foods.[77] FDA regulation 21CFR § 582.7330 also permits the use of gum arabic as a stabilizer in animal drugs and feeds.[78]

The US Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) regulation 27CFR § 24.246 permits the use of FCC-quality acacia gum for clarifying and stabilizing wine.[79] For use as an excipient in pharmaceutical drug product formulations (functioning as an emulsifying, gelling, release-modifying, suspending, and/or viscosity-increasing agent, or wet binder), the Acacia USP-NF monograph serves as the basis for quality specifications.[74] In addition to the Acacia USP-NF monograph, there is an Acacia Syrup USP-NF monograph, with other ingredients of sucrose, sodium benzoate, vanilla tincture, and purified water.[80] In 2021, the FDA granted a citizen petition to add acacia gum (gum arabic) as one of the defined dietary fiber ingredients.[81]

In Canada, the Natural and Non-prescription Health Products Directorate (NNHPD) lists various uses for "Acacia" in licensed Natural Health Products (NHPs), with the accepted species listed as *S. senegal* and *V. seyal*. For the medicinal purposes category, acacia is listed as an extract item.[82] An additional listing for "Acacia Senegal Gum" for non-medicinal purposes includes uses as a gum adhesive, thickening agent, emulsifying agent, stabilizing agent, adhesive, binder, controlled release vehicle, delivery system, and fragrance enhancer ingredient.[83]

In the EU, the *European Pharmacopoeia* (PhEur) monograph defines "Acacia" (Acaciae gummi) as "air-hardened, gummy exudate flowing naturally from or obtained by incision of the trunk and branches of *Acacia senegal* L. Willd. (syn. *Senegalia senegal* (L.) Britton), other species of Acacia of African origin and *Acacia seyal* Delile."[84] For use in cosmetics products, the defined ingredient "Acacia senegal gum" is listed for fragrance and film-forming functions, and "Acacia senegal gum extract" as a viscosity-controlling ingredient.[85] The defined ingredients "Acacia Seyal Gum" and "Acacia Seyal Gum Extract" have humectant (moisture-preserving) properties listed as an ingredient function.[85]

For use as a food additive, United Nations agencies (e.g., Joint FAO/WHO Expert Committee on Food Additives),[73] the *Japanese Specifications and Standards for Food Additives*,[86] and the Korean Ministry of Food and Drug Administration also have published specifications.[87] In Africa, monographs are published in unofficial, yet authoritative, compendia, including the *African Herbal Pharmacopoeia*, which describes "*A. senegal*,"[66] and the *West African Herbal Pharmacopoeia*, which provides separate monographs for "*A. nilotica*" and "*A. senegal*."[67]

MODERN RESEARCH

Constituents and Pharmacological Effects

Acacia gum is described as an arabinogalactan-protein complex[5,88] with salts of calcium, magnesium, and potassium. Arabic acid (not to be confused with its monosaccharide homonym, which is also known as arabinonic acid) is the primary polysaccharide[66] which is a highly branched, complex chemical structure that contains galactose, arabinose, rhamnose, and glucuronic acid.[2,89] Additionally, the main amino acids of serine, hydroxyproline, leucine, and proline are present in both species, with *S. senegal* generally containing higher amounts of amino acid content compared to *V. seyal*.[90,91] The phytochemical constituents have demonstrated variability, which can be influenced by ecological location, tree maturity, tapping conditions, climate, soil, and

Acacia tree (*A. seyal*) in Ein Khadra Desert Oasis, Nuweibaa, South Sinai, Egypt. Photo ©2024 اسور ال (La Rossa)

water availability.[5,90,91] Furthermore, post-harvesting techniques and processing conditions (e.g., variability in storage, heat, and pressure) also affect the chemical composition of acacia gum.[91]

Experimental in vitro studies have demonstrated acacia gum's prebiotic properties in human fecal microflora and dietary fiber fermentation models, which report an increase in the production of total short-chain fatty acids (SCFAs).[92,93] SFCAs are metabolites (e.g., acetate, propionate, butyrate) that are formed when dietary fibers are fermented by bacteria in the gastrointestinal tract.[94] SFCAs are purported to be beneficial for digestive health by supporting the intestinal epithelia cell structure and intestinal motility.[94] The prebiotic potential of acacia gum was evaluated in an in vitro colon model study over a 24-hour period and compared to a positive control, a prebiotic called fructo-oligosaccharides (FOS). The colonic bacteria population counts were followed in the study for both the acacia gum and the FOS control. Acacia gum increased *Bifidobacterium* (a probiotic bacteria) bacteria population counts after the 12- and 24-hour fermentation time points, though FOS had a faster fermentation rate at the 6-hour mark. At 24 hours, both FOS and acacia gum reported significantly higher *Bifidobacterium* counts compared to the negative control. Additionally, acacia gum and the prebiotic control FOS demonstrated a similar pattern of increasing SCFAs production.[95]

