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Review

Locust bean gum: Processing, properties and food applications—A review

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ABSTRACT

Locust bean gum or carob gum is a galactomannan obtained from seed endosperm of carob tree i.e. *Ceratonia siliqua*. It is widely utilized as an additive in various industries such as food, pharmaceuticals, paper, textile, oil well drilling and cosmetics. Industrial applications of locust bean gum are due to its ability to form hydrogen bonding with water molecule. It is also beneficial in the control of many health problems like diabetes, bowel movements, heart disease and colon cancer due to its dietary fiber action. This article focuses on production, processing, composition, properties, food applications and health benefits of locust bean gum.

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1. Introduction

Locust bean gum is a white to creamy white powder obtained after milling of seed endosperm of fruit pod of the carob tree, a member of legume family, botanically known as *Ceratonia siliqua* L. which is found in Mediterranean regions. Hence, locust bean gum is also known as carob gum. The carob seed is consists of three parts i.e. husk, endosperm and germ. The processing of carob gum first involves the removal of hull from the seed which can be attained via thermo-mechanical or by chemical treatment [1]. After removal of the outer layer i.e. the hull, the seeds are split lengthwise and the germ portion is separated from the endosperm of carob seed. Further, the isolated endosperms are subjected to grinding, sifting, grading, packaging and finally marketed as locust bean gum or LBG. All the operations in LBG processing are designed such that any impurity from husk or germ portion can be avoided which can ultimately alter the properties of the carob gum. Galactomannans are linear polysaccharides consists of β-(1–4)-mannose backbone with single D-galactopyranosyl units attached via α-(1–6) linkages as side branch. These side branches are not distributed uniformly in the main backbone chain [2,3]. There are also present some unsubstituted β-D-mannopyranosyl chain segments, alternating with β-D-mannopyranosyl units substituted with α-D-galactopyranosyl side branches [4–7]. Carob galactomannan is one of the commercial galactomannans guar gum and tara gum; and among these galactomannans LBG has the lowest galactose content about twenty percent [8]. Locust bean gum generally has an average mannose to galactose ratio of about 3.5 which is highest among the commercially available galactomannan such as guar gum (1.8) and tara gum (3.0). The degree of galactose substitution on mannose chain affects water solubility of the galactomannan. This is reason because guar gum is cold water soluble whereas LBG shows low solubility at ambient temperature and there is a requirement of heat treatment for maximum solubility to achieve the best water binding capacity [9]. The molecular size, mannose to galactose ratio, galactose distribution in the mannose backbone chain influences solubility and also controls the rheological properties of LBG. Different chromatography techniques can be used to characterize carob galactomannan structure. The molecular weight distributions can be determined using size exclusion chromatography and mannose to galactose ratio can be generally determined using gas chromatography. LBG is considered as the first galactomannan used as additive in industries such as paper industry, textile industry, pharmaceutical industry, cosmetic industry and food industries. The important characteristic of this gum that make it a useful industrial gum is its ability to form very viscous aqueous solution at relatively low concentration, to stabilize emulsion and to replace fat in many food products. Being non-ionic in nature, locust bean gum solutions are not influenced by pH, salts and heat treatment. Locust bean gum can be used in combination with other hydrocolloids such as carrageenan and xanthan gum as it shows synergistic action with them and forms a gel with more elasticity and strength [10]. Locust bean gum is suitable for many food applications as it provides a creamy mouthfeel. It is typically added in cream-cheese spreads to impart richness and spreadability. It is especially useful in preventing syneresis in various food products. LBG also create a smooth mouthfeel in sauces. LBG's ability to bind water makes it an excellent choice for frozen applications, such as ice cream as it will slow down and reduces the size of ice-crystal formation as the moisture is retained within the ice cream. LBG also finds application in yoghurt manufacture. In yoghurt, it reduces the syneresis and enhances water holding capacity of yoghurt when used at certain levels [11]. Recently, LBG is used in edible films and improved the properties of films such as water vapor permeability, oxygen permeability, tensile strength and elongation-at-break [12]. In edible coatings, when locust bean gum is used in combination with other hydrocolloid such as κ-carrageenan; it improves the properties of the film due to its synergistic action. LBG is also used as thickener, stabilizer and gelling agent in various food products such as baked foods, beverages, dairy products and processed fruit products. Locust bean gum is classified as GRAS (Generally recognized as safe) by FDA and is used for its stabilizing, thickening and fat-replacing properties [13].

2. Production

Locust bean gum is extracted from the seed endosperm of the carob tree plant botanically known as *C. siliqua*. It belongs to the subfamily Caesalpinioideae of the Leguminosae family [14]. Carob plant is typical tree of semiarid environments. It is very abundant in the Mediterranean region since ancient times and is currently produced in Spain, Italy, Cyprus and other Mediterranean countries. Its localization also extends to different regions of North Africa, South America, and Asia. Other known carob producing countries are Morocco, Greece, Algeria, Turkey, Israel, India and Pakistan. Carob plant is long-lived evergreen tree and after germination, it grows to about 10 m height in 10–15 years. The carob tree may not be fully grown until it is 50 years old and it starts to bear good quantities of pods at the age of 15 years. The pods reach to full size in July but are ripened in October. Hot and dry climatic conditions are required for good yields. Large trees can yield up to half ton of pods per annum. Carob tree yields large brown fruits known as carob pods. These carob pods are sickle shaped and are 10–20 cm in length and 2–4 cm in width. These sickle shaped pods contain 10–15 oval shaped carob seeds or kernels. The polysaccharide from seed endosperm of carob tree is also referred in the literature as carob bean gum, carob seed gum, carob flour, or even *ceratonia* [15]. World production of carob seeds is estimated at about 315,000 tons per year, produced from two lakhs hectare. The main producers include Morocco (38%), Spain (28%), Italy (8%), Portugal (8%), Greece (6%), Turkey (6%) and Cyprus (2%) [14]. Recently, growing interest for locust bean gum has been observed due to its various industrial applications. Locust bean gum is used as a thickening and stabilizing agent in food, cosmetic and pharmaceuticals industries [16]. In food industry it is a food additive with E-number E-410 in the European Union [17]. Pharmaceutical applications of locust bean gum are mainly due to its ability as controlled release excipient in tablets. Biodegradability, low toxicity and low cost of locust bean gum contribute for its increasing utilization in various fields.

3. Processing

The carob pods are kibbled to separate the seeds from the pulp portion. The processing of carob seeds includes dehusking (acid or thermo-mechanical), splitting, milling, sifting, clarification and drying. The processing of carob seeds is very difficult due to its very tough and hard seed coat. The dehusking of carob kernels is achieved by treatment of carob seeds with dilute sulphuric acid or with thermo-mechanical treatment known as acid peeling and thermal peeling, respectively. In acid peeling process, carob seeds are treated with sulphuric acid at elevated temperature to carbonize the seed coat. The remaining portions of the seed coat are separated and removed from the endosperm portion by efficient washing and brushing process. The peeled kernels are dried and cracked and the more friable germ gets crushed. The germ parts are sifted off from the unbroken endosperm halves known as splits. The carob bean gum produced from the carob splits by this process is whitish in color and has higher viscosity. In thermo-mechanical peeling process, roasting of carob kernels are carried out in rotating furnace where the seed coat gets pop off from the internal portions of carob kernels. The endosperm halves or carob splits are obtained