



Edible seaweeds provide carrageenan: it is used as a stabiliser

The top 5 secrets to high-quality chocolate and enriched milks

Best-practice chocolate and enriched milk drinks don't become sedimental or show creaming during their shelf-life – and they owe it all to a group of networks that work closely together.

Consumer ideas of what constitutes a desirable chocolate or enriched milk drink can differ widely. Some expect it to be highly viscous, while others prefer a plainer, milk-like viscosity. While considered by the vast majority of manufacturers to be a problem, sedimentation may even be treasured by some consumers as a core brand attribute, as is the case with the traditionally glass-bottled Cocio brand of chocolate milk in Scandinavia.

In that same Scandinavian market however and in other markets around the globe, sedimentation is an undeniable problem, particularly in cartoned packaging, as consumers often forget to vigorously shake the carton before consumption, resulting in a drinking experience that varies almost with every sip. Further, labels saying “shake well before use” or the more physically demanding “shake vigorously before use” may be

perceived negatively, perhaps because they call attention to the presence of added substances. But such labels are having to be applied to a growing variety of chocolate and enriched drinks, as we shall see.

From chocolate milk to everything-else-milk

Dairy manufacturers have been quick to jump onto the healthy living bandwagon, developing new products with added vitamins, iron, oat fibres, calcium, conjugated linoleic acids (CLA), magnesium and more. The same issue however raises its ugly head: generally speaking, adding things to milk will destabilise the product and endanger both on-the-shelf appeal (for bottled products) and consumer enjoyment (for both bottled and carton products). Even coffee milk, while not widely considered a health-driven product, suffers from the same effect. And a related problem in long shelf-life products is the phenomenon known as ‘creaming’.

Sedimental blues

Sedimentation begins the moment the drink has been produced. But, of course, it really

starts to work its dark magic once on the shelf. At worst, two distinct layers can appear. In chocolate milks, the bottom one is an (appropriately) dark chocolate colour, while the one just above it has been described as having a “white-livered” appearance by at least one source. In assessing the sedimentation aspect of such drinks, sensory evaluations tend to focus upon:

- The amount of sedimentation
- The fineness of the sediment
- The ease or resistance with which it re-mixes with the milk when shaken

While some particle-containing drink manufacturers have managed to work out how to achieve a consistent and strong suspension, many others have not. For this latter group, there is much to be gained by deploying up-to-date techniques to combat the problem.

Four networks acting in concert

Essentially, any drink containing insoluble particles is prone to sedimentation. Their resistance to sedimentation, if it is to be effective throughout the shelf-life of the product,

[Photo source: <https://en.wikipedia.org/wiki/Carrageenan>]

first requires manufacturers to consider the choice of milk and particle type.

To reduce the likelihood of sedimentation, state-of-the-art recipes for chocolate drinks based on fresh milk can make the most of four distinct, yet interacting networks that together enable an extremely robust suspension, keeping cocoa particles in their place while ensuring emulsion stability, creaminess and other benefits.

These four networks are physical effects enabled by:

1. Emulsifiers, which increased flocculation of fat globules to form a three-dimensional network
2. Stabilisers, forming the essential carrageenan network
3. Microcrystalline cellulose (MCC), whose effect on the formation of hydrogen bonds forms yet another network
4. In chocolate milks and other enriched milk drinks that may contain cocoa powder, the tannin component in the powder bonds proteins to add further strength to the drink's suspension

If all four of these networks are present, as they may be in a sophisticated product, the combined result will hold the cocoa particles

Of course, gravity means the network is also subject to subsidence under its own weight, but this is countered by adherence to the inside of the container. And at the same time, the stabilised network improves the drink's mouth-feel.

1: carrageenan

Extracted from seaweed, carrageenan is by far the most commonly used stabiliser in chocolate milk. In Europe, carrageenans are divided into two distinct groups: refined carrageenan (E-407) and semi-refined carrageenan (E-407a), both of which can be used in chocolate milk. And it's a sub-group of these, namely Kappa carrageenan, whose chemical composition has proved useful in chocolate milk because of the way it reacts with milk proteins to form a three-dimensional network.

