HYDROCOLLOID INSIGHTS

Future-Proofing Dairy & Non-Dairy Texturizing Systems

Formulators are urged to find backup hydrocolloid systems amid supply chain shortages and increased transport costs.

by Nesha Zalesny

Troubles abound in the supply chain. Nearly every ingredient available to formulators is on allocation, sold out, or has a lead time of a few months. Just-in-time is becoming an antiquated business model in light of shipping prices and scheduling. The good news is dairy products and dairy alternatives are experiencing a surge in popularity. The bad news: many of the ingredients that are used to add mouthfeel or stability to these products are facing shortages or shipping delays. What can food manufacturers do to work around the current situation?

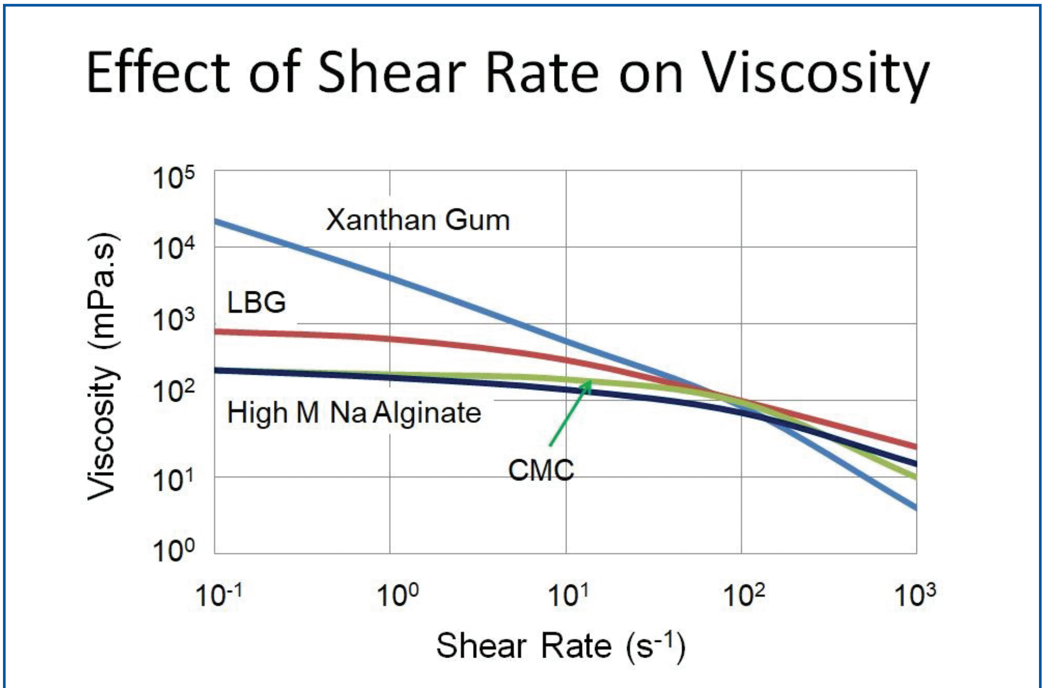
Manufacturers need to begin to qualify secondary and tertiary suppliers that are geographically compatible; begin developing texture maps that will help formulators switch ingredients but maintain familiar textures and flavors; and most importantly, implement new labeling technology to inform and educate consumers.

Global vs. Local Economy

Traditional dairies are prime examples of a local economy. For many dairies, the raw material comes from cows pasturing within a 150-mile radius. Raw milk has a very short shelf life. The milk needs to be chilled, then processed within a matter of hours (12–72 hours depending on conditions). For this reason, cows and dairies are located close to one another. Dairies bring a lot of value to their local economies. Dairies that make milk-based products such as yogurt, cheese, or ice cream rely on local milk. But they also need globally sourced ingredients such as sugar, cocoa, pectin, gelatin, starch, guar, or locust bean gum. In the recent past, purchasing agents could simply buy premixed stabilizing blends and have them shipped just prior to the manufacturing run.

This changed in 2021. Just-in-time manufacturing has become a thing of the past because of raw material shortages, surging demand, and shipping issues. This is especially true for plant-based items where nearly every ingredient, aside from water, comes from somewhere else. Plant proteins may come from Canada; the stabilizers may come from Italy and China. The sugar may come from Brazil or India. As an example, what used to cost US$2,500 for 20 metric tons to ship from India to Europe now costs close to US$19,000. This adds nearly US$1/kg to whatever is being shipped. For high-value products, this additional charge is absorbable. For low-value commodities, this does not make a lot of sense. A better strategy would be to find local sources of hydrocolloids.

