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Review Article

Application of Glucomannan

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ABSTRACT

Glucomannan (GM) a water-soluble polysaccharide possesses mannose residues which are extracted from tubers, bulbs, softwoods and roots of many plants. Glucomannan is considered to be a dietary fibre which is actually present in some plant species in the form of hemicelluloses component in the cell wall. Its structure consists of linear chain of mixed residues of α-1,4 linked D-mannose and D-glucose monomers arranged in blocks. The molecular weight of native GM lies between $1\times10^4 - 2\times10^6$. Low molecular weight GM could be obtained by de-polymerization technique. The average molecular weight of Konjac Glucomannan (KGM) is 500,000 – 2,000,000 and varies with species, growing area, storage time and processing methods. The glucomannan from different sources vary in its mannose to glucose ratio. Konjac tuber glucomannan has a molar ratio of 1.6:1 or 1.4:1 (ratio differs with konjac breeds), Orchid tubers and Scotch pine have molar ratios of 3.6:1 and 2.1:1 respectively. Diversity of glucomannan also depends on degree of acetylation in GM chain. Values of degree of acetylation are 5to10% or every 19th sugar residue (attached randomly at C-6 position in KGM), is actually responsible to facilitate dispersion and solubility by inhibiting the intra-molecular hydrogen bonds. This solubility function is attractive for multiple pharmaceutical applications. However increase in acetylation degree in GM slows the gelation process. The intrinsic viscosity of KGM solution is highest among the polysaccharides that facilitate swelling behaviour and hence gel formation that finds application in food industry. Gels have good stability, films, hydrogel, beads, micro and nanoparticles of Glucomannan may have potential usage in therapeutic drug delivery systems without causing toxicity. It may also be useful in treatment of chronic constipation, decreasing serum cholesterol, and increasing insulin sensitivity. As a food supplement it could play a significant role in weight loss. Carboxymethylated glucomannan improves the properties of paper, such as burst index, dry tensile index, and wet tensile index. These diverse applications make Glucomannan a most sought after biomolecule.

Keywords: Biomolecule; Glucomannan; Diverse application

INTRODUCTION

GM is considered as a dietary fibre[1] which is actually a water-soluble polysaccharide. It is present in the form of hemicelluloses component in the cell walls of some plant species. GM consists of mannose residues which are extracted from tubers, bulbs, softwoods, roots etc., of many plants.[2–9] Its structure comprises of linear chain of mixed residues of 1,4 linked D-mannose and D-glucose monomers arranged in blocks. The mannan residues are perhaps mediated with one or two glucose residues.[10–14] The glucomannan from different sources varies in its mannose to glucose ratio for example glucomannan extracted from Konjac tubers have a molar ratio of 1.6:1 or1.4:1 (ratio differ with konjac breeds) while those extracted from Orchid tubers and Scotch pine have molar ratios of 3.6:1 and2.1:1 respectively.[10–12,15,16]

The diversity of glucomannan depends on degree of acetylation in GM chain. Generally the acetylation degree values are 5 to 10% or of the every 19th sugar residue (attached randomly at C-6 position in KGM), actually facilitates dispersion and solubility by inhibiting the intra-molecular hydrogen bonds. This solubility function is attractive for multiple pharmaceutical applications. However, increase in acetylation degree in GM slows down the gelation process.[17–20]

The molecular weight of native GM lies between 1×10^4 to 2×10^6, and average molecular weight of KGM is 500,000–2,000,000. The molecular weight varies with species, growing area, storage time and processing methods. Low molecular weight GM could be obtained by de-polymerization. The intrinsic viscosity of KGM solution is highest among the polysaccharides. This property facilitates swelling behavior and gel formation. The gels have good stability and are generally thermo irreversible.[10,11,21–24]

APPLICATIONS OF GLUCOMANNAN

In Food Industry

Glucomannan finds major application in food industry as a food additive as emulsifying agent and thickening agent. It has been reported that GM properties such as emulsification, suspension, stabilization and thickening are pH dependent. For example KGM possess water retention, suspension, and stabilization properties at pH less than10.[25,26]

Gelation and high viscosity are the prominent properties of glucomannan that can be utilized in food industry, such as thickener in the syrup, jelly, edible film, noodle, and binder in sausage as reported for GM from *Amorphophallus konjanc.*[7]

Health Benefits

Alleviations of Constipation

Glucomannan is a soluble fiber and it has been examined for the treatment of constipation. Glucomannan may relieve constipation by decreasing fecal transit time.[27] In the treatment of chronic constipation, glucomannan significantly improves symptoms of constipation while being well-tolerated and free of relevant side effects.[28]

Reduction in Cholesterol levels

Glucomannan significantly improve the total cholesterol in obese patients.[29] In a trial in healthy men, administration of 3.9 grams per day of glucomannan four weeks, decreased total cholesterol, low-density lipoprotein, triglycerides and systolic blood pressure. Notably, triglycerides dropped by 23%.[30] Glucomannan has also been tested in children with high cholesterol in conjunction with a diet. Researchers have reported greater decreases in total cholesterol and low density lipoprotein in girls when compared to boys.[31] When GM is used in conjunction with chitosan, glucomannan decreases serum cholesterol, possibly by increasing steroid excretion via the faeces.[32] Beneficial effect is obtained with a daily intake of 4 g of glucomannan (normal blood cholesterol levels).

