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BASIL SEED GUM: EXTRACTION, MODIFICATION, AND APPLICATIONS IN FOOD AND PHARMACEUTICALS

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ABSTRACT
One of the polysaccharides, basil seed gum (BSG), produced by the extraction of the seeds of basil plants, has attracted growing interest lately thanks to its versatile nature and potential to be used as a multifunctional food additive or a pharmaceutical ingredient in the food and pharmaceutical sectors. BSG increases the microbial stability and rheological and textural characteristics of the food systems and has prebiotic action, which maintains the health of the gut. BSG has several bioactivities and has been proven to have antioxidant, anti-inflammatory, antidiabetic, antibacterial, and anticancer activities, which make it a prospective therapeutic agent in weight management and metabolic process regulation. Recent research reports its use in the state-of-the-art pharmaceutical applications of novel drug delivery, nanoliposome formation, enhanced bioaccessibility of lycopene, and controlled release of drugs in tablet applications. It also has emulsifying, gelling and stabilising properties, which increase its functionality in food and biomedical preparations. The development of methods of extraction and chemical alterations has improved its functionality and increased its use in industries. Altogether, BSG is a biopolymer that has serious potential in the nutraceutical development, targeted therapies and eco-friendly biomaterials.
Keywords: Basil Seed Gum, Hydrogels, Drug Delivery, Prebiotic Activity, Functional Food, Sustainable Biomaterials
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INTRODUCTION

BSG is a natural polysaccharide extracted from the seeds of *Ocimum basilicum L.*, and is a plant of the Lamiaceae family. This is a biopolymer that has had wide functional and pharmaceutical properties that have been widely reported in the literature.[1,2] The basil seeds have found their way around the world as they are native to parts of Africa, America and Asia, but this demonstrates the versatility and usability of the basil seeds. Basil seeds offer a great nutritional value as they comprise a broad assortment of lipids, minerals, dietary fibres, phenolic compounds and proteins like rosmarinic acid and orientin acid. All these properties give great advantages to dietary and medicinal uses, which make the basil seeds apt prospects for weight management and beverage formulations.[3-6] BSG is a novel hydrophilic colloid derived from basil seeds, which has excellent functional properties rheology, gelation, emulsification, adsorption, and stability, which are comparable to commercial gums. Because of their physiological effects, such as the maintenance of blood sugar levels, detoxification, and the weight and cholesterol levels, BSG is widely used in the pharmaceutical industry. Besides, BSG has been known to be a good source of dietary fibre. In addition, the seed of basil has widespread application in folklore medicine on the planet. These seeds are supposed to help in relieving coughs, colds, hoarseness, stomach aches, haemorrhoids, kidney stones, as well as urine problems, when taken orally. Moreover, they can help to lose weight.[7,8] To treat animal bites, vitiligo and eczema, arthritis and rheumatism, and to prevent skin disorders, dry basil seeds should be discarded to create a skin ointment through the mixing of a mustard oil or ghee powder with the basil.[9] According to recent studies, basil seeds have anticancer, antioxidant, antibacterial, anti-inflammatory, and anti-diabetic properties.[10-14] BSG is a natural vegetable gum that has a considerable functional attribute and value to the food and pharmaceutical industry. It has therefore received a lot of scholarly attention and has been designed to take applications in numerous industries such as food, medical devices, and oil mining.[15-17] There are several pharmacological effects that basil leaves offer and are also commonly used in meals such as soups, rice and stews. Traditionally, basil has been used in malaria, respiratory, kidney, ear, anorexia, arthritis and menstrual problems. BSG has demonstrated potential biological efficacy in relation to different pathogens, including viral, bacterial, and fungal microorganisms. In herbal medicine,