Essentially, the carrageenan forms a helix with negatively charged sulphate groups turning outwards. This helix interacts with the positively charged casein micelle. When carrageenan is used as a stabiliser, and in order for the network to be formed, the chocolate milk must be cooled to below 25°C before filling, or below 25°C during constant rotation if in-can or in-bottle sterilisation is used. It is important to store the product at tempera-

So the margin between the two states is narrow. Unless, that is, the stabiliser is accompanied by mono- and diglycerides. This increases the dosage margin, and has the useful effect, due to the creation of a network between fat globules and whey proteins, of reducing the amount of carrageenan required to form a stable product. But more on that in a moment.

Another factor to be taken into account, of course, in determining the right dosage of carrageenan, is the variation that may occur in the composition of the milk, depending on the season. But there's more still to the dosage decision. It also depends, for example, on:

- The milk's fat content, as more fat requires less stabilising
- The cocoa content, because more cocoa demands less stabiliser
- The choice of heat treatment (Sterilisation requires less stabiliser than UHT, which in turn requires less than a pasteurised product)

2: the MCC/CMC complex

To consumers, it may seem surprising that refined wood pulp has a contribution to make to keeping milk drink particles in their place. But microcrystalline cellulose (MCC), as it is officially known, or rather a MCC/

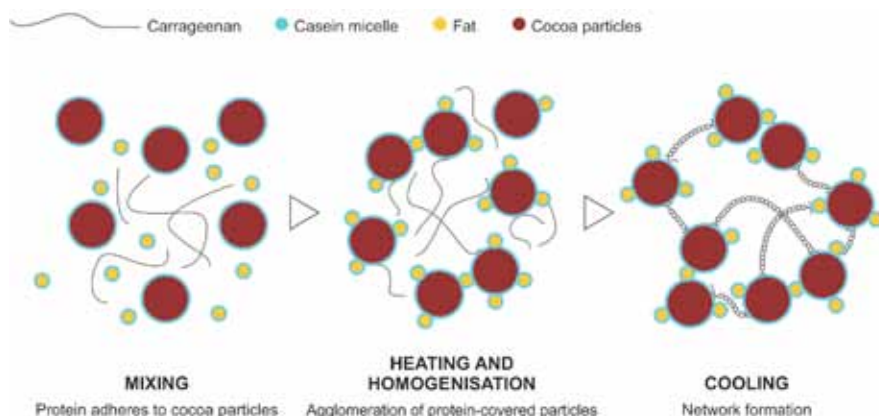


Figure 1. Formation of carrageenan network in chocolate milk

– or other particles contained in enriched drinks – tightly in suspension, preventing them from migrating to the bottom of the container. It's a 'thixotropic' network, referring to the fact that if shear is introduced to the suspension, for example by stirring, the network will be broken down, but will tend to revert to its pre-shear state again once the disturbance stops.

tures below 30°C, as the network will start to break down in the heat (see figure 1).

Dosaging carrageenan is somewhat like walking a tightrope. And it is a fine line indeed: a dosage that is just a little too low will quickly produce undesirable levels of sedimentation. Slightly overdo the dosage, on the other hand, and the product is likely to acquire a heavy, gelled body.

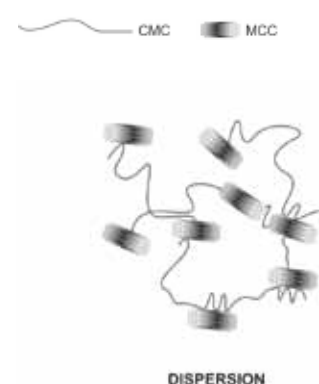


Figure 2. MCC/CMC network

CMC complex, is often used in combination with carrageenan.

MCC is derived from plant fibres from which the crystalline part of the cellulose is extracted. In a dispersion, MCC forms hydrogen bonds, creating the second of our three-dimensional networks. As an added bonus, MCC-based products can also lend more body and creaminess to the drink.

