Carbohydrate Polymers 94 (2013) 814–821

Contents lists available at SciVerse ScienceDirect

Carbohydrate Polymers

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

Review

Locust bean gum: A versatile biopolymer

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ARTICLE INFO

Article history:
Received 14 December 2012
Accepted 13 January 2013
Available online 11 February 2013

Keywords:
Locust bean gum
Carob bean gum
Polysaccharides
Galactomanans
Pharmaceutical applications

ABSTRACT

Biopolymers or natural polymers are an attractive class of biodegradable polymers since they are derived from natural sources, easily available, relatively cheap and can be modified by suitable reagent. Locust bean gum is one of them that have a wide potentiality in drug formulations due to its extensive application as food additive and its recognized lack of toxicity. It can be tailored to suit its demands of applicants in both the pharmaceutical and biomedical areas. Locust bean gum has a wide application either in the field of novel drug delivery system as rate controlling excipients or in tissue engineering as scaffold formation. Through keen references of reported literature on locust bean gum, in this review, we have described critical aspects of locust bean gum, its manufacturing process, physicochemical properties and applications in various drug delivery systems.

Contents

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http://dx.doi.org/10.1016/j.carbpol.2013.01.086

1. Introduction

Polysaccharides have been finding, in the last decades, very interesting and useful applications in the biomedical and, specifically, in the biopharmaceutical field (Marita & Ana, 2012). The source of natural polymers is the carbohydrate molecules. These polysaccharides have been extracted or isolated from plant seed sources such as locust bean gum, guar gum, tara gum and tamarind. The polysaccharides or gums are derived from the endosperm of various plants (mainly from leguminosae) seeds, where they function as reserve materials utilized during germination. Most of these polysaccharides share basic structural similarities known as galactomanans. Thus galactomanans are polysaccharides consisting mainly of the monosaccharide mannose and galactose units. The mannose elements from linear chain linked with galactopyranosyl residues as side chain at varying distances depending on the plant origin (Cerqueira, 2009). Like other galactomanans, locust bean gum is also derived from the endosperm of the seeds of *Ceratonia siliqua* Linn. belonging to the family Fabaceae.

Polymers are macromolecules comprised of repeating units of small molecules, the monomer. The monomers can be linked together to form linear polymer or branched polymer or cross-linked polymers. Linear polymers and branched polymers are referred as thermoplastic materials as they flow on heating. They also show solubility in certain solvents. Locust bean gum is branched polymer (Paramita, Biswanath, & Sabyasachi, 2011). Biopolymers or natural polymers are an attractive class of biodegradable polymers since they are derived from natural sources, easily available, relatively cheap and can be modified by suitable reagent. The specific application of plant derived polymers in pharmaceutical formulation include their use in the manufacture of solid monolithic matrix system, implants, films, beads, micro particles, nano particles, inhalable and injectable system as well as viscous liquid formulations (Alonso, Teijeiro, Remunan, & Alonso, 2008; Chamarthy & Pinal, 2008; Pandey & Khuller, 2004). The successful formulation of stable and effective dosage form therefore depends on the careful selection of excipients. The present trend focuses on an increasing interest in the use of natural ingredients in food, drugs and cosmetics (Bhardwaj, Kanwar, Lal, & Gupta, 2000; Miyazaki, Kubo, & Attwood, 2000; Quong & Neufeld, 1999; Sultzbaugh & Speaker, 1996; Tonnesen & Karlsen, 2002). Traditionally, excipients were in drug formulations as inert vehicles that provided the necessary weight, consistency and volume for the correct administration of the active ingredient, but in modern pharmaceutical dosage forms they often fulfill multi-functional roles such as improvement of the stability, release and bioavailability of the active ingredient, enhancement of patient acceptability and performance of technological functions that ensure ease of manufacture (Beneke, Viljeon, & Hamman, 2009; Hamman & Tarirai, 2006).