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basil seeds were traditionally used in the treatment of diarrhoea, fever, flu, asthma, cough, bronchitis, and other symptoms. BSM (basil seed mucilage) is also used as an emulsifying hydrocolloid, thickener, surface active agent, fat replacer, stabiliser, and a texturizer. Basil has the most important pharmacological properties, which include the radio-protective, antimicrobial, anti-inflammatory, immunomodulatory, antistress, antidiabetic, antioxidant, prophylactic, anticancer, antipyretic, and antirheumatoid. Basil contains the phenolic constituents of flavonol glycosides and phenolic acids, and a wide range of fatty acids, such as myristic, α-linolenic, capric, lauric, arachidonic, stearic, oleic, palmitic, and linoleic acids. An increase in light and temperature increases its antioxidant activity. Basil has an abundant antioxidant profile with p-hydroxybenzoic acid, rutin, apigenin, vanillic acid, rosmarinic acid, quercetin, chlorogenic acid, and caffeic acid being present. The basil essential oils constitute different compounds that include alpha-pinene, beta-pinene, eugenol, n-cinnamate, beta-caryophyllene, 1,8-cineole, ocimene, borneol, geraniol and methyl chavicol. Out of them, terpenoids, eugenol and chavicol stand out remarkably.[2] Basil is used in Indian, Chinese, Persian, and Italian foods. Chemical structure, such as the essential oil content, differs among varieties of various species, cultivars, and even among growth conditions. Cropping seasons, genotype, and geographical location are some of the factors that have a great influence on the biochemical components of medicinal plants.[18-27] Basil is culturally akin to the goddess Tulsi in certain parts of Asia, where in India it is considered a component of folk medicine[28] and is used both in medical and religious orthodox Christian rituals.[29] Basil polysaccharides have been historically employed in traditional Chinese medicine for cancer treatment.[30] Another application of Basil seed mucilage in the food industry includes hydrocolloid emulsifiers, thickening agents, surface-active compounds, fat replacers, stabilisers, and texture modifiers. Besides functionality, polysaccharides derived from basil have multiple biological activities, such as antitumor, antioxidant, anti-ageing, antibacterial, anti-atherosclerotic, and immunomodulatory. These polysaccharides also exhibit good potential in the treatment of diabetes mellitus.[31] Since the BSG has been separated from the mucilage of the seed of *Ocimum basilicum* by precipitation through alcohol in an optimised ratio with water. Along with BSG, Basil seed mucilage (BSM) has a range of favourable characteristics, including remarkable exceptional viscoelastic, cost-effective production, excellent efficacy of film forming, edibility, hydrophilicity, antagonistic qualities, and high biocompatibility. BSG is chemically mostly composed of high molecular weight polysaccharides (around 2320 kDa), which can be separated into various fractions depending on the molecular weight, usually known as PER-BSG fractions.[5, 32-37] Mucilage is a complex carbohydrate, and it shows great water-absorbing properties. Some of the seeds, such as basil, are rich in mucilage. Basil seeds have a strong inner nucleus and an outer covering comprising a fibrous biofilm of pectin. The outer pericarp, on being steeped in water, swells into a gel-like material, demonstrating its potential as an edible gum source due to the abundance of mucilage.[38-40] BSG is a hydrocolloid that is naturally found in Basil seeds. The process of extracting BSG is endothermic, spontaneous, and irreversible. Past research evidence shows that BSG has the potential to be used as a multifunctional emulsifier, stabiliser, thickening agent, gelling agent, and fat substitute in pharmaceutical and food preparations.[41] The extraction and functional properties of BSG have been examined before. To illustrate this, Hosseini-Parvar *et al.* (2010) have enhanced the extraction process by using freeze-drying instead of the traditional drying process at 50 ^{o}C, which enhanced the effectiveness and even the quality of extracted gum.[42] It is known that high temperatures during extraction help in liberating water-soluble polysaccharides within the cell wall matrix into the extraction medium, thus boosting extraction. This heating action reduces the viscosity of the mucilage, reduces its adhesiveness and liberates the polysaccharides. In this regard, the mass transfer coefficient grows with temperature, and it has a strong influence on diffusion kinetics and viscosity parameters of the extraction process.[43] The addition of BSG with ethanol and protease enzyme improves its functional and rheological properties.[5] Given the rigorous nature of BSG gel, it has been suggested to do a penetration test to determine the textural qualities of the gel. At a concentration of 3.0% (w/w), BSG show gelation with a consequent hardness of 13.50 g. BGS gel underwent thermal treatment in 50, 75 and 100 ^{0}C over 20 minutes to give similar gel hardness, but treatment at 121 ^{0}C resulted in structural damage and destruction of the gel network. Overnight freezing the gel at -25 ^{o}C greatly increased its rigor consequently meaning that gel structure can be improved through freezing. Adhesiveness is a characteristic of a gel sample whereby the sample has the propensity to adhere, which influences the quality of food, food appearance and food shelf life. The BSG is comparatively high in polymer content, which increases the viscosity and stability during thermal processing and also maintains the gel structure even after freezing.[44,45] The mixture of BSG and locust bean gum (LBG) and guar gum (GG) in various proportions (100-0, 20-80, 40-60, 60-40, 20-80 and 0-100) was tested. The 20-80 blend of the BSG-LBG exhibits the least non-Newtonian behaviour when compared to all the other blends. The flow behaviour index (n) is found to be constant with an increase in the BSG ratio. The interactions between BSG and other hydrocolloids were also studied. Combinations of BSG with locust bean gum (LBG) and guar gum (GG) in various proportions were shown to exhibit higher zero-shear viscosity (η^0), which is one of the requirements of having the capacity to suspend particles in food systems. These synergies between BSG and galactomannans indicate their aptness for the application of different food recipes. Increasing the difference in the BSG percentage in the gum amalgams would cause structural degradation and heighten thixotropic behaviour.[46] Fractionation analyses have shown that BSG is a complex compound that comprises a pentosan fraction that contains a high proportion of uronic acids and two fractions that have a higher proportion of hexose sugars. Hydrolysis of the mucilage was controlled by using dilute H_2SO_4 to generate an acid-resistant core polysaccharide, which was mostly made of mannose and glucose in a 2:10 ratio.[47] This review will gather the existing information on basil seed gum (BSG) and its oligosaccharides, such as extraction procedures, structure, functional properties, and varied applications. It also aims at determining the gaps in the research and the direction of future research in their sustainable application in food, pharmaceutical and biomedical sectors.

