Ingredients

Dairy Products and Carrageenan: a Perfect Pairing

by Karen Laustsen

Carrageenan is an important additive widely used within the food industry. Simplified, carrageenan has been defined in three main types: kappa, iota and lambda. However it would be more correct to mention a range of intermediate structures.

Kappa carrageenan is known to provide a strong and brittle gel, and iota carrageenan to perform a cohesive and thixotropic gelling behavior.

Both kappa and iota are manufactured from farmed seaweed (Eucheuma Cottonii contains kappa and Eucheuma Spinosum contains iota).

Lambda carrageenan provides a thickening and creamy viscosity with a full body mouthfeel. Since it is the only carrageenan which is cold soluble in water as well as in milk, lambda is unique and exists only in wild growing hybrid seaweed of which most types (Gigartina y Chondrus species) actually contain a combination of Kappa and lambda carrageenan (see article by Ian Healey, Food Marketing & Technology, vol.24 No 5 p 61-63). These hybrid carrageenan types are known as kappa-2, and the ratio between kappa and lambda is what will characterize the overall functional behavior of each species.

Applied in a food product, it is very important to choose the correct and appropriate carrageenan type. Each commercial carrageenan is standardized to perform a specific function, and only when used correctly, can the food manufacturer fully benefit from the specific and positive attributes that it can offer.

The Dairy Industry

Carrageenan is generally the preferred stabilizer and texturizer for neutral dairy products.

As can be seen from figure 1, the gelling profile of the various seaweed types differs considerably, which means that in formulating a commercial carrageenan, the carrageenan manufacturer needs to choose the most economic and technically best combination of carrageenan extracts for each specific dairy product as well as taking into account the manufacturing condition used by the dairy producer.

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A typical kappa extract has a very strong milk reactivity and provides a firm gel but with an empty mouthfeel. The strong gelling characteristic of the kappa carrageenan can make this extract very useful in boosting a gelling performance of a dairy carrageenan in applications like hard cheeses and demouldable milk desserts, but it is unsuitable for sensitive dairy applications like stabilizing chocolate milk and creams, where the tendency of the kappa to further reacting and firming up during storage is unwanted.

A iota carrageenan provides an elastic thixotropic milk gel especially well suited for cold filled dairy products and for whipped applications.

Lambda provides a milk viscosity with body and creamy mouthfeel. As earlier mentioned, Lambda is a unique extract as it is the only carrageenan able to dissolve and function in cold milk, where all other carrageenan types need to be heated until pasteurizing temperature in order to dissolve and set after being cooled down. This ability makes Lambda carrageenan the only choice for stabilizing cold instant dairy powders. The most important Carrageenan extracts for dairy applications are however derived from the wild growing hybrid seaweed types Gigartina and Chondrus, that have a well balanced milk reactivity, providing controlled milk gelling with good stabilizing and creaminess. The performance of these hybrid Kappa-2 carrageenan depends on the actual ratio of kappa and lambda.

By intermixing different kappa-2 extracts and having the possibility to add extra gel strength by applying kappa, or elasticity by adding iota, or improving the creaminess by addition of extra lambda extract, gives the carrageenan manufacturer unlimited options for creating unique textures and making tailor made solutions for individual customers.

Gel formation and milk reactivity of carrageenan

The theory of the interaction and gelling behavior of carrageenan with milk protein is not fully understood. However it involves several factors and is above all dependend on the pH of the product. One aspect of the milk reactivity of carrageenan is that of a gelation phenomenon, involving a highly specific interaction between carrageenan and kappa casein forming a complex that aggregates into a three-dimensional gel network.

Carrageenan is a negatively charged compound, independent of the pH of the medium. Milk protein, on the other hand, is amphoteric, and changes from being overall positively charged below the isoelectric pH of the milk casein (pH 4.6) to being negative charged at pH-values above the isoelectric pH.

Milk contains large amounts of calcium ions, and one way of explaining the reaction between carrageenan and kappa casein is by the formation of calcium s between the two molecules.

At a low pH, where carrageenan and milk protein are oppositely charged, a carrageenan-kappa casein complex will form and precipitate. At pH-values above 4.6, carrageenan and kappa casein exhibit the same overall charge, but the

Figure 1: Milk reactivity of different carrageenan seaweed extracts.