The biological activity of polysaccharides is being increasingly recognized for human applications (Rinaudo, 2008). Polysaccharides have been marking a strong position in the biomedical field, as their different chemical structure and physical properties comprise a large source of materials that can be used in different applications, varying from tissue engineering and preparation of drug vehicles for controlled release, to imagine techniques and associated diagnosis. In general, polysaccharides play leading role as a thickening, gelling, emulsifying, hydrating and suspending agent, finding diverse applications in the above mentioned areas (Rinaudo, 2008). The most common basic unit of polysaccharides is the monosaccharide D-glucose although D-fructose, D-galactose, L-galactose, D-mannose, L-arabinose and D-xylose are also frequently present. Some polysaccharides comprise monosaccharide derivatives in their structure, like the amino sugars D-glucosamine and D-galactosamine, as well as their derivatives N-acetylneuraminic acid and N-acetylmuraminic acid, and simple sugar acids (glucuronic acid and iduronic acid). In some cases, polysaccharides are collectively named for the sugar unit they contain, so glucose-based polysaccharides are called glucans, while mannose-based polysaccharides are mannans (D'Ayala, Malinconico, & Laurienzo, 2008).

Locust bean gum (Fig. 1) is a popular natural polymer which is mostly used in food industry as well as in pharmaceutical industry. This natural polymer is conventionally used as an excipients in manufacturing different formulation which mainly depends on its thickening and gelling property (Paramita et al., 2011). Locust bean gum is a non starch polysaccharides consisting of galactose and mannose in the ratio 1:4 and hence they are known as galactomanan (Parvathy, Susheelamma, Tharanathan, & Gaonkar, 2005). The mannose elements from a linear chain linked with galactopyranosyl residues at side chain at varying distance depending on the plant origin (Sharma, Dhuldhoya, & Merchant, 2008). Being a galactomanan, locust bean gum has a wide application in pharmaceutical field. It is also known as carob bean gum and is derived from the seeds of the leguminous plant *C. siliqua* Linn. belonging to family Fabaceae. This gum is widely cultivated in the Mediterranean region and to smaller extent also in California. The brown pods or beans of the locust bean tree are processed by milling the endosperms to form locust bean gum (Beneke et al., 2009).

Locust bean gum mainly consists of a neutral galactomanan polymer made up of 1,4-linked D-mannopyronosyl units and every fourth of fifth chain is substituted on C6 with a D-galactopyranosyl unit (Dea & Morrison, 1975; Venkataraju, Gowda, Rajesh, & Shiva, 2007). The ratio of D-galactose to D-mannose differs and this is believed to be due to the varying origins of the gum materials and growth conditions of the plant during production. The physicochemical properties of galactomanan are strongly influenced by the galactose content and distribution of the galactose units along the main chain. Longer galactose side chains produce stronger synergistic interaction with other polymers and greater functionality. Since it is a neutral polymer and its viscosity and solubility are therefore little affected by pH changes within the range of 3–11 (Deuel & Neukom, 1954; Yang, Zhou, & Deng, 2004).

Locust bean gum has a wide potential in drug formulation due to their extensive application as food additives and their recognized lack of toxicity. It can be tailored to suit the demands of applicants in both the pharmaceutical and biomedical areas. In this context, it has been showing its application in the design of drug delivery systems, providing the delivery of a defined dose, at a chosen rate, to a targeted biological site. This review article is prepared to focus on the present use and the diversified application of locust bean gum in both the pharmaceutical and biotechnological fields.

2. Processing of locust bean gum

Locust bean gum is extracted from the seeds of the carob tree (*C. siliqua*), which is very abundant in the Mediterranean region although its localization also extends to various regions of North Africa, South America and Asia.

2.1. Manufacturing principle

Carob seeds, which represent approximately 10% of the weight of the fruit, are industrially processed by hull cracking, sifting, and milling operations to isolate and grind the endosperms, which are then sold as crude flour (Bouzoita et al., 2007; Dakia, Blecker, Robert, Whatelet, & Paquot, 2008). The endosperms are recovered after separation of the husk and the germ and milled. The clarified gum is obtained by dissolution in hot water and then recovery by precipitation in ethanol or isopropanol. Fig. 2 shows the processing flow chart of locust bean gum.