Extraction Strategies and Chemical Composition

BSG polysaccharide is an anionic heteropolysaccharide comprising a glucomannan core with a ratio of mannose and glucose of 2:10 (43 and 24.29) interconnected with (1→4) bonds in addition to a xylan chain (24.29). The xylose residues are conjugated with acidic side chains. Glucan minor components make 2.31% of the structure.[5,48,49] Another common technique of retrieving BSG is water mining. It is a phased process, which includes purification, extraction, precipitation, by use of isopropyl alcohol (IPA) or ethanol, drying, and raw material selection as well as filtration, to produce BSG powders (Fig.-1). Subsequent research conducted by Razavi *et al.* (2009) developed the best conditions of extraction of basil seed mucilage. These parameters have a large impact on the yield, protein content and viscosity, with temperature being the most influential determinant. The best extraction parameters include the temperature of pH of 8, seed-water ratio of 1:66 and 69 °C. This leads to an extraction yield of 20.49, an apparent viscosity of 581.37 millipascal, and a protein composition of 2.17. The extraction yield of BSG is calculated on a wet basis as per the methodology of Razavi *et al.* (2009).[50]

$$\text{Yield (\%)} = \frac{mass\ of\ extracted\ gum\ (g)}{\text{mass of basil seed (g)}} * 100$$