At temperatures below 80°C, MCC's functional properties are largely unaffected by fluctuations, so cooling and storage temperatures become less critical. That makes MCC-based products a good choice where cooling below 25°C is not an option – or if the storage is likely to be at more than 30°C, as is often the case in South East Asia or the Middle East, for example (see figure 2). Because MCC does not react with the milk proteins in the same way as carrageenan, the risk of separation due to overdosing is less. That said, overdosing will result in heavy body and high viscosity.

3: the effect of carefully selected emulsifiers

The emulsifiers used in enriched milk drinks are typically mono- and diglycerides produced by the reaction of edible vegetable fats or oils when combined with glycerol. The resulting molecule (Figure 3) is composed of a hydrophilic and a lipophilic part, positioned at the interface between fat and protein on the one hand, and water on the other. These molecules are formed during homogenisation and ageing of the product.

The mono- and diglycerides form a complex with the whey proteins, making the fat globule membrane more resistant to coalescence, and reducing fat separation in the product at the same time. But that's not all – these emulsifiers lower the net charge of the membrane, creating a three-dimensional

network that acts to increase the creaminess of the milk – and the consumer's sensory perception of a thick, luxurious product. Importantly, and perhaps somewhat counter-intuitively, the emulsifiers also guard against creaming in the finished product.

4: cocoa particles

For chocolate milk drinks, the work performed by carrageenan, the MCC/CMC complex and emulsifiers to create a robust suspension is further assisted by the cocoa particles themselves. A typical recipe contains around 1-2% cocoa powder – meaning there is no shortage of particles to distribute and hold in position.

From the moment the milk and cocoa powder are mixed, casein is almost immediately adsorbed to the particles. The strength of this particular network-building effect depends on the degree of alkalisation of the cocoa powder. That is because cocoa powder contains polyhydroxyphenols, which polymerise during alkalisation into tannins, known for their protein-binding properties.

In general, the heat stability of chocolate milk is lower than that of milk, however, the closer the pH of the cocoa powder is to the pH of the milk the less impact it has on the suspension's stability. It is important, too, to consider the particle size of the cocoa powder, as the network simply cannot support particles that are too heavy. In fact, Palsgaard recommends that less than 0.5% of the particles be larger than 75 micrometres.

Of course, the advantages of this fourth network are lost on enriched milk products that do not contain cocoa powder. Calcium-fortified, non-chocolate milks, for example, which face the task of suspending particles of calcium instead of cocoa, are similarly subject to unattractive settling, but lack the networking effect of their cocoa cousins.

Yet the suspension challenge is no less important to address. For example, where sedimentation has occurred, the consumer may lose the fortifying benefits of the drink – and, at worst, ends up with a mouthful of solids and a distinctly chalky taste.

The creation of a durable suspension in this type of milk drink can largely be achieved, for example, by combining a small-particle-size, solid-precipitated calcium source with the networks built by the combination of carrageenan, the MCC/CMC complex and gellan gum, together with the right choice of emulsifier. Gellan gum is a polysaccharide produced by fermentation that creates a gel structure in solutions, keeping the calcium particles in suspension. The gellan network is formed independently of the proteins in the drink and has only limited influence on viscosity, making it well-suited for a plain milk product.

As with cocoa-based milk products, there is, however, one more network that can make a significant difference, and which can only be created with many years of experience.

The fifth network: global know-how

Working with the four preceding networks is not something one can expect to get right first time. In fact, it takes in-depth experience and a lengthy track record of varied recipes and testing before it is possible to quickly determine the right balance of ingredients and effects. So, in fact, there is a fifth network that plays an important role in achieving the best results: Palsgaard's own, global knowledge network.

