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Carrageenan

Textural Ingredient for Food Systems

Carrageenans are a family of linear sulphated polysaccharides extracted from red seaweeds (family *Rhodophyceae*) mostly of genus *Chondrus*, *Eucheuma*, *Gigartina* and *Iridaea*. The name is derived from a type of seaweed that is abundant along the Irish coastline. Gelatinous extracts of red seaweed have been used as food additives for hundreds of years.

***Chondrus crispus* seaweed**

About Carrageenan

Carrageenan can be used as textural ingredient with extremely effective gelling properties. Carrageenan is commonly used in many food and non-food applications like meat, water dessert jelly, dairy products, beer fining, ice cream, air freshner, pet foods and many more.

Due to its ability to interact with milk proteins, carrageenan is widely used in milk-based applications like in ice cream to prevent whey separation, in milk gels to obtain the desired consistency, in chocolate milk to avoid the precipitation of cocoa particles and in low-sugar jams and jellies for gelling purposes. Further it is used as a gelling agent for water dessert jelly.

In meat products, gelling properties of carrageenan bind moisture, reduce cooking loss and syneresis and improves slicing properties, while sausages and similar emulsified products benefit from improved firmness and texture.

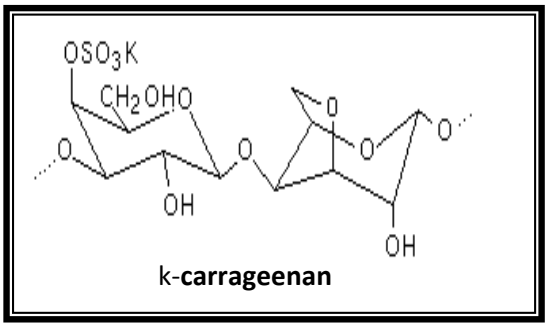
Carrageenan with other gums and salts designed for controlled release of fragrance in water gel systems. Due to its firm gelling property, it is used as medicinal ingredients in the preparation of surgical jellies and bandages. It is also used as textural ingredient in toothpaste preparation.

Carrageenan is divided into three basic forms

Three distinct types of carrageenan are recognized commercially: kappa, iota and lambda. Each is a linear polymer with a disaccharide repeating unit consisting of sugar residues linked alternately through the C3 and C4 positions. The sugar residues are D-galactose and 3, 6-anhydro-D-galactose. Sulfate ester groups are located in various positions on one or both residues of the repeating unit.

1. Kappa Carrageenan

Kappa carrageenan is the most commonly used type of carrageenan. Its most important properties are its high gel strength and strong interaction with milk proteins. About 70% of the world's carrageenan production is based on kappa carrageenan. It is isolated mostly from the tropical seaweed *Kappaphycus alvarezii* (also known as *Eucheuma cottonii*).



k-**carrageenan**

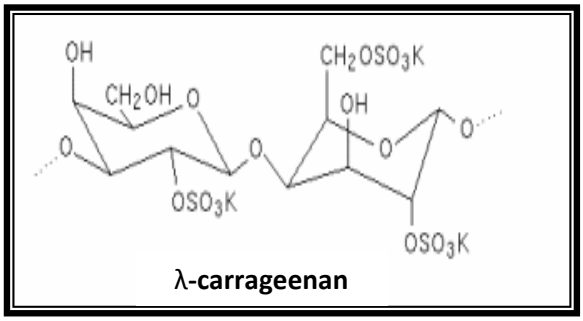
- Soluble in hot water
- The addition of potassium ions induces the formation of a durable, brittle gel; it also increases the gelling and melting temperatures.
- Strong, rigid gel, some syneresis, forms helix with K+ ions. Ca++ ions cause helices to aggregate and the gel to contract and become brittle.