Salehi *et al.* (2015) have found that the extraction of BSG is spontaneous, irreversible and endothermic, with positive ΔH values (between 0.26 and 7.87), low ΔG values (between 1.62 and 4.42), and positive ΔS values (between 8.12 and 33.2). The greatest extraction percentage (17.95) was achieved at a seed to water ratio of 1:30, pH of 7 and 50 ^{0}C of temperature. The impacts of temperature (20, 50, and 80 ^{0}C), pH (5, 7 and 9), and seed-to-water (1: 20 and 1: 30) were studied to optimise. High temperatures also cause a lower mucilage viscosity, resulting in a less sticky slurry and release of mucilage. An increase in temperature was observed to lower the viscosity of mucilage and lead to the ease of separation and enhancement of mass transfer during extraction. Temperature is therefore an important factor in establishing extraction efficiency through the increased rate of soluble polysaccharides diffusion of the seed matrix out of the extraction media.[43] Hosseini-Parvar et al. (2010) made a change in the extraction process of BSG, which aimed at freezing-drying the gathered gum, rather than using vacuuming at 50 °C.[42] Alteration of the process of BSG extraction leads to high apparent ash content, total carbohydrate and viscosity and also a decrease in protein and fat level.[51] Amid, B.T. and Mirhosseini, H. (2012) suggest that basil seeds had been placed in deionized water, a shaker (WNB 7, Memmert, Germany) with

20 minutes of shaking, and a water/seeds proportion of 30:1. Table-1 gives information on the different levels of temperature (50 and 30C) and agitation rate (0, 50 and 100 rpm).[52] In another study by Keisandokht *et al.* (2018), microwave-assisted extraction (MAE) produced a high average gum yield of 10.46 per cent in comparison with the traditional method of extracting basil seed gum (BSG) using hot Soxhlet. Besides, in an acidic environment (pH =4), BSG extraction was significantly higher than in a basic environment (pH =11) using MAE. [53] Various drying methods have been used in the production of basil seed mucilage (BSM), such as the use of the traditional oven drying method, solvent exchange then oven drying and the use of the supercritical carbon dioxide (SC-CO 2) drying method (Fig.-3).[54]

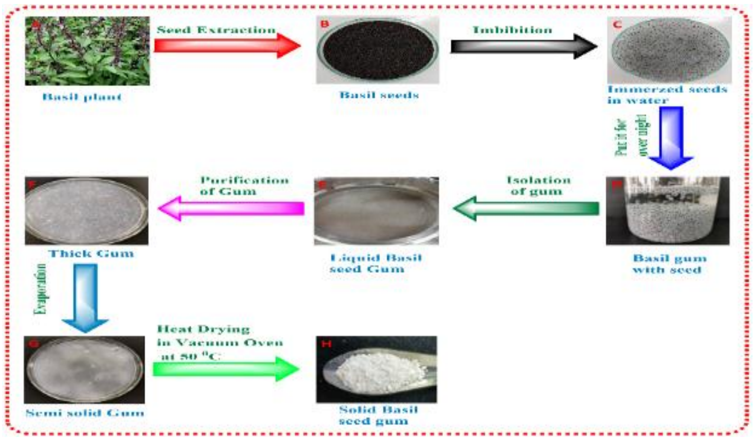


Fig.-1: Schematic Showing the Extraction of Basil Seed Gum: (A) Plant of Basil, (B) Basil's Seeds, (C) Basil Seeds Immersed in Aqueous Solution, (D) Gum With Basil Seed, (E) Liquid Basil Seed Gum, (F) Thick Gum, (G) Semi-Solid Gum, (H) Powder of Gum

The chemical structures of unrefined and refined BSGs are compared in Table-1[50], illustrating the significant impact of purification on BSG's chemical makeup. BSG, characterised as a greater molecular weight polysaccharide, exhibits two distinct fractions based on molecular weight distribution: PER-BSG, with a yield (67 %) and a greater molecular mass (5980 kDa) and SUPER-BSG, showcasing diminished yield (31%) and molecular mass (1045 kDa) (Naji-Tabasi *et al.)*.[5] According to Hosseini-Parvar (2009), BSG comprises 0.4%, 29.6%, 16.1%, 8.9%, 4.1%, 5.7%, and 2.2% (w/w) proportions of galacturonic acid, glucose, galactose, mannose, xylose, arabinose, and rhamnose, respectively.[42]