Qualifying new ingredients is a massive undertaking. Every ingredient from plant-based proteins to hydrocolloids to sugar has its own nuance. The current shipping situation, along with environmental concerns and new carbon footprint labeling, is providing impetus for food manufacturers to re-evaluate sourcing and qualify new sources or new formulations.



› *Figure 1: A viscosity chart for several hydrocolloids. (Source: IMR International)*

Texture Mapping Beverages

If a local source of a hydrocolloid cannot be qualified, another strategy may be to replace the ingredient with an alternative hydrocolloid. To do this, R&D needs to understand the texture of their product. For beverages, some questions to ask may be: How does the product behave while sitting on the shelf? How does it feel in the consumer's mouth? These properties can be correlated with viscosity. An almond milk stabilized with gellan gum and locust bean gum will be nearly gel-like while sitting on the shelf, but have a low viscosity when the consumer drinks it. What other hydrocolloids are available that can give similar viscosity at these important points? Will consumers reject the product if there is variance in viscosity?

A general idea of the flow properties of the hydrocolloid is useful. Formulators should put together a viscosity chart of the hydrocolloids they regularly use similar to Figure 1.

A chart like this one, where the hydrocolloids are at the same use level—say 0.5%—and in the same environment, e.g., standard tap water, can help formulators get an idea of where to start. The viscosity to the far left of the chart (low shear range) indicates how the product will look while sitting on the shelf. The viscosity at approximately 60 1/s is how it will feel in the mouth. In the example chart, carboxymethyl cellulose (CMC) and the alginate have a similar viscosity at 60 1/s and may be interchangeable in a beverage system.

Making the Switch

Unfortunately, the substitution of ingredients is rarely straightforward. The next step, of course, would be to test it in the target food system. Often formulators end up having to test multiple systems to achieve the texture they want. The ionic environment can be extremely important to the stabilizer. In neutral pH dairy or non-dairy beverage systems, carrageenan and high acyl (HA) gellan are both highly functional.

In neutral pH dairy beverages, carrageenan may be the preferred solution because it is synergistic with dairy proteins. This enables formulators to use very low levels in chocolate milk. For neutral pH non-dairy beverages, carrageenan can be used but at higher use levels. For the plant-based system, HA gellan gum may be a better solution as the protein source is not essential for gellan gum functionality.

Viscosity Considerations

When making changes to texturizing/stabilizing systems, consumers often do not know exactly what is different, just that something is. The human mouth is very sensitive to changes in viscosity. The texture will also influence the flavor.

Non-dairy beverage formulators who are using gellan gum find that the texture is very clean. Often other texturizers such as carob bean gum (LBG), tara gum, or guar gum are added to impart textures familiar to consumers. These hydrocolloids have a fairly flat flow curve. LBG is featured in Figure 1. This flat flow curve means that it does not suspend particles that well (low viscosity at 0.1 1/s), but LBG has a higher viscosity at 60 1/s, which is what consumers will notice. LBG, of course, is extremely expensive right now.

Once formulators are comfortable with the hydrocolloid used to suspend protein or cocoa particles, they can turn their attention to mouthfeel. Basic viscosity testing paired with sensory testing can help manufacturers understand what textures appeal to consumers and make stabilizer choices based on this information. Non-gelling sodium alginate, CMC, tara or guar, or lower levels of xanthan gum or starch may impart a similar mouthfeel.

Protein Stabilization

In cultured dairy or non-dairy drinks or directly acidified protein beverages, knowing the viscosity is less important than keeping the protein stabilized in the finished product. In low pH systems, protein denatures and will become an unpleasant talc texture in the mouth. It will also precipitate out and settle on the bottom of the bottle. That is unless it is protected. Pectin and CMC are the only two hydrocolloids that interact with protein and can protect it in low pH systems. Other hydrocolloids interact with protein in low pH systems, but they generally do not protect the protein; they will worsen or speed the precipitation. High methoxyl (HM) pectin or CMC will form a protective layer around the protein called a micelle. This protective layer repulses other pectin/protein micelles, which prevents the proteins from bumping into one another, forming a bond (bridging flocculation) and dropping immediately out of the solution.

Gelling Systems

Having a list of gelling agents along with texture notes and functionality gives a place to start when trying to change gelling agents (see Table 1). Adding a column for approved suppliers and pricing notes would also be helpful.