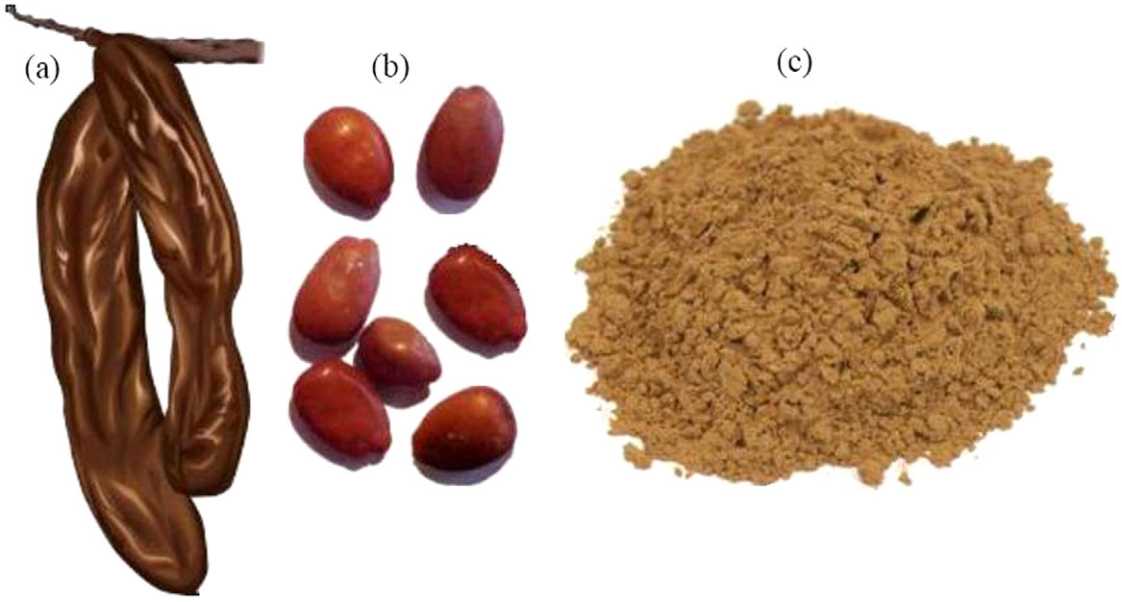

Fig. 1. Locust bean gum (a) pods, (b) seeds and (c) powder.

2.2. Manufacturing aspect

The carob kernels are difficult to process, since the seed coat is very tough and hard. By special processes, the kernels are peeled without damaging the endosperm and the germ. The following procedures are applied.

2.2.1. Acid peeling process

The kernels are treated with sulfuric acid at a certain temperature to carbonize the seed coat. The remaining fragments of the seed coat are removed from the clean endosperm in an efficient washing and brushing process. The peeled kernels are then dried, cracked and the more friable germ gets crushed. The germ parts are sifted off from the unbroken endosperm halves. The carob bean gum produced by this process is whitish and has higher viscosity.

2.2.2. Thermal peeling process

Alternatively, the kernels may be roasted in a rotating furnace where the seed coat more or less pops off from the rest. The endosperm halves are recovered from the burned husk and the crashed germs. This process yields a product of somewhat darker color. The effect is that no sulfuric acid as processing aid is necessary and therefore, no effluent originates from the production process.

Afterward, the isolated endosperm is ground to fine particle size powder which represents the final product "Carob bean gum".

3. Physicochemical properties of locust bean gum

Various properties are there which make locust bean gum a good choice in drug delivery (Paramita et al., 2011).

- They are biocompatible, biosorbable and biodegradable in nature.
- It is non-teratogenic and non-mutagenic according to Joint FAO/WHO Expert Committee on Food Additives held in Geneva, April' 75.
- Acceptable shelf-life.
- Degradation products are excreted readily.

3.1. Composition and properties

Locust bean gum is comprised of a high molecular weight polysaccharides composed of galactomanans consisting of a (1–4)-linked β-D-mannose backbone with (1–6)-linked side chains of α-D-galactose (Daas, Grolle, Vliet, Schols, & de Jongh, 2002; Mathur & Mathur, 2005), being thus neutral polymers (Beneke et al., 2009). INEC technical committee reports that the standard method using the consumption of sodium chlorite is unsuitable and recommends a gel permeation chromatography method. This provides a molecular weight range of 50,000–300,000.