- Slightly opaque gel becomes clear with sugar.
- Approximately 25% ester sulfate.
- Compatible with water miscible solvents
- Insoluble in most organic solvents
- Typical use levels — 0.02 to 2.0%

2. Lambda Carrageenan

Lambda carrageenan is a highly sulphated type of carrageenan mainly used for its ability to impart mouth feel and a creamy sensation to dairy products. Lambda carrageenan does not gel. Commercially it is supplied as it is extracted from the seaweed which is as a kappa / lambda mixture. It is isolated mainly from *Gigartina pistillata* or *Chondrus crispus*

- Free flowing, non-gelling pseudo-plastic solutions in water.
- Partially soluble in cold water, fully soluble in hot water.
- No gel, random distribution of polymer chains.
- Addition of cations has little effect on viscosity.
- Compatible with water miscible solvents.
- Insoluble in most organic solvents.
- Stable over a wide range of temperatures, including freeze/thaw cycles.
- Soluble in 5% salt solution, hot or cold.
- Approximately 35% ester sulfate.
- Typical use level — 0.1 to 1.0%



λ-carrageenan

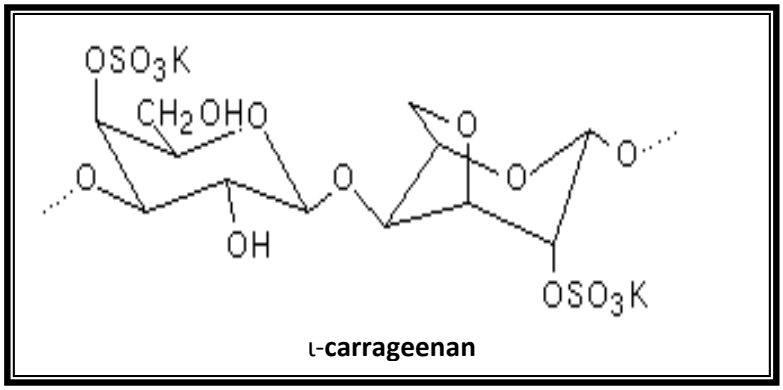
3. Iota Carrageenan

Iota carrageenan is a type of carrageenan with a sulphate content intermediate between kappa and lambda carrageenan. Iota carrageenan forms an elastic gel with good freeze, thaw and re healing properties. It is isolated mostly from the Philippines seaweed *Eucheuma denticulatum* (also called Spinosum).

- Dilute solutions exhibit thixotropic characteristics.

- Soluble in hot water; sodium iota carrageenan is soluble in cold and hot water.
- The addition of calcium ions will induce the formation of a durable elastic gel, and increase gelling and melting temperatures.
- Elastic gels, forms helix with Ca++ ion. Limited aggregation contributes to elasticity, no syneresis.
- Clear gel.
- Freeze/thaw stable.
- Insoluble in most organic solvents.
- Approximately 32% ester sulfate.
- Typical use levels — 0.2 to 2.0%

The primary differences which influence the properties of kappa, iota and lambda carrageenan are the number and position of the ester sulfate groups on the repeating galactose units. Higher levels of ester sulfate lower the solubility temperature of the carrageenan and produce lower strength gels, or contribute to gel inhibition. The sulfate groups are associated with metal cations such as sodium, potassium and calcium. Their relative proportions determine whether or not the carrageenan will dissolve in a particular medium at a certain temperature. Sodium salts of carrageenan are soluble in cold water.



ι-**carrageenan**

Applications of Carrageenan in various sectors

The practical utility of carrageenan stems from two key properties; its ability to form strong gels with certain salts or other gums and its ability to interact with certain dairy proteins. Carrageenan is mainly used in the food industry with some applications in the toiletries industry. Industrial applications of carrageenan are rare.

1. Use of carrageenan in Dairy Products

The main applications for carrageenan are in the food industry, especially in dairy products. Kappa

carrageenan added to cottage cheese will prevent separation of whey. It is also added to ice cream to prevent whey separation that may be caused by other gums that were added to the ice cream to control texture and ice crystal growth. The cocoa in chocolate milk can be kept in suspension by addition of similar amounts of kappa. Dry instant chocolate mixes, to be mixed with water or milk, can have improved stability and mouth feel using lambda or a mixture of carrageenans.