Toxicity

In 2017, EFSA's Panel on Food Additives and Nutrient Sources Added to Food determined that there is no safety concern for the general population in their assessment of acacia gum as a food additive within the recommended dietary exposure limits.[8] Additionally, the available studies of acute, sub-acute, and genotoxicity indicate no signs of toxicity.[8,66] Hypersensitivity may occur from the carbohydrate structure of acacia gum in atopic individuals with pollen sensitivity, which is based upon a few limited case reports.[8,66]

Human Clinical Studies

Acacia gum is primarily known in the food, beverage, cosmetic, dietary supplement, and pharmaceutical industries for its ability to improve physiochemical properties through emulsification and stabilization. Acacia gum's dietary soluble fiber content has been the focus of a few clinical studies. For example, acacia gum has demonstrated prebiotic properties in digestive health.[96,97] Additionally, its impact on metabolic, cardiovascular, and inflammatory risk factors has been evaluated,[98-101] and oral health studies have been performed.[102,103] Table 1 highlights selected clinical studies specifically on acacia gum mono-preparations.

ADULTERATION AND SUBSTITUTION

There are vast numbers of gum-producing trees belonging to the family Fabaceae including species in the genera *Senegalia*, *Vachellia*, *Acacia*, *Albizzia*, and *Combretum*, all of which produce exudates that are all variously marketed as gum arabic or acacia gum, at least regionally.[66,107]

Gum derived from *S. senegal* is the most commonly encountered gum arabic in the global marketplace, followed by gum from *V. seyal*.[1,2] Acacia gums from these two species generally appear to be marketed as different products, at least in Sudan, with different names for the respective gums: "gum hashab" for *S. senegal* and "gum talha" for *V. seyal*.[66,107] With the adoption of a more narrow definition by some regulatory and governmental agencies requiring acacia gum (gum arabic) to be derived from either *S. senegal* or *V. seyal*,[2,8] it should be expected that gums from those two species will continue to dominate the marketplace and that gums from other species will be generally directed toward smaller, more regional markets. For example, in Zimbabwe gum from *A. karroo* is sold as gum arabic but is reported only to be traded locally.[107]

There are pharmacopeial methods to identify acacia gum, assess purity, and detect adulterants.[84,86] Additional methods are able to distinguish between acacia gum derived from different species. Gum from *S. senegal* breaks with glassy fracture, while gum derived from *V. seyal*, which is more brittle and not as hard, breaks in a different manner.[73] Optical rotation can also be used to differentiate between these species: aqueous solutions of gum from *S. senegal* are levorotatory (rotates the plane of a polarized light ray counterclockwise) whereas solutions of gum from *V. seyal* are dextrorotatory (clockwise).[73,86] Gums derived from other *Acacia sensu lato* species are also reported to be dextrorotatory.[69] Finally, high resolution mass spectrometry has been reportedly used to successfully characterize the botanical origin (*S. senegal* versus *V. seyal*) of acacia gum used as a fining agent in wine,[108] and this method may prove similarly useful in non-oenological applications.

Table 1. Selected Clinical Studies of Acacia Gum in Chronological Order since 2012