The various galactomanans can be differentiated by the displayed mannose:galactose ratio (M/G ratio), the substitution pattern of side chain units and their molecular weight, the latter being influenced by harvesting and manufacturing practices, among other factors (Picout, Ross-Murphy, Jumel, & Harding, 2002). The M/G ratio varies, therefore, depending on the distribution of the galactose units over the mannose backbone, being approximately 4:1 for locust bean gum (Coviello, Alhaique, Dorigo, Matricardi, & Grassi, 2007), 3:1 for tara gum and 2:1 for guar gum (Andrade, Azero, Luciano, & Goncalves, 1999). This ratio is main characteristic affecting galactomanans solubility, as higher water solubility is afforded by higher galactose content (Rinaudo, 2008), an effect that has been justified by the introduction of an entropic, and perhaps steric, barrier to the ordered mannose chains (Picout et al., 2002). This observation makes guar gum the most soluble and also the most widely used of the galactomanans. Fig. 3 shows the structure of locust bean gum consisting of mannose and galactose.

3.2. Possible impurities

The commercial samples of carob bean gum contain approximately 5–12% moisture, 1.7–5% acid-soluble ash, 0.4–1.0% ash, and 3–7% protein. The samples of clarified carob bean gum contains approximately 3–10% moisture, 0.1–3% acid-soluble matter, 0.1–1% ash, and 0.1–0.7% protein.

The possible impurities are

- Husk (reflected by the acid-insoluble-matter criterion).
- The germ (adequately reflected by the protein criterion).