Lambda or a mixture can also improve liquid coffee whiteners by preventing the separation of fat. In UHT sterilized milk, kappa carrageenan added to prevent fat and protein separation. Lambda or kappa may be added to natural cream to help maintain the lightness (incorporated air) if it is whipped.

2. Use of carrageenan in water based Foods

Gelatin jellies have long been favoured because they melt at body temperature, giving a smooth mouth feel and easy release of flavours. However, if they are stored for a day or two, they toughen and are less pleasant to eat. Gels made from iota carrageenan have the disadvantage of a high melting temperature, so they are not as smooth to eat as gelatin gels. They do not melt on hot days and do not require refrigeration to make them set, so these are advantages in hot or tropical climates, and a further advantage is that they do not toughen on storage. Combining various carrageenans with locust bean gum, konjac flour and starch, a variety of melting and non-melting gels and gel textures are developed. Long-life refrigerated mousse desserts, based on carrageenan and pectin rather than gelatin, are suitable for vegetarians and some ethnic groups.

Conventional fruit jellies are based on pectin and a high sugar content to help set the jelly. In a low- or non-calorie jelly the pectin must be replaced and mixtures of kappa and iota carrageenans have proved to be suitable. Fruit drink mixes to be reconstituted in cold water contain sugar (or aspartame), acid and flavour. Addition of lambda

carrageenan gives body and a pleasant mouth feel. Sorbet is a creamy alternative to ice cream with no fat; use of a mixed kappa and iota together with locust bean gum or pectin provides a smooth texture to the sorbet.

Low-oil or no-oil salad dressings use iota or kappa to help suspend herbs, etc. and to provide the mouth feel that is expected from a normal salad dressing. The interaction of carrageenan and protein can be used in the clarification of beer, with the complex formed precipitating from the wort.

3. In Toothpastes

The essential ingredients in toothpaste are chalk or a similar mild abrasive, detergent, flavour, water and a thickening agent that will provide enough body to the paste to ensure that the abrasive is kept in suspension and that there is no separation of water. A thixotropic thickener is preferable, i.e. that has gel-like properties when allowed to stand but that will flow when pressure is applied to it. Iota carrageenan is one of the most useful thickening agents; it meets the above criteria and gives a paste that is easily rinsed from the toothbrush.

4. In Pet Foods

The meat used in canned pet foods is usually waste cuts from the abattoir. It is chopped into chunks or smaller pieces, mixed with water, flavours, seaweed flour (kappa carrageenan) and locust bean gum, canned and cooked. The two hydrocolloids help to bind the meat together and depending on the concentrations used, either provide thickened gravy around the meat pieces or a flavoured jelly, either of which enhances the appearance of the product as it is removed from the can.

5. In Meat Products

In preparing hams, addition of carrageenan to the brine solution used in pumping improves the product because the carrageenan binds free water and interacts with the protein so that the soluble protein is retained. For successful penetration, the brine solution must have a low viscosity, but dissolved carrageenan would increase the viscosity. The carrageenan is therefore dispersed in the water after the brine salts are added; the carrageenan does not dissolve because of the high salt concentration, but as the ham cooks it does dissolve and is then effective.

There is a growing consumer demand for pre-cooked poultry products such as chicken and turkey pieces. Poultry processors were concerned about the loss of water during cooking (this lowered their yield per unit weight of product) and the loss in texture and eating quality that resulted. By injecting brine containing salt, phosphate and carrageenan into the muscle of the meat, these problems are overcome. As the meat cooks, the carrageenan binds water within the poultry muscle and improves texture and tenderness.

Hydrocolloids are being tried as fat replacements in low-fat products, with varying degrees of success. When fat or salt are reduced, meat and poultry can suffer loss of tenderness, juiciness and flavour. Low-fat products formulated with phosphates and carrageenan can have the juiciness and tenderness restored. Kappa carrageenan has been used with some success in replacing half the normal fat in frankfurters. Reduction of fat in ground meat products like hamburgers results in a different mouth feel and dry taste, which consumers do not always accept. Iota carrageenan can be mixed with fresh ground beef and when cooked it provides fat-like characteristics and moisture retention that make the product more acceptable.

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