Table-1: The Chemical Makeup of *Ocimum basilicum*[50a,b]

S.No.	Chemical Composition (%)	Unrefined	Refined
1	Carbohydrates	74.19 ± 0.61	79.62 ± 0.86
2	Lipid	11.55 ± 0.29	9.71 ± 0.25
3	Protein	2.01 ± 0.11	1.56 ± 0.08
4	Moisture	7.39 ± 0.18	5.79 ± 0.12
5	Ash	5.88 ± 0.14	3.32 ± 0.17

[a] Data presented as mean ± standard deviation, [b] Derived from a dried substance

The chemical structure of basil seed gum (BSG) is given below in Fig.-2 (Guan *et al.* 2023).

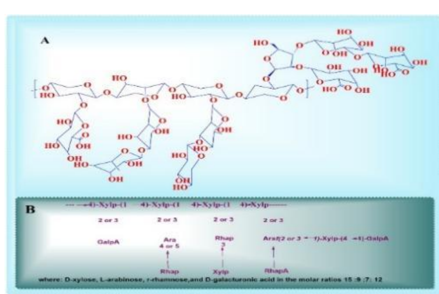


Fig.-2: Schematic Showing the Chemical Structure of BSG (A) and its Linkage Position (B).[4]

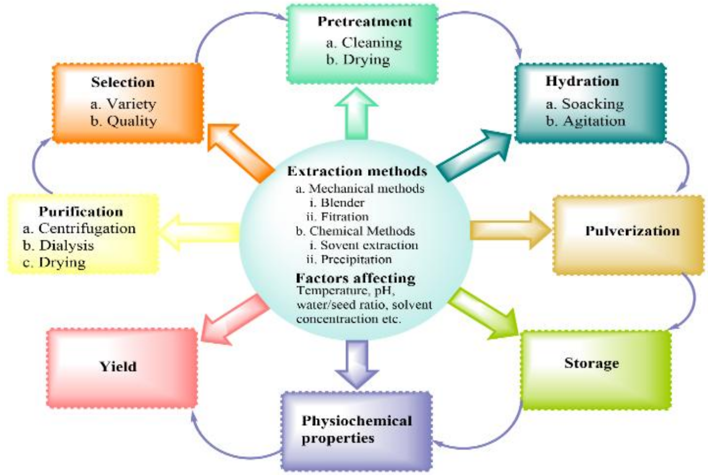
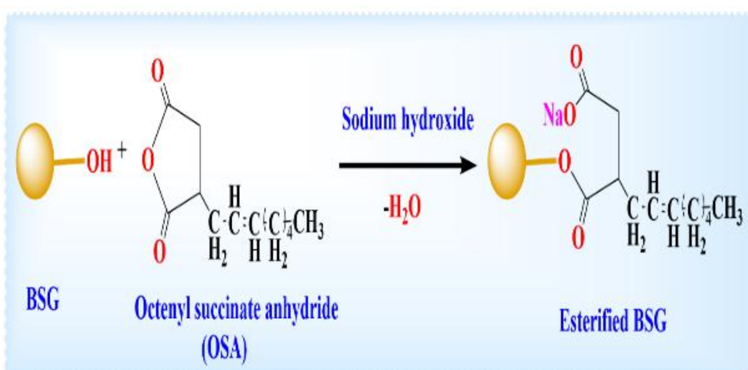