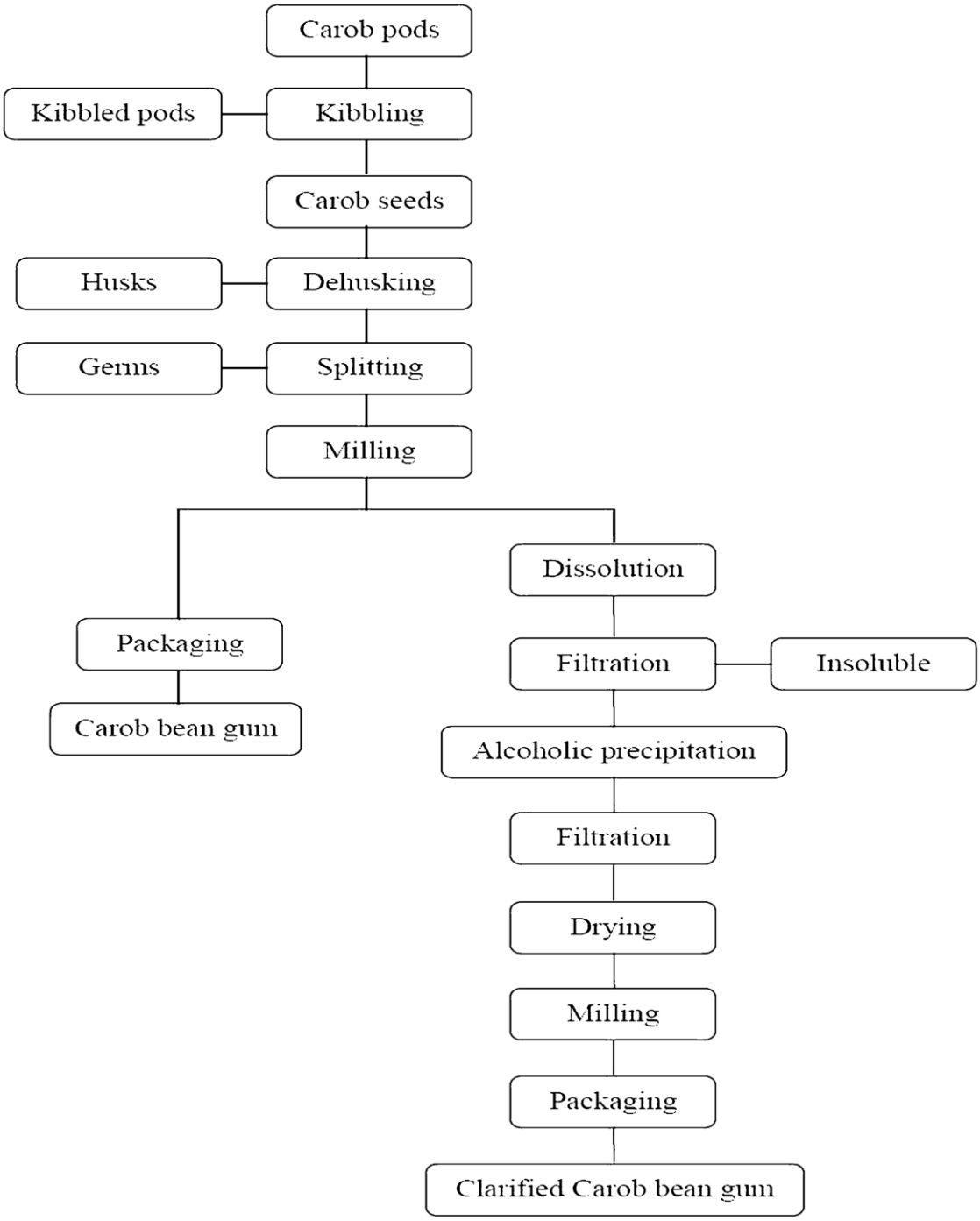

Fig. 2. Locust bean gum processing flow chart.

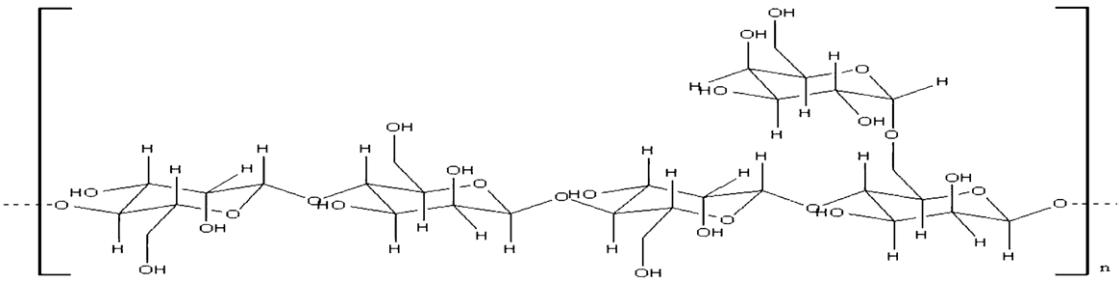

Fig. 3. Structure of locust bean gum consisting of mannose and galactose.

- Residual amounts of ethanol or isopropanol for washing or extraction solvent (limited to 1%, singly or in combination).
- Microbiological contamination.

4. Applications of locust bean gum

The natural origin, as well as some specific individual characteristic, is an asset to make products more appealing to consumers. In the field of drug delivery many efforts being devoted, in the last decades, to the development of an appropriate delivery system that avoid or minimize side effects, while improving the therapeutic efficacy. The application of natural polymers in pharmaceutical formulation in extremely varied, comprising the production of solid monolithic matrix system, implants, films, beads, microparticles, nanoparticles, inhalable, and injectable systems, as well as viscous liquid and gel formulations. Within these dosage forms, polymeric materials have different functions such as binders, matrix formers, drug release modifiers, coatings, thickeners, or viscosity enhancers, stabilizer, disintegrators, solubilizers, emulsifiers, suspending agents, gelling agents, and bioadhesives (Beneke et al., 2009).

There are various reports available showing that locust bean gum can be used in pharmaceutical and biotechnological purpose.

4.1. Applications in oral drug delivery

Oral controlled release system continue to be the most popular once among all the delivery systems and locust bean gum shows a wide application in the development and preparation of various novel drug delivery systems. The application of locust bean gum in oral delivery system is mainly focus on its use as matrix forming material in tablets, benefiting from the fact that polysaccharides are generally considered to play an important role in drug release mechanisms from matrixes (Naganagouda, Salimath, & Mulimani, 2009). In these systems, usually intended to provide systemic drug absorption, locust bean gum contributes with its swelling ability to afford a control release of the drug. Moreover, in most case it is observed that the association of locust bean gum with second polymer affords an improved effect, benefitting from specific interaction occurring between the polymers.