Gelling agents for dairy or non-dairy yogurts or desserts will need their own type of mapping. There are many gelling hydrocolloids, each with its own texture profile. Companies that work with these hydrocolloids often use texture analyzers to characterize these hydrocolloids. These instruments have a sensitive arm with a probe. As the probe presses into the gel, a computer captures how much force is required to fracture the gel. The computer program can also determine elasticity and cohesiveness of the gel and a number of other characteristics.

For example, gelatin at 1% forms an elastic but brittle gel. It fractures and breaks apart easily, but the gel melts in the mouth. Agar at 1% is a very firm, brittle gel. It is not elastic and does not wobble like gelatin, nor does it melt in the mouth. K-carrageenan and low acyl (LA) gellan gum are somewhat similar. Iota-carrageenan, xanthan/carob gum blend, and HA gellan gum form a wobbly gel, but these also do not melt in the mouth. Blending these gelling agents with one another or with viscosifiers—like LBG or tara—is a way to create novel textures.

In dairy yogurts, gelatin is highly functional. It has many appealing properties, such as producing a yogurt with a high sheen appearance. Gelatin takes time and low temperatures to fully set, which makes mixing white mass with fruit prep easy. Gelatin yogurts have a lightly gelled texture that melts in the mouth. Finally, yogurt made with gelatin can melt and reset multiple times.

Gelatin is not suitable for plant-based yogurts or desserts. Other gelling agents can be used instead, but they will have different textures. Pectin is fairly commonly used in high-protein or Greek-style yogurts. In this case, there is enough protein that forms coagulate, which imparts texture. Pectin is usually present to prevent syneresis. In plant-based systems, pectin, agar, starch, and xanthan/LBG blends are very successfully used to give both texture and prevent syneresis. Gellan gum or carrageenan have also been successfully used.

› *Table 1: A (non-exhaustive) list of gelling agents with functionality. (Source: IMR International)*

Gelling Agents

Gelling Agent	Solubility	Gel Temp	Mechanism	Reversibility	Transparency
Agar	90°C	Set 32-39C Melt >85-95C	Cooling	Thermoreversible	Turbid
Carrageenan					
Kappa	50-60°C	Set & melt 10°C apart, varies by solute	K^+	Thermoreversible	Transparent in K^+ form
Iota	50-60°C		Ca^{++}	Thermoreversible	Transparent
Gellan	75-85°C	30-50°C	Mono & divalent Ions	Thermoreversible	LA Transparent HA Opaque
Gelatin	70°C	Set 20°C Melt 30°C	Cooling & time	Thermoreversible	Clear
Pectin					
HM	Room temp	50-90°C	Cooling pH & solids	Nonreversible	Clear
LMC	Room temp	Depends on system	Ca^{++}	Depends on system	Clear
LMA	Room temp	Depends on system		Depends on system	Clear
Sodium Alginate	Room temp	Room temp	Ca^{++}	Nonreversible	
Xanthan/LBG	70°C	49-55°C	Cooling	Thermoreversible	Opaque

Ice Cream Stabilizers

Ice cream is a complex system of air bubbles, ice crystals, fat globules, protein, and melted water. Hydrocolloids and emulsifiers keep all these components stable. Dairy ice creams generally contain a very small amount of carrageenan to help keep the mix stable during processing. They also have a combination of LBG and guar. Of course, LBG is experiencing some massive market fluctuations. Formulators looking to reduce their usage or replace it have a few options. Tara gum is being used successfully in ice creams right now, but the availability of tara can also be spotty. What these two hydrocolloids do well is prevent ice crystal formation when the ice cream is heat-shocked. Citrus fiber also does this well. What it does not do is add any creaminess or lubricity to the ice cream. Citrus fiber should be used in conjunction with guar or xanthan gum.

Plant-based frozen desserts are gaining in popularity. These products are relatively new and formulators are struggling with emulsifying systems that will keep plant-based fats mixed with the water and protein in the ice cream. This is especially true if they are trying to avoid mono and diglycerides. Adding viscosity to the water phase can help keep the oil droplets physically separated. LBG, tara, or guar are primarily used, but other manufacturers are turning to cellulosics, such as microcrystalline cellulose and CMC. Plant-based frozen desserts will require higher levels of hydrocolloids to remain stable during processing and to control melt.

Flexible Labeling

Qualifying secondary suppliers or ingredients will do no good if it is too expensive to relabel the product. Current labeling practices are lagging far behind the times. The technology exists to print custom designs on Pop-Tarts and pasta; there are printers that can print instant labels