International Journal of Biological Macromolecules 88 (2016) 361–372

Contents lists available at ScienceDirect

International Journal of Biological Macromolecules

journal homepage: www.elsevier.com/locate/ijbiomac

Guar gum as a promising starting material for diverse applications: A review

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ARTICLE INFO

Article history:
Received 30 December 2015
Received in revised form 28 March 2016
Accepted 1 April 2016
Available online 1 April 2016

Keywords:
Galactomannan
Cluster bean
Polysaccharide
Food
Agriculture

ABSTRACT

Guar gum is the powdered endosperm of the seeds of the *Cyamopsis tetragonolobus* which is a leguminous crop. The endosperm contains a complex polysaccharide called galactomannan, which is a polymer of D-galactose and D-mannose. This hydroxyl group rich polymer when added to water forms hydrogen bonding imparting significant viscosity and thickening to the solution. Due to its thickening, emulsifying, binding and gelling properties, quick solubility in cold water, wide pH stability, film forming ability and biodegradability, it finds applications in large number of industries. In last few decades a lot of research has been done on guar gum to fit it into particular application, as such or by its structural modifications. This review gives an overview of the nature, chemistry and properties of guar gum and discusses recent developments in its modifications and applications in major industries like hydraulic fracturing, explosives, food, agriculture, textile, paper, cosmetics, bioremediation, drug delivery, medical and pharmaceuticals. This article would help researchers engaged in biopolymer area and other end-users who want to begin research in natural polysaccharides.

1. Introduction

Polysaccharides are complex polymers comprising multiple monosaccharides units interlinked with glycosidic linkages to form a large, branched or unbranched chain. The polysaccharides obtained from biological origin are called natural polysaccharides. Natural polysaccharides are developing interest as source of materials because of their non-toxicity, safety, biodegradability, biocompatibility, renewability, cheaper prices and availability factors [1]. In living organisms, they usually have two roles, either structure or storage-related. Cellulose and starch are structural and energy storage polysaccharides in plants, whereas chitin and glycogen are in animals, respectively [2]. Based on their unique multifunctionality, they exhibit specific properties and play a peculiar role in the product derived from them. Most of the natural polysaccharides used in food, pharmaceutical and cosmetic industries are regarded as safe for humans. The industrial applications of natural polysaccharides have expanded tremendously in recent years because of their multipurpose role as thickener, suspending agent, moisturizer, emulsifier, emollient as well as wound-healing agents. The use of natural polysaccharides in other industries like food, pharmaceuticals, cosmetics, textile, paper, paint, adhesive etc. is also flourishing due to their environmental safety.

Natural gums are naturally originating polysaccharides, capable of producing considerable increase in the viscosity of solution, even at smaller concentrations. Being of biological origin, the gum molecules show tremendous variation in length of linear chain, branching characteristics, molecular weight, etc. They also contain other moieties like proteins, in slightly variable ratio, which affect their behavior. They are generally insoluble in oils or organic solvents such as, hydrocarbons, ether or alcohols. On hydrolysis, they may yield combination of arabinose, galactose, xylose, rhamnose, dextrose, mannose, uronic acids, etc. Besides, gums also contain other active principles which generate pharmacological activities exhibited by them.

Natural gums are hydrophilic polysaccharides derived from plants or microbial sources. Depending upon the source, they are classified as plant exudate gum, seed gum, microbial gum or marine gums. Exudate gums, like gum arabic, gum karaya, salai gum, etc., are produced by the disintegration of plant cellulose through the process called gummosis. Seed gums, such as guar gum, tamarind gum, locust bean gum, etc., are obtained from the embryos of

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http://dx.doi.org/10.1016/j.ijbiomac.2016.04.001
0141-8130/

some seeds, where they are actually stored as food reserve. Microbial gums are produced by certain selected microorganisms viz. xanthan gum from *Xanthomonas campestris,* gellan gum from *Pseudomonas elodea* and dextran gum from *Leuconostoc* spp., in course of fermentation. Marine gums like carrageenans, alginic acid, etc. are either cell walls of variety of algae, other sea weeds or stored in intracellular regions as reserve food materials. Starch, cellulose, galactomannan, xyloglucan, sodium alginate, xanthan gum, dextran, carrageenan and hyaluronic acids are some of the commonly used and commercially important polysaccharides [2].

Out of these polysaccharides, galactomannans are often used in food products to improve the viscosity of the aqueous recipes. They are linear polysaccharides consisting of a mannose backbone to which galactose units are attached as side chains. Galactomannans exhibit a wide range of new and commercially useful properties. They constitute the second largest storage polysaccharides group, and have been found in the form of endosperm or cell wall in the seeds of many plants [3–7]. Though many plants are reported as a source for galactomannan, only locust bean, guar, tara and cassia gum are manufactured commercially. Out of these sources of galactomannans, guar gum being readily available at cheaper cost is extensively investigated by various researchers.