Milk gel strength:
0,2% carrageenan in skim milk heated to 90°C for 10 min and cooled to 5°C. Measured by TA-XTplus

Kappa (Eucheuma Cotonii)
Iota (Eucheuma Spinosum)
Lambda (Gigartina Stellata)

Hybrid seaweed especially relevant to the milk industry (kappa-2 extracts):
Kappa/lambda (Chondrus from Spain)
Lambda/kappa (Gigartina from Chile)
Kappa/lambda (Chondrus from Canada)

Figure 2: A spoonable cream with 15% fat, stabilized with 0,25% Ceamlacta 2441
**Ingredients**

- Ceamlacta 2444 0.7 – 1.0%
- Modified starch 0 – 1.5%
- Sugar 12.0%
- Fruit pulp/juice 20.0%
- Whole milk (3.5% milk fat) to 100%
- Lactic acid (80% solution to reach desired pH)
- Flavor and color Optional

**Process**

1) Blend the dry ingredients and disperse into the cold milk by means of a tri-blender.
2) Preheat to 75 °C for dissolving and add the fruit pulp/juice slowly during agitation. When a homogeneous appearance is reached, adjust the pH with lactic acid solution to desired pH 4.7-5.0.
3) Homogenize at 50 bars.
4) UHT heat treat at e.g. 140 °C for 4 sec.
5) Cool to 65 - 70 deg C, and fill into cups at this temperature.
6) Refrigerate to allow gel setting.

**Milk desserts**

Milk puddings, custard or flans are often manufactured using a combination of hydrocolloids for cost optimizing, but in order to achieve good eating quality, carrageenan is being applied as an important part of the formulation. The recommended use level of carrageenan depends on the desired texture and on which specific carrageenan type is being selected.

For hot filled puddings a kappa-2 carrageenan with relatively high kappa content is preferred if the dessert should be firm and demouldable. For softer dessert types a kappa-2 carrageenan with higher ratio of lambda than kappa will be more relevant providing the richer and creamier eating quality.

If the dessert is to be cold filled, only the thixotropic iota carrageenan is applicable for gel set textures, as a kappa-2 based carrageenan in same use level will provide a spoonable texture. A combination of carrageenan and starch is common practice, with the starch providing extra body and mouthfeel. The ratio of carrageenan to starch will determine the final organoleptical quality. The higher carrageenan content and the lower content of starch the better is the eating quality of the final dairy product.

Carrageenan also has the advantage of a low processing viscosity and will reduce the negative effect that an otherwise too high starch level will give to flavor release and mouthfeel.

Recently CEAMSA however has developed Ceamlacta 2444, which is a combination of carefully selected carrageenan extracts combined with pectin for further milk protection. This new stabilizer is able to provide excellent texture and stability to a slightly acidified dairy system, enabling the dairy manufacturer to make a new type of refreshing dairy dessert. (see figure. 5)

**Milk beverages and creams**

For ice creams and soft serve, carrageenan is one of the key components in the stabilizer blend. The functional request of such ice cream stabilizer is to control consistency and to ensure that the texture of the ice cream remains smooth and with a good “stand up” and a creamy melting behavior at the time of serving. Another important factor is prevention of ice crystal growth during freezing, hardening and storage, a functionality provided by the carrageenan.

**Figure 3:** Carrageenan is a key component in stabilizer blends for ice cream and soft serve

**Figure 4:** Demouldable neutral dairy dessert stabilized with 0.4 % Ceamlacta 2550 and 1% starch. For acidified dairy products a conventional carrageenan will not be applicable. The newly developed Ceamlacta 2444 will provide stability and correct texture of fruity type dairy desserts with a pH as low as 4.7 -5.0.

**Figure 5:** Fruity dairy dessert, hot filled

**Figure 6:** Taking advantage of the positive interaction of carrageenan with milk proteins will enable the cheese manufacturer to economically improved texture and stability of processed cheese.
Chocolate milk

In the production of chocolate milk, the cocoa particles will form a sediment if a suitable stabilizer is not added, thus resulting in an unacceptable organoleptical quality of the final product. The stabilizer of choice is a soft kappa-2 carrageenan that in a use level as low as 0,015 – 0,025% will provide a very soft gelled network that will keep the cocoa particles in suspension and thus provide both stability and improved mouthfeel. The correct application of carrageenan will also assist in the prevention of the typical chocolate milk problems such as the formation of a brown top layer, marbling or curdling.

The exact use level of the carrageenan will depend on factors like quality and quantity of the cocoa powder used, the fat and protein content of the milk and finally, on the processing conditions like heat treatment and filling temperature. Generally, it is very important to cool to below 15°C, in order for the carrageenan to quickly start generating the thixotropic net-work. A too high filling temperature will result in an insufficient suspending viscosity for keeping the cocoa particles in suspension, thus creating sedimentation and stability problems. A higher use level of carrageenan will overcome the stability problem, but will result in an increased viscosity and in too thick and lumpy chocolate milk when consumed from the refrigerator.

Conclusion

The advantageous synergy that exists between carrageenan and milk proteins makes carrageenan an important and cost effective additive for a wide range of dairy applications. Apart from controlling the texture and stability, the carrageenan will also improve the overall organoleptical quality and extend the shelf-life of the finish dairy product. Considering the increased complexity of the different types of carrageenan now available and considering the aim of choosing an adequate and cost optimized carrageenan type for each specific dairy application, it is advisable to consult the carrageenan supplier for obtaining recommendations and guidelines.

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