Fig.-3: Methods of Extraction for BSG from Basil's Seeds

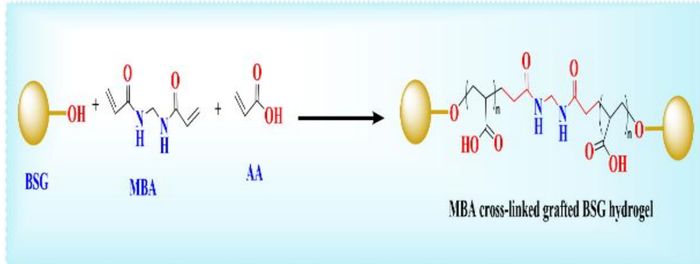
Structural Modification

Many natural plant gums struggle to expand and disintegrate quickly enough to meet commercial standards, often containing water-insoluble contaminants. Consequently, adjustments are needed to enhance the quality and broaden the applications of natural plant gums when used as food additives.[4] In another research, Gahruie *et al.* (2019) prepared BSG dispersions in deionised water and left them to hydrate overnight, then adjusted the pH to 8.0 with sodium hydroxide. An ethanolic solution containing octenyl succinic anhydride (OSA) was added to the BSG dispersion to achieve different weight ratios (WRs). The reaction was maintained at 8.0 for 90 minutes before being terminated with HCl at pH 6.0. The precipitates were washed three times with absolute ethanol (Scheme-1). The tailored samples were denoted as S_0, S_1, and S_3, with another lowercase letter indicating significant differences ($p<0.05$).[55] In 2020, the authors published two papers, with the first focusing on modifying BSG using octenyl succinic anhydride (OSA). Their study revealed significant enhancements in rheological and interfacial properties with OSA modification, including increased molecular weight and improved stability of BSG emulsions and foams. This suggests OSA as a promising material for altering BSG to produce stable emulsifiers and thickeners.[35] In a 2020 study by Gahruie et al., they found that incorporating fatty acids into BSG thin films improved their anti-moisture, mechanical and physical properties. Palmitic acid treatment made the films more reducing moisture content, hydrophobic, and water solubility while enhancing vapour separation. Lauric acid or caprylic acid addition increased tensile strength by ensuring uniform diffusion throughout the solution[56], and Fig.-4 for the various techniques used corresponding to modification of BSG.



Scheme-1: Chemical Representation of the Esterification Reaction between the BSG and OSA

Other recent research has seen the development of new applications of BSG in biomedical and food systems. Hydrogels Ghumman *et al.* constructed pH-responsive hydrogels made of basil seed gum and acrylic acid through free-radical copolymerization in the release of captopril(Scheme-2).[57]