Numerous reviews on guar gum are available which focus on guar gum and its applications either in drug delivery or pharmaceuticals or other areas. However, there is no specific review reported as yet on guar gum discussing its chemistry, properties, modifications and applications of modified derivatives in extensive areas altogether. This review discusses in detail, the recent developments on guar gum, its derivatives and their applications in wide-ranging areas.

2. Guar gum

2.1. Cultivation

Guar or cluster bean is an annual agricultural crop *Cyamopsis tetragonolobus*, belonging to family leguminosae. It is grown in arid zones of west and north-west India, Pakistan, Sudan and parts of USA. Guar gum, also called as Cyamopsis gum, Guaran, Guyan, Guarina or Glucotard, is a natural non-ionic, water soluble polysaccharide obtained from guar plant. The guar plant is about 0.6 m tall, and resembles soybean plant in general appearance and its pod arrangement on the vertical stem. The pods measuring 5–12.5 cm, contain, on an average 5–6 spherical, light brown seeds [8]. Guar gum is extracted from the guar seeds, which is present in the form of endosperm. This acts as a reserve food supply for the embryo at the time of germination. Guar seed being dicotyledonous, two endosperm halves are present in it. These endosperm halves surround the embryo, also called as germ, and they are in turn surrounded by hull. Color of the hull differs from variety to variety which is usually light tan to dark in color. The germ and hull of guar seed are collectively called as guar meal, which is very rich in protein. Embryo is the innermost part which contributes nearly 43–47% of the weight of the seed. Endosperms surrounding germ comprises 35–42% weight, whereas outermost hull contributes 14–17% [9]. The prevalent monsoons of the Indian sub-continent provides ideal climate for guar crop. India and Pakistan collectively grows about 90% of world's guar. India accounts for 80% of the world's total guar production [10]. India's total guar seed production in the year 2013–2014, was 3388.4 thousand tons, out of which about 84.5% was produced by Rajasthan state alone [11]. The seeds are processed to obtain guar gum and part of guar seeds it is exported as such. India is the leading exporter of guar seeds as well as guar gum [12]. In the year 2013–2014 around 650 thousand tons

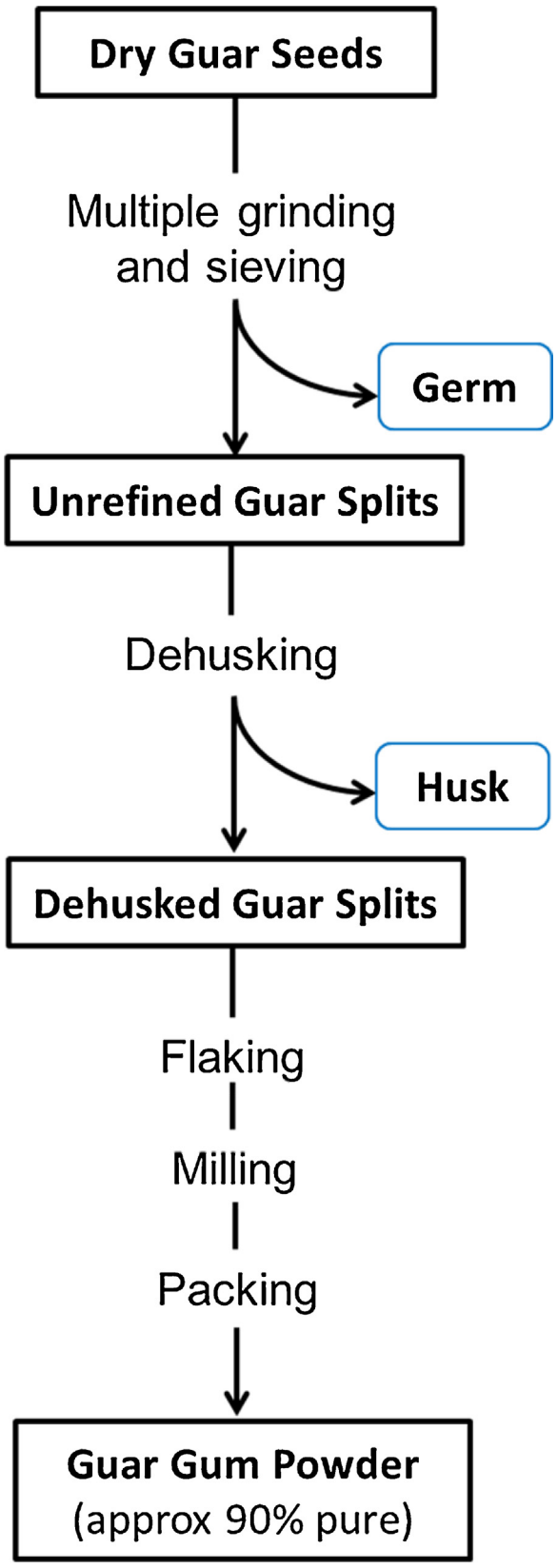

Fig. 1. Schematic flow chart for guar gum extraction.