Technical Article

Introduction to Carob and Locust bean gum

Introduction

The Carob tree goes under many different names in various parts of the world. Furthermore in some countries such as Italy there are regional variations in the naming. The most well known names internationally are Carob and Locust bean. Other regional names include Johannisbrotbaum (Germany), Alfarrobeira (Portugal) and Garrofer or Garrover (Catalonia).

Did you know?

The Carob has a very uniform seed size, about 200mg and was used as a standard weight in medieval times by

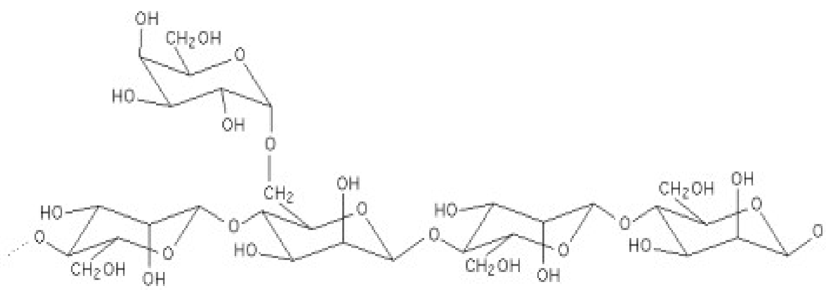
jewellers. It has been perpetuated until this day as the unit of gold measurement the carat.

The Carob tree has been recognised as a value resource for many centuries. Its origins lie in the middle east where it grows in dry areas with poor soils. The Ancients Greeks brought the Carob tree from its native lands to the Mediterranean basin whereas Arabs moved the tree along the north African coast and into Spain and Portugal. Hence it is believed that the Carob that occurs wild in the Mediterranean basin is actually a domesticated species that has 'gone wild' rather than an intrinsic wild specie of that area. The history of the Carob tree in the USA is somewhat clearer and more recent being introduced in to the USA by the Patents Office in 1854. The Carob is scientifically called *Ceratonia Siliqua* and is regarded as a very ancient leguminous plant. It is placed in the tribe Cassieae although there is some dispute about exactly where Carob fits taxonomically (Irwin and Barnaby 1981). Interestingly two new subspecies of Ceratonia where first described as late as 1980, one from Oman and the other from Somalia, possibly the distant relatives and original stock of the Ceratonia now grown commercially.

The Carob tree is important in the Mediterranean basin as a crop that can be grown on marginal lands where few other crops can be grown economically. Traditionally Carob trees are inter planted with olives, grapes and nuts. The Carob pods with their high sugar content are then used as cattle fodder. More recently the major interest in the Carob tree has been the extraction of the gum from the seeds.

Locust bean Gum structure

Locust bean gum is a linear consisting of β-(1,4)-D-mannose units. Approximately every fourth mannose units is substituted with a small side chain consisting of a 1,6 linked α-galactose sugar. The exact distribution of the sidechains has been the subject of a lot of study (McCleary) and the best description is probably using Markov chain extension statistics where the chain is built up from one end in a linear fashion and the presence of a galactose sidechain on a residue is determined by the presence or absence of any residues on the preceding two units.



Locust bean gum is very similar to other galactomannans. The main difference being the level of galactose sidechains present. The range extends from fenugreek, which is completely substituted to ivory nut mannan which is essentially unsubstituted.

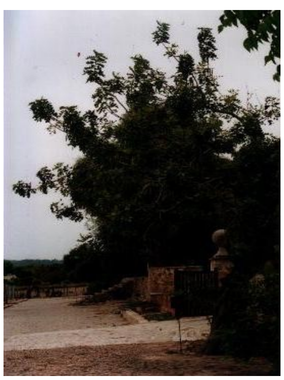
The level of substitution has a major impact on the properties of the gums as polymannan can associate and self cross link. Hence ivory nut mannan can be completely insoluble whereas fenugreek shows the properties of a simple random coil. Locust bean gum shows intermediate properties in that it is soluble but shows substantial aggregation in solution.

Galactomannan substitution levels

Ivory nut mannan	no galactose
Locust bean gum	1 galactose / 4 mannose
Tara gum	1 galactose / 3 mannose
Guar gum	1 galactose / 2 mannose
Fenugreek gum	1 galactose / 1 mannose

Production

When Carob pods arrive at the processor they are stored in ventilated areas to allow their moisture to settle down to about 8%, this improves their storage life. The first operation is kibbling the pods to separate the seed from the pulp.



The pulp is then ground to various sizes or dried and fine milled to produce Carob powder for the food industry.The seeds have their skins removed by either an acid treatment where sulphuric acid at a raised temperature is used to carbonise the outer skin which can then be removed by a combination of washing and brushing or by a roasting process where the skins are roasted so they literally peel off.