The first work reporting locust bean gum application in tablet formulation as single polysaccharide excipients dates to 1998, when Sujja-areevath et al. reported the production of sodium diclofenac mini-matrixes containing 49.5% locust bean gum. Optimized tablets had a drug/polymer ratio of 1/1, as higher ratios led to loss of matrix integrity. The formulation containing locust bean gum evidenced lower swelling (50% in 6 h) than those containing xanthan (250% in 6 h) or karaya gum (150% in 6 h) and the swelling rate was observed to approximately follow Fick's diffusion law. However, drug release kinetics and polymer erosion were non-Fickian and, as compared with the other gums, tablets based on locust bean gum displayed the fastest erosion in phosphate buffer pH 7.0 (65% versus 45% and 25% for xanthan and karaya gum, respectively) (Sujja-areevath, Munday, Cox, & Khan, 1998). Another work consisted in the design of a locust bean gum matrix tablet for the incorporation and release of theophylline and myoglobin. The tablet was further cross-linked with glutaraldehyde in an attempt to provide the network with the potential for an effective controlled release. However, that effect was not observed as release rate is similar in the presence and absence of the cross-linker (80% in 8 h). This observation is justified by the fact that locust bean gum has only a few side chains and only a reduced number of cross-linkages take place within the polymer network which is not enough to affect the drug release mechanism. In contrast, tablets composed of guar gum, which has a higher number of side chains and thus allows stronger cross-linking, evidence a strong difference in drug release profile between cross-linked and non-cross-linked matrix (Coviello et al., 2007).

4.2. Applications in mucoadhesive drug delivery

Locust bean gum has find a wide place in the preparation of mucoadhesive buccal tablets in combination with chitosan in different combinations where locust bean gum to chitosan ratios are 2:3, 3:2, 4:1. Vijayraghavan et al. prepared mucoadhesive buccal tablets of propranolol HCl containing various weight ratios of locust bean gum and chitosan and coated it with 5% (w/v) ethyl cellulose. The mucoadhesive property of the formulation containing 2:3 was highest compared with other ones. Even its drug release profile was 98% in 60 min. Further bioavailability study was carried out taking 16 healthy human volunteers. The bioavailability was highest for the formulation containing 2:3 of locust bean gum to chitosan. Therefore the study indicated that the locust bean gum along with chitosan show a mucoadhesive property for buccal tablets (Vijayaraghavan, Vasanthakumar, & Ramakrishanan, 2008).

It has also been used in the design and preparation of oral controlled release anhydrous bioadhesive tablets for theophylline (Ali, Khar, Ahuja, & Karla, 2002; Cuna, Alonso, & Torres, 2001; Deshmukh, Jadhav, & Sarkarkar, 2009; Lim, Forbes, Berry, Martin, & Brown, 2002; Takishina, Onishi, & Machida, 2002; Vermani, Garg, & Lourence, 2002). Tablets of anhydrous theophylline were prepared by direct compression method and were subjected to in vitro drug dissolution for 12 h using the USP dissolution apparatus basket type at a speed 100 rpm and temperature $37 \pm 0.5\,^{\circ}C$ using gastric fluid pH 1.2. The bioadhesive strength of the tablets was measured as the force of detachment against the porcine gastric mucosa. The in vitro release study as well as the retention time of the bioadhesive tablets on the mucous membrane were investigated to develop a bioadhesive polymer based controlled release delivery system and to evaluate the performance of such a delivery device. The formulation containing locust bean gum showed a good bioadhesive property. It was also found that an increase in the gums combination increases the drug release profile beyond 12 h whereas no significant effect of gum concentration on the bioadhesive strength of the tablet.

4.3. Applications in buccal drug delivery

The administration of drugs through the buccal mucosa offers two major advantages, which include avoiding pre-systemic elimination within the gastrointestinal tract and first-pass hepatic effect (Mujoriya, Dhamande, Washkhede, & Angure, 2011; Sudhakar & Kuotsu, 2006). Therefore, buccal drug delivery mainly envisages improving the bioavailability of poorly absorbable drugs in the intestinal area (Senel, 2010). One of the most important features to be exhibited by buccal delivery systems is a strong mucoadhesiveness, which is usually obtained using mucoadhesive polymer (Remunan-Lopez, Portero, Vila-Jato, & Alonso, 1998; Sudhakar & Kuotsu, 2006). Locust bean gum reported to have mucoadhesive profile although not as strong as other polysaccharides like chitosan.