Scheme-2: Schematic Chemical Modification of BSG into a pH-Sensitive Hydrogel

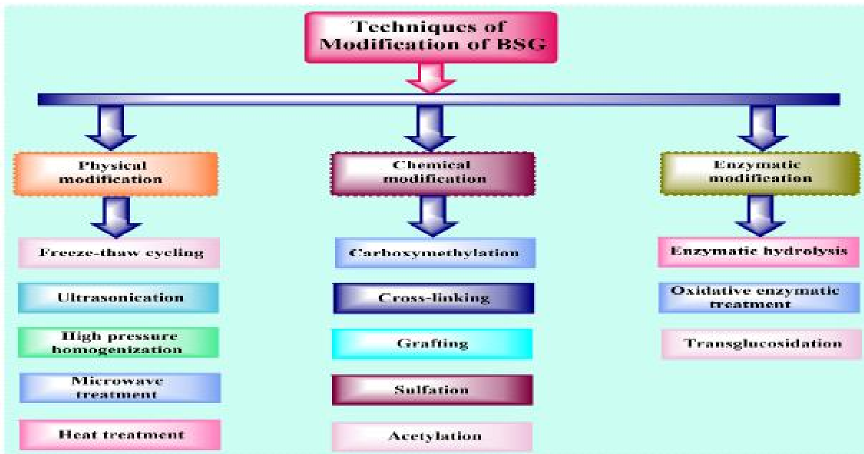


Fig.-4: Methods of Modification of *Ocimum basilicum*

Potential Applications

The present investigation sought to show that simultaneous encapsulation of BSG substantially improved the stability and regulated release characteristics of extract from broccoli sprouts enriched with sulforaphane, within nanoliposomes. In a separate study, tri-layered nanofibers were developed through the use of zein in the outer layers, and a mixture of polyvinyl alcohol (PVA) and BSG with lycopene in the middle layer to enhance the bio accessibility of lycopene. The rheological properties, surface tension and electrical conductivity of PVA/BSG solutions at various volume ratios were systematically evaluated. Scanning electron microscopy (SEM) analysis demonstrated that a 30:70 ratio of PVA to BSG produced the most effective nanofiber matrix for lycopene entrapment. Lycopene encapsulation efficiency within the tri-layered nanofibers was observed to range from 81.7% to 92.26%. Differential scanning calorimetry (DSC) analysis confirmed successful lycopene encapsulation, as evidenced by enhanced thermal stability in the DSC thermograms.[58] In addition to this, scientists have been examining the use of pH-sensitive films based on Ocimum basilicum mucilage, which can be used in advanced wound treatment. A composite formulation consisting of glutaraldehyde (GA) as a cross-linking agent and polyvinyl alcohol (PVA) as a monomer, along with glycerol serving as a plasticiser, was synthesised to attain superior optimal flexibility and mechanical properties. The refined Mu-Gly2 configuration of the hydrogel film derived from BSG displayed remarkable thermal resilience and demonstrated advantageous oxygen permeability and water vapour transmission rates, measured at 4.31 bar and 2630 g/m²/day, respectively. This formulation ensures adequate moisture delivery to the wound environment, thereby significantly promoting the wound healing process.[16] Due to its hydrophilic properties and three-dimensional structure, BSG holds potential as a drug delivery system. The –COOH functional groups within the BSG polymer chains facilitate crosslinking interactions with calcium ions, leading to the synthesis of BSG nanoparticles (BSG NPs). These NPs exhibit the capacity to encapsulate bioactive molecules such as glutathione (GSH), which are primarily absorbed in the intestinal tract. Studies have shown that BSG NPs could serve as an innovative carrier for the oral administration of tripeptide molecules, such as GSH.[5] In a study, utilisation of supercritical fluid technology was employed to synthesis a three-dimensional (3D) nanoscale network of BSG featuring an average pore diameter of 40 nanometers, notably devoid of clustering. The resultant material demonstrated superior structural integrity and biocompatibility. Due to its capability to form robust 3D architectures with enhanced biological adhesion properties, BSG is identified as a cost-effective polysaccharide with significant potential for applications in pharmaceutical and biomedical domains.[54] BSG has also been specially modified chemically. As an illustration, scanning electron microscopy (SEM) and Fourier-transform infrared spectroscopy (FT-IR) have been used to characterise ethylated BSG with regard to changes in structure. The findings indicate that BSG holds significant potential as an innovative platform for localised drug delivery, effectively enabling controlled in vivo release of therapeutic agents.[59] Li-Sha *et al.* (2022) studied composite gels composed of Phaseolus vulgaris protein isolate and basil seed gum, in which the glucono-delta-lactone (GDL) and sodium citrate induced the formation of the gel, leading to structures with unique mechanical characteristics.[60] BSG can act as a dissolution agent in drug pills. Compared to starch, when BSG is used at 10% (w/w), the disintegration time of tablets remains shorter (154s vs. 269s), and the release level of the medication is unchanged. Tablets prepared using BSG were stable within four weeks at 45 °C without any significant changes in vitro drug release patterns, hardness or in disintegration time.[61] Ghumman *et al.* (2022) constructed a cross-linked hydrogel based on acrylic acid and BSG via the free radical copolymerization technique into a pH-responsive hydrogel. Their study shows that BSG-co-poly (AA) based hydrogel can replace traditional dosage forms with long-term and controlled delivery of drugs.[57] Arachin and basil seed gum (ABG) composite gels were prepared in this work, and they had different mechanical properties. Aar-BSG composite gel crosslinked with NaCl and transglutaminase in particular, has shown improved hardness, springiness and elasticity. To come up with an innovative vitamin D3 (VD3) delivery system, these composite gels were used. It was seen that VD3, when enclosed in composite gels, provided better stability to it in relation to changes in temperature, UV-irradiation, and extended storage.[62] Moreover, the untreated basil seed mucilage has been investigated as a green biosorbent in dispersive solid-phase extraction and enrichment of antibiotics, including doxycycline, tetracycline, and oxytetracycline, and the analysis was conducted by HPLC-UV. In order to extract tetracyclines under an acidic environment, the hairy basil seed was dispersed in the sample solution effectively using ultrasonic waves.[63] Along with the research, a yield of 36.3% of basil seed oil was obtained, and it was encapsulated in hydrogel beads with the help of alginate (S1), gelatin/alginate (S2), and alginate/modified starch/basil seed gum (S3). Of these, S3 beads exhibited the highest long-term stability (180 days), with S2 having better encapsulation efficiency but experiencing greater hydrolysis. In general, the bead hydrogel multilayer strategy demonstrates potential perspectives of basil seed oil in functional foods.[64] BSG oligosaccharides were formed by enzymatic hydrolysis of xylanase and increased probiotic growth, viability and prebiotic action in yoghurt. Optimized yogurt created with the use of BSG and BSG oligos was used with stability, serum release, and working health benefits.[65]