The acid process generally produces whiter products but is not so easy to handle. The deskinned seed is then split and gently milled. This causes the brittle germ to break up while not affecting the more robust endosperm. The two are separate by sieving. The separated endosperm can then be milled by a roller operation to produce the final LBG powder. The other products obtained are residual pod, which can be ground and used as a food ingredient high in fibre and antioxidants, and the germ which is rich in protein.

LBG producers are concentrated around the Mediterranean. Including Spain (5 producers), Portugal (2), Morocco (2), Italy (1). As a general rule the whitest coloured and highest gel strength is obtained from Portuguese LBG with a gradual deterioration in properties as you travel east across the Mediterranean. There are major differences in the properties of LBG from different regions but these differences have not been adequately assessed by academia.

The Carob pod can be split into two fractions: pulp and seed. Carob pulp varies in properties depending on the harvesting time, cultivar and farming practises. However a basic analysis would be (Puhan and Wielinga, 1996):

Component	Percentage
Seed coating	30-33
Endosperm	42-46
Embryo/germ	23-25

The protein content is fairly low on digestibility due to it being bound to the fibre and tannin content of the pulp. The pulp can also be dried and ground to a fine powder where it is used as a cocoa substitute. Carob chocolate is a milder flavour than dark chocolate, more akin to milk chocolate but is lower in calories and free from the caffeine and the bromine that is found in cocoa. Pulp can also be extracted to form a sweet syrup that is popular as a drink in some countries. Carob pulp has also been used in fermentation processes to produce both proteins and alcohol.

The endosperm contains the polysaccharide known as Locust bean gum (LBG).

The seed coating contains a high level of antioxidants which could explain the empirical observation that technical grade LBG with its higher level of seed coating is more retort stable in applications like petfood than the much cleaner food grade LBG (Batista et al, Mitchell). The presence of excessive skin is often related to a high acid insoluble matter content. The antioxidant properties of the seed coat also offer the potential as a new food ingredient.

The germ contains about 52% protein and the protein level in LBG is used as a quality indicator reflecting the efficiency of germ removal from the endosperm. The germ also contains about 8% lipids and 27% carbohydrate. High levels of the yellow germ in LBG powder cause the solutions to degrade faster due to polysaccharide degrading enzymes present.

LBG properties

LBG comes in a variety of forms, basically they can be divided into high grade, industrial and technical (Wielinga, 1989). A basic composition of the different grades can be seen in the table below. For those buying LBG the key parameters to be aware of are:

1. Acid insoluble residues gives an indication of how well the skin has been removed from the seed. Hence the lower the acid insolubles the better.
2. Protein gives an idea of how well the germ has been separated from the endosperm. Hence the lower the protein level the better.

Carob pod split open

The polysaccharide from the endosperm is a long chain β-(1-4)-mannose polymer with α-(1-6)-galactose units appearing as single unit side chains. This puts the galactomannan in the same general family as other polysaccharides such as guar, fenugreek, tara and cassia. The ratio of galactose to mannose i LBG is roughly 1:4. The distribution is believed to be roughly random although this area has not been adequately investigated in terms of relating structure to variety. Recent work by Henk Schols at Wageninen in the Netherlands (11th Wrexham conference) has shown that there are considerable variations across a selection of LBG sources. However the work was flawed by not identifying the source of each LBG sample in terms of variety, region and farming/harvesting conditions, but the main point, that there are differences, was proved. However the techniques exist to elucidate the structure of a galactomannan (Mc Cleary) and it would be extremely useful to identify structural variations between varieties or farming/harvesting conditions and relate this to functional properties such as synergism with other gums and performance in end use applications.

LBG is only partially soluble in cold water. The mannan sections of the polymer chain can bind together to form a crystalline region which is thermodynamically more stable than the solution state. Hence even when in solution at ambient temperature there is a tendency for the polymer chains to wish to aggregate. This makes the accurate measurement of molecular weight difficult due to the presence of aggregated species in solution. However it also has some advantages. The aggregation can be increased by reductions in water activity and reduction in solution temperature which ultimately forms a

3D network and a gel. This is exactly what happens in ice cream during freezing. Their are two great advantages of this: firstly a weak gel structure does not impart a slimy or slippery mouth feel to the ice cream and more critically the formation of a weak gel on cooling imparts excellent meltdown resistance to the ice cream.

The synergy of LBG with kappa carrageenan is the basis of the majority of non gelatin dessert jellies as well as most of the jelly used in canned pet foods. The texture of a LBG/carrageenan gel can be manipulated to be close to gelatin and the higher melting temperature is a positive advantage in warmer countries or countries where refrigeration is not present in every household.

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LBG has several functional properties that its users are looking for. One of the largest food uses of LBG is in cream cheese where it is used to bind water and produce a spreadable texture without imparting sliminess.

There have been several patents and articles covering different ways to manufacture or mimic LBG from a different source. The only method known to have been commercialised is the treatment of guar with an alpha-galactosidase enzyme to produce a galactose depleted guar with properties similar to LBG.

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