Therapeutic role in Type 2 diabetes

Glucomannan can also be used as therapeutic adjunct for type 2 diabetes. It has been found to improve the lipid profile and alleviate the fasting blood glucose levels in type 2 diabetics.[33] Glucomannan is also effective in increasing insulin sensitivity and improving glycemia and risk factor for coronary heart disease.[34]

Weight loss

The use of glucomannan for weight loss has given mixed results.[29,35,36] Systematic review and meta analysis of clinical trials failed to show that glucomannan supplement could play any significant role in weight loss.[37] A 2015 research meta analysis originally showed a statistically significant reduction in bodyweight, but no reduction in BMI when glucomannan was compared to placebo. Finding a critical mathematical error in two of the source documents, other researchers updated the meta analysis. In the corrected analysis glucomannan showed no difference in weight loss, but the BMI decreased statistically more in the placebo group.[6,38,39]

Drug delivery

It has been reported that films, hydrogel, beads, microparticles and nanoparticles of Glucomannan may have potential usage for drug delivery systems without causing toxicity. KGM is used in drug delivery system, for bio-adhesive properties, improvement in cellular therapy and as gel filler material in prosthetic implants in pharmaceutical industry.[40]

Pre-biotic activity

In the lower gut fermentation of glucomannan dietary fiber can produce short chain fatty acid (SCFA). Previously reported studies prove that in case of konjac glucomannan there was increase in acetic acid, propionic acid, and butyric acid content both in in vitro and in vivo.[41–43] In order to get fermented in colon, fiber must reach colon without digestion in the upper gut and selectively stimulate growth and/or activity of gut microbiota that confer health benefits to the host. Those are related with the prebiotic activity. The ability of glucomannan in stimulating growth of bifidobacteria and lacto-bacillus, and suppressing *Escherichia coli* and *Clostridium perfringens* have been reported.[41–43] Theoretically, glucomannan might be used by lactobacilli and bifidobacteria as there were enzymes secreted by other colon microbiota. It could hydrolyze glucomannan to produce oligosaccharide or monosaccharide,[44] such as mannopentaose, mannotetraose, mannotriose, mannobiose, and mannose.[45] The enzymes were β-glucanase and 1,4 and β-D-mannanase secreted by bacilli and clostridium groups.[46] Hydrolyzed product may be fermented easily by cecal bifidobacteria through bifidoa shunt[44] and Embden Meyerhof Parnas (EMP) pathway.

Probiotic effect

Polysaccharides of glucomannan may be hydrolysed to lower molecular weight molecules by the action of acids or enzymes specifically mannanases or cellulases. The hydrolysates produced from konjac glucomannan by the two enzyme systems mannanase and cellulase is effective for stimulating the growth of lactic acid bacteria.[47]

In cosmetic industry

The symbiotic ability of probiotic bacteria and konjac glucomannan hydrolysates (GMH) to inhibit acne-inducing bacterium, Propionibacterium acnes growth was studied in vitro. All strains of probiotic bacteria were tested. They all were able to inhibit the growth of this species of skin bacterium where the inhibition was significantly (P<0.01) enhanced by the presence of the GMH prebiotic. As the current treatment of acne is based on topical or systemic drugs, it is worth examining further the bio-therapeutic activities of the GMH and selected probiotics with a view to future use as prophylactic or therapeutic synbiotics for treating acne infections.[48]

Blended polymers

Glucomannan and its derivatives combine with natural or synthetic polymers to boost up the desired properties of polymer. Chitosan and alginate are now the two most frequently studied polymers for blends.

Paper strengthening agent

The previously reported study demonstrated that carboxymethylated glucomannan could improve the paper properties. Addition of 0.9% carboxymethylated glucomannan significantly increased the density, burst index, tensile index, folding endurance of paper. Polyamide-epichlorohydrin (PAE) is found to improve the wet strength of paper. Combination of 0.6% PAE and 0.6% carboxymethylated glucomannan increase the burst index, dry tensile index, wet tensile index of paper by 14.1%, 25%, 34.3%, respectively, as compared to that of the control, where there is decrease in the folding endurance. The dry tensile index and wet tensile index were increased with increasing the carboxymethylation time of glucomannan. When the carboxymethylation time was 40 min, these properties were increased by 13.4% and19.3%, respectively, as compared with that of the 25 min carboxymethylation time. The results indicated that PAE and carboxymethylated glucomannan had a synergistic effect. SEM analysis showed that paper strengthening agent could increase the combination of fibers in paper.[49]

Water binding properties

Carboxymethyl modification of konjac glucomannan affects water binding properties. The water binding properties of konjac glucomannan (KGM) and carboxymethyl konjac glucomannan (CMKGM) has various applications in food, pharmaceutical, and chemical engineering fields. The equilibrium moisture content of CMKGM was lower than that of KGM at the relative humidity in the range 30–95% at 25°C. The water absorption and solubility of CMKGM in water were lower than that of KGM at 25°C. Carboxymethyl modification of KGM reduces the water adsorption, absorption and solubility. Both carboxymethylation and deacetylation could confer hydrophobicity to CMKGM.[50]

CONCLUSION

Primary root and tuber crops starchy roots, tubers, rhizomes, corms and stems have high water content (70-80%). These crops contain mainly carbohydrates (largely starches that account for 16-24 percent of their total weight) with very little protein and fat (0-2% each). It is used mainly for human food (as such or in processed form), for animal feed and for manufacturing starch, alcohol and fermented beverages including beer (http://www.fao.org). For economic and commercial benefits there is a need to separate out the biomolecules; evaluate its nutritional importance as well as study for other diverse industrial applications.

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