Publication	Study Design	Interventions	Outcome
Babiker et al (2012)[98]	A 6-week, two-arm, R, PC, DB study evaluated effects of acacia gum on body mass index (BMI) and body fat percentage in healthy females (N = 120).	Treatment group (n = 60): 30 g/day of acacia gum (*S. senegal*, Dar Savanna Ltd.; Khartoum, Sudan) divided into 5 sachets, each taken with 250 mL of water after a meal; 3 sachets (18 g total) in morning and 2 sachets in evening (12 g total) Placebo group (n = 60): 1 g/day of pectin also in divided doses Weight, height, body fat percentage, and skin fold thickness were measured at baseline and at end of study.	BMI and body fat percentage significantly decreased in acacia gum treatment group after 6 weeks. Morning nausea, mild diarrhea, sensation in the mouth, and bloating were reported in treatment group but resolved after first week.
Babiker et al (2017)[99]	A 3-month, DB, R, PC study evaluated the effects of acacia gum on blood glucose, cholesterol (lipids) levels, and BMI in people with type 2 diabetes mellitus (T2DM) (N = 91; average age of 50) on oral hypoglycemic medication for T2DM.	Treatment group (n = 46): 30 g/day of acacia gum (*S. senegal*, Dar Savanna Ltd.; Khartoum, Sudan), divided into 2 sachets (15 g each) to be taken in morning in 250 mL of water Placebo group (n = 45): 5 g/day of pectin	Significant decrease in fasting blood glucose and hemoglobin A1c (HbA1c). From baseline, reductions in total cholesterol (8%), low-density lipids (LDL) (19%), triglyceride (10%), and BMI (2%), and an increase of high-density lipids (HDL) (19%). Mild gastrointestinal adverse effects of nausea, diarrhea, and bloating were reported first 2 weeks of the study.
Elamin et al (2017)[104]	A 4-week, open-label, R clinical trial evaluated effects of acacia gum supplementation in individuals with chronic kidney disease (CKD) (N = 36).	Treatment groups: 10 g, 20 g, or 40 g/day of acacia gum (premade packages of soluble granules; Agri-Rapid Acacia RE; Agrigum, UK) Lab studies and clinical interviews were performed at baseline and at end of the study intervention.	30 patients completed the study, with significant findings reporting a reduction of C-reactive protein (CRP) marker, a non-descriptive inflammatory marker; this also included the lower dose treatment group (10 g/day). However, other inflammatory markers —interleukin (IL), interferon (IFN), tumor necrosis factor (TNF) — measured in study did not show any significant effects; acacia gum was well tolerated.
Babiker et al (2018)[100]	R, DB, PC study evaluated effects of acacia gum on visceral adiposity index (VAI), blood pressure, and anthropometric obesity markers in people with T2DM (on oral hypoglycemic medication; N =97; average age of 50).	Treatment group (n = 50): 30 g/day of acacia gum (*S. senegal*, Dar Savanna Ltd., Khartoum, Sudan) Placebo group (n = 47): 5 g/day of pectin daily Included measurements of blood pressure, anthropometric obesity markers, VAI, and blood lipid levels, fasting blood glucose, and HbA1c.	All participants completed the study. Significant decreases of secondary outcomes in BMI, VAI, and body adiposity index in treatment group were seen. Additionally, a decrease of triglycerides and increase of HDL was reported in treatment group. No changes in waist circumference, waist-to-hip circumference, or diastolic blood pressure levels.
Kamal et al (2018)[105]	12-week, single-arm, controlled phase II clinical trial evaluated effects of acacia gum on inflammatory blood markers and disease severity scores in people with rheumatoid arthritis (RA) (N = 40; 18-70 years of age; 95% female).	Treatment group: 30 g/day acacia gum (*S. senegal*) powder, dissolved in 200 mL of water in morning Each study participant regularly completed a disease activity score (DAS 28), an indicator tool used to track RA symptoms/activity. Lab parameters (complete blood count, liver, and kidney function tests) and inflammatory blood markers (erythrocyte sedimentation rate and tumor necrosis factor-alpha) were assessed at baseline and end of study.	All participants completed the study. At end of study, inflammatory markers decreased with less swollen and tender joints. No changes in complete blood count (evaluation of red and white blood cell numbers, hemoglobin, platelets, and hematocrit) or kidney function tests. Less than a quarter of acacia gum-treated participants reported digestive symptom adverse side effects, which resolved during the study.
Bielfeldt et al (2021)[103]	R, controlled, monocentric clinical study evaluated effects of acacia gum product on salivary flow rate in participants with dry mouth (xerostomia) (N = 26).	Each participant was randomly assigned to one of 2 treatment groups. Study participants were provided control product on Day 1 and the treatment product on Day 3 (both of which were dissolved in mouth after 5-10 minutes), or inversely Investigational product: ipalat® Hydro Med (Dr. Pfleger Arzneimittel GmbH; Bamberg, Germany), a pastille containing the active ingredients of gum arabic, natrosol, sodium hyaluronate, and carrageenan; other ingredients include maltitol syrup, honey flavor, primulae extract, bitter fennel (*Foeniculum vulgare*, Apiaceae) oil, star anise (*Illicium verum*, Schisandraceae) oil, and sucralose Control: Parafilm containing paraffin wax and polyolefins Salivary flow rate (unstimulated to stimulated conditions) and visual analog scale were assessed at baseline. Examination of oral cavity was performed to determine safety tolerance, along with pulse rate and blood pressure measurements.	All participants completed the study. 2 mild and 2 moderate reactions reported with the investigational pastille with 5 mild and one moderation reaction with control product. Baseline unstimulated salivary flow rate in treatment group was 0.203 g/min and 0.213 g/min in control group. The salivary flow rate increased significantly to 8.03 g/10 minutes compared to control at 3.72 g/10 minutes.
Jarrar et al (2021)[101]	12-week, single-blind, R, PC, parallel-design clinical trial evaluated effects of acacia gum powder supplementation on specific cardiovascular and metabolic risk factors in adults (N = 80).	Treatment group (n = 40): 20 g of acacia gum (*S. senegal*) powder in prepared sachet, 2x/day in hot water, tea, milk, or a meal Placebo group (n = 40): 1 g of pectin in prepared sachet, 2x/day in hot water, tea, milk, or a meal At baseline and at end of study, waist circumference, weight, body fat mass, blood glucose, HbA1c, cholesterol, and blood pressure levels were measured. Also, satiety and bowel movements were followed by questionnaire.	61 participants completed the study (treatment group = 31 participants and control group = 30), with 19 participants that did not finish study due to lack of compliance. At end of study, authors reported significant decreases in blood pressure (both systolic and diastolic) in the treatment group. No changes to cholesterol and HbA1c levels were reported. No significant differences for body mass, waist circumference, or body fat mass. Treatment group participants reported decrease of bloating and increase in satiety and quality of bowel movements.
Larson et al (2021)[106]	Study evaluated effects of acacia gum on satiety, glycemic response, food intake, and digestion tolerance in healthy subjects (N = 48; 18-65 years of age).	Group A: Control group; prepared breakfast only (orange juice and bagel); no acacia gum Group B: Prepared breakfast with 20 g of acacia gum dissolved (Nexira; Rouen Cedex, France) Group C: Prepared breakfast with 40 g of acacia gum dissolved Each participant was randomly placed into 3 groups to receive each of the treatments and office visits separated by 1 week. Measurements of blood glucose, digestive tolerance, and satiety were measured at baseline and after 30, 60, 120, 180, and 240 minutes. Computerized visual analog scales were used to assess satiety symptoms, digestion symptoms by subjective questions, and blood glucose levels with glucometer.	Glycemic response did not show any significant differences throughout the study. Satiety did show improvement at 15-, 30- and 240-minute mark. Bloating and flatulence were higher in 40 g group compared to control group; however, treatment overall was well tolerated.