After many years of supplying the dairy industry with emulsifiers and stabilisers, Palsgaard has managed to build up a significant knowledge bank that supports its customers in arriving at the right recipe, equipment and process parameters in far less time than might otherwise be expected. It is the result of countless trials conducted in well-equipped application labs around the world. In Denmark, Singapore, Mexico and

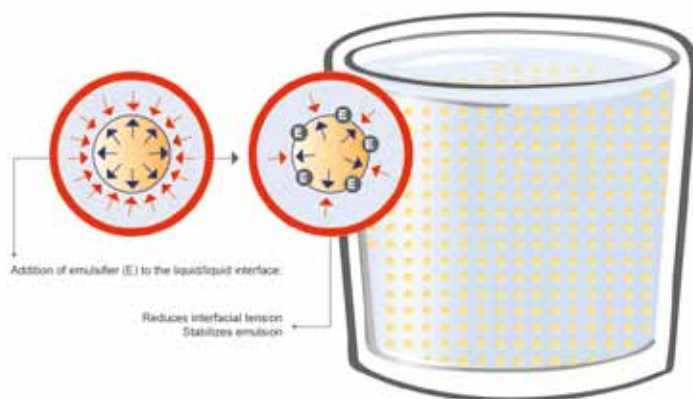


Figure 3: An emulsifier is a molecule with ambiphilic properties (part of the structure is hydrophilic and other moieties are lipophilic). In a multiphase system the emulsifier will adopt a favourable position with respect to energy. The emulsifier reduces surface tension between the phases.

China, for example, application specialists spend days on end to create blends that take key factors such as milk quality, recipe, process conditions and sensory preferences into consideration. The labs are able to

ing mouth-feel to chocolate milk. It is composed of mono- and diglycerides, carrageenan and guar gum – and it is an excellent choice for most chocolate milks. It is an integrated product rather than a dry-blend-

Manufacturers working with high-calcium milk can use Palsgaard® Chomilk 173 or Palsgaard® Rec-Milk 131 (declared as gellan gum, mono), as well as diglycerides and locust bean gum, depending on factors such as



Chocolate milk with no sedimentation

perform systematic trials with pasteurised, UHT or sterilised products, making shelf-life studies that cover the entire shelf-life of chocolate or enriched milks.

Try this

Most often, such trials are conducted together with manufacturers – either in Palsgaard labs or on the factory floor. In one case, for example, an Asian-based customer was experiencing gelation and sedimentation of the company's calcium milk. That is not unusual, of course, as calcium milks have a greater tendency to gel over time. Even so, the company was experiencing unacceptably short shelf-life – no more than a couple of weeks at best before the product began to show soft lumps, a prior stage to becoming gelatinous. Working together with Palsgaard's dairy team, the recipe and process parameters were reproduced in one of its labs, and a process of experimentation managed to extend the product's shelf-life to as much as six months.

Recommended solutions

So which products does Palsgaard recommend for manufacturers looking to arrive at uniform products with good creaminess and mouth-feel and high storage stability?

Palsgaard® ChoMilk 150 is a carrageenan-based product designed to bring uniformity, pleasant creaminess and an appeal-

ing mouth-feel to chocolate milk. It is composed of mono- and diglycerides, carrageenan and guar gum – and it is an excellent choice for most chocolate milks. It is an integrated product rather than a dry-blend-

This brings several advantages:

- Free-flowing properties
- Uniform product without the risk of de-blending during storage and transportation of the emulsifier and stabiliser mixture
- No dust formation
- It can be added to the milk without pre-mixing with sugar.

For situations where cooling is a problem, however, a different member of the Palsgaard® ChoMilk family is likely to have the best effect. If the local climate, logistics challenges or other factors make it difficult to cool the product below 25°C after production, or if it is to be stored above 30°C, Palsgaard advises using Palsgaard® ChoMilk 173. This specialised product is declared as MCC, mono- and diglycerides, carrageenan and CMC – and it works well in chocolate milk drinks with relatively low protein content (either due to the milk's own protein level or as a result of dilution with water) and even in enriched applications. Suitable for use in a wide variety of applications, Palsgaard® Chomilk 173 is a dry-mixed product, so the suspension of the product in milk is facilitated by dry-mixing the product with sugar before it is added.

Chocolate milk with sedimentation



milk type, calcium particle type and the concentration of particles in the product.

All of the Palsgaard® ChoMilk products are capable of delivering a consistently high-quality product without visible creaming or sedimentation, and with appealing consumption characteristics.

About the author

Hanne K. Ludvigsen since 1995 is Product & Application Manager for Dairy & Ice Cream at Palsgaard A/S. She has more than 25 years of experience of working in the food industry including R&D, product development and product management.



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