Challenges and Future Perspectives

In general, BSG is known to be a multifunctional plant-derived polysaccharide with desirable physicochemical properties such as gel-forming property, emulsification property, viscosity-modifying property, water-holding property, film-forming property and solubility, which predisposes it towards application in food and pharmaceutical industries and biomedical materials. It is a sustainable substitute for synthetic polymers due to its natural origin, biocompatibility, and biodegradability. BSG is used in pharmaceuticals to aid in controlled release, bioadhesive systems, nanoparticles, hydrogels, wound healing formulations, transdermal patches, and also to allow probiotic and enzyme encapsulation. The food area has its challenges that include standardization, regulatory acceptance, scalability, and interactions with the active pharmaceutical ingredients (APIs) despite its promise. Future studies in this field should aim at maximizing the functional characteristics of BSG, pharmacokinetics and toxicology, as well as advanced delivery technology such as multilayer tablets, hydrogel, and 3D printing of dosage forms. By filling these loopholes, it will assist in positioning BSG as a safe, effective and environmentally friendly excipient and food additive.

CONCLUSION

Overall, BSG is a natural hydrocolloid that has a wide range of functional characteristics with a considerable applicability to the pharmaceutical and food industry. It possesses both the nutritional and therapeutic properties that include, especially, the high proportions of dietary fibre, which justify its use in weight management and functional drinks. The physiological benefits of BSG, such as anti-inflammatory, anti-diabetic, antioxidant, antibacterial, and anticancer, are based on the traditional medicinal application. The utility of BSG is rheologically versatile as it is applicable in the pharmaceutical, nutraceutical, and industrial formulations. Its extraction parameters (temperature and pH) have critical effects on its yield, viscosity and protein content, whereas purification processes significantly modify its chemical profile. Specialised chemical modes of modification are additional improvements in its usage in specific applications such as controlled drug release, emulsions, and bioadhesive systems. It is worth mentioning that BSG is capable of forming stable nanoliposomes, enhancing the bioaccessibility of lycopene, and regulating the release kinetics of drugs in tablet matrices, which highlights the potential of this substance as a multifunctional excipient and food additive that is sustainable.

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CONFLICT OF INTERESTS

The author declares that there is no conflict of interest.

AUTHOR CONTRIBUTIONS

The present work is related to *SDG-3: Good Health and Well-being*. All the authors contributed significantly to this manuscript, participated in reviewing/editing and approved the final draft for publication. The research profile of the author can be verified from their ORCID ids, given below:

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