Tablets containing locust bean gum or a mixture of locust bean gum and xanthan gum as matrix materials were produced in order to improve the bioavailability of metoprolol, by avoiding an extensive first-pass effect of the drug. Formulation containing only locust bean gum resulted in a progressive release of the drug. With 7.5% of polymer leading to 98% release in 45 min an increase to 15% locust bean gum resulted in decreased release rate, registering approximately 45% in the same period. Combinations of xanthan gum and locust bean gum revealed more effective for tablet formulation, considering physical integrity, hardness and mucoadhesion

strength. Tablets with locust bean gum/xanthan gum ratio of 2:1 exhibited complete drug release in 45 min, as desired, but also poor drug permeation. To overcome this limitation, 1% sodium lauryl sulfate was incorporated in the formulation, resulting in improved drug permeation across porcine buccal mucosa (Yamagar, Kadam, & Hirlekar, 2010).

4.4. Applications in matrix tablet preparation

Locust bean gum has got synergistic effect with xanthan gum when used in matrix tablets. Venkataraju et al. did a comparative study of xanthan gum, locust bean gum and combination of xanthan gum and locust bean gum in different proportions to prepare matrix tablets (Venkataraju et al., 2007). Xanthan gum is a hydrophilic, anionic hetero-polysaccharide whereas locust bean gum is non-ionic polysaccharide and its hydration process is independent of pH. The drug release is slower from the matrices which were composed of both xanthan gum and locust bean gum compared with the tablets whose composition was only locust bean gum and xanthan gum. The burst release of drug from xanthan gum matrix tablet in acidic pH was observed. Again in case of locust bean gum matrix tablets a rapid erosion of hydrated layer was found. But this burst release in acidic pH was absent especially in case of combined xanthan–locust bean gum matrix tablets (Vermani et al., 2002). It exhibited a well-controlled effect by the use of synergistic interaction between two biopolymers to produce a strong and elastic gel around the core of matrices in the presence of a ternary component by controlling the drug release from the matrices containing the xanthan–locust bean gum formulation (Munday & Cox, 2000). A commercially available tablet system (TIMER) developed by pen west pharmaceutical company consisting of locust bean gum and xanthan gum showed in vitro and in vivo controlled release potential (Toko, 1991).

4.5. Applications in colon drug delivery

The rationale for the use of polysaccharides in the production of delivery systems aimed at colonic delivery of drugs mainly relies on the presence of large amounts of polysaccharides in the human colon. This is a consequence of the fact that this region is particularly colonized by great number of bacteria, which produce many enzymes (Jain, Gupta, & Jain, 2007; Raghavan, Muthulingam, Leno, & Ravi, 2002). Apart from the obvious application in providing a local therapeutic effect, for instance in inflammatory colonic diseases, systemic colonic delivery of drugs is also an option, especially for those drugs observing difficult absorption from the upper gastrointestinal tract. This possibility derives from the fact that the colon lacks various digestive enzymes present in the upper regions, mainly proteinases, thus possessing a less hostile environment in comparison with the stomach and small intestine (Chourasia & Jain, 2004; Sinha & Kumaria, 2001).

A first study on locust bean gum application in colonic drug delivery systems consisted in the production of butanediol diglycidylether cross-linked locust bean gum films, used as coating in theophylline tablets. The films evidenced very high swelling ability (300–500%) and were shown to undergo degradation by colonic microflora, potentiating an application in colonic drug delivery. However, mechanical instability of the films was observed, especially at higher coating quantities, thereby suggesting their non-suitability for application in colonic carrier production (Hirsch, Binder, Schelmann, Kolter, & Bauer, 1999).

Locust bean gum is also used for preparation of colon targeted drug delivery system along with chitosan. If locust bean gum and chitosan is taken in the ratio of 2:3, then a good colonic activity is obtained. From in vitro and in vivo studies revealed that locust bean gum and chitosan was capable of protecting the drug from being release in the stomach and small intestine and was susceptible to colonic bacterial enzymatic action with resultant drug release in colon (Kumar, Patil, Patil, & Paschapur, 2009).

4.6. Applications in ocular drug delivery

A unique work reports the use of locust bean gum in the formulation of a drug delivery system to the eye. Locust bean gum/i-carrageenan microparticles encapsulating gentamicin were prepared by emulsification, to be further incorporated in a polyvinyl alcohol gel that is applied on the ocular surface. Formulations without locust bean gum showed an initial burst release within the first 6 h, which decrease by more than 50% by the addition of 10% locust bean gum (Suzuki & Lim, 1994).