DB = double-blind; PC = placebo-controlled; R = randomized; RCT = randomized controlled trial

SUSTAINABILITY AND FUTURE OUTLOOK

Both *S. senegal* and *V. seyal* are well-adapted to desert and drought conditions and grow in areas where few other trees can flourish[6,7]; this, along with widespread propagation, will contribute in part to long-term sustainability of acacia gum production. Gum production is promoted and quality increased when trees are faced with environmental and physiological stressors including high temperatures, drought, insect predation, and physical injury to the tree whether occurring naturally or intentionally by humans.[4] Although these species are drought tolerant, extreme drought conditions lasting consecutive years do increase rate of desertification, and encroaching sands can kill the trees.[109] Pressures on sustainable supply of acacia gum are of a different nature than that of many crops in which increased stress, herbivory, and climate change are seen to negatively impact productivity. While herbivory and depredation from locusts, birds,[110,111] and longhorn beetles (*Cerambycidae*)[111] have at times been reported to drastically reduce or nullify productivity of gum trees, political unrest and lack of good livelihoods and fair wages for collectors are seen to be greater threats to acacia gum production than environmental stressors.[2] Reports that acacia gum is often harvested by vulnerable groups, such as women, ethnic minorities, politically displaced, and the very poor,[2] may further contribute to market volatility and suggests avenues of redress that could stabilize market and product availability in gum-producing regions.

There are efforts in some countries and by some international organizations[2,4] to provide optimum shares of economic returns to gum collectors and other stakeholders, specifically fair compensation, and thus encourage sustainable agroforestry practices and help prevent desertification and slow climate change (i.e., better wages to collectors will encourage better gum-tree management practices). The governments of some acacia gum-producing countries are encouraging and/or incentivizing farmers to set up plantations of cultivated *S. senegal* trees, helping to ensure sustainable acacia gum production.[4] Across Sahelian Africa, much of acacia gum is harvested from wild trees or from semi-wild, managed "gum gardens"; however, they are also widely cultivated and grown in large plantation-like farms, both in Africa and in other gum-producing countries such as India and Pakistan.[112]According to the International Legume Database and Information Service, the conservation status of *S. senegal* is listed as "Not Threatened."[113] According to the IUCN Red List of Threatened Species, the conservation status of *V. seyal* is listed as "Least Concern."[15]

FairWild Foundation does not list any suppliers that currently provide certified FairWild® acacia gum (gum arabic); however, they list two companies that could add certification for this ingredient if demand was sufficient.[114] According to the USDA Organic Integrity Database, only four countries currently produce certified organic acacia gum (gum arabic): Chad, India, Senegal, and Sudan.[115] Acacia gum grown in India may in fact not be gum from *S. senegal* or *V. seyal*, but it may be derived from *V. nilotica*, the official species in the *Indian Pharmacopoeia*.[116] In addition to countries producing organic acacia gum, a number of other countries process and distribute the organic product.[115]

Given the widespread and extensive use of acacia gum across multiple sectors of global industry, it is reasonable to conclude that quantities needed to meet the demand in the international marketplace will only continue to increase in the future.[2,4] With increased visibility and commitment to fair value shares for collectors, harvesters, and processors, and with reforms to address revenue segregation and combat gender inequality, acacia gum production has the potential to promote better rural livelihoods and greater economic equitability while at the same time helping to mitigate climate change. HG

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