4.7. Application in topical drug delivery

The use of locust bean gum was also described in a formulation for topical application. The authors prepared a hydrogel with a locust bean gum/xanthan gum ratio of 1/1, which was used to incorporate niosomes (Marianecci et al., 2011). These are non-ionic surfactant vesicles, which offer several advantages over conventional liposomes, including higher chemical stability, lower costs, and greater availability of materials (Lilia Romero & Morilla, 2011; Sinico & Fadda, 2009). Niosomes were loaded with several distinct drugs, such as calcein, ibuprofen, and caffeine. The subsequent incorporation of niosomes on the hydrogel provided a protective effect on vesicle integrity and a slow release of the drugs from the polysaccharide system up to 50 h (Marianecci et al., 2011).

4.8. Solubility enhancement of poorly water soluble drugs

Locust bean gum has property to increase the solubility of some lipophilic drugs. This has been proved by the fact that when lovastatin, poorly water soluble drug was taken to prepare solid dispersion by using modified locust bean gum as carrier. Locust bean gum was modified by heating where there is irreversible decrease in viscosity keeping its swelling property unchanged. It was found with increase in concentration of modified locust bean gum; there is an increase of solubility of lovastatin. Dissolution study revealed that solvent evaporation is the most convenient and effective method for solubility of enhancement of poorly soluble drug, lovastatin. In vivo study showed significant decrease in HMG Co-A reductase activity increase of solid dispersion of lovastatin compared to that of plan lovastatin. Thus modified locust bean gum can be use as potential carrier in enhancing the dissolution rate and bioavailability of lovastatin (Patel, Tekade, Gattani, & Surana, 2008).

4.9. Biotechnological application

4.9.1. Tissue engineering

Tissue engineering provides combination of cells, acellular biomaterials, drugs, genes or gene product that may be designed, specified, fabricated and delivered simultaneously or sequentially as therapeutic agents (Yarlagadda, Chadrasekharan, & Shyan, 2005). One of the tissue applications of tissue engineering is tissue scaffolds. Tissue scaffolds are three-dimensional interconnected matrix of high porosity which is used as scaffold for seeding cells for tissue reconstruction, repair or remodeling. Tissue scaffolds are either naturally derived or synthetic in nature. The scaffolds are classified in two different categories based on their shelf-life. The two categories are permanent and temporary implants. Permanent scaffolds those that retain their shape and strength through the process of regeneration/repair of the organ while the temporary scaffolds degrade over the period of time with the regeneration of organ or tissue.

Various galactose based polysaccharides are used as natural scaffold. Locust bean gum is used for preparation of multidirectional scaffold (Mohan & Nair, 2005) suspension of gum was inserted into a freeze capsule and freeze dried. The resulting cell culture process scaffold was 1–10 mm thick and opaque when dry and greater than 2–20 mm, thick and opaque when wet. Scaffolds of locust bean gum can also be prepared by unidirectional freezing-axial, radial, log method also. Thus locust bean gum scaffold can be prepared and cell culture can be inserted within it for its growth and bioactivity.

5. Conclusion

Locust bean gum is a polysaccharide belonging to the group of galactomanans, being extracted from the seeds of the carob tree (*C. siliqua*). Polysaccharides have been finding, in the last decades, very interesting and useful applications in the biomedical and, specifically, in the biopharmaceutical field. The conventional use of locust bean gum as an excipients in drug products generally depends on the thickening, gel forming and stabilizing properties. A need for prolonged and better control of drug administration has increased the demand for tailor made polymers. Various significant works have been carried out in combination with the other polymers to make the formulation sustained and targeted. Polymer controlled drug delivery is still in the development stage. Thus the large variety of applications as well as the steadily increasing number of research workers engaged in the studies of locust bean gum due to their unique properties have made significant contributions to many types formulations and suggest that the potential of locust bean gum as novel and versatile. Locust bean gum will be even more significant in future.

Acknowledgment

The authors are highly thankful to S.S.R. College of Pharmacy, Silvassa for providing all the necessary support and the essential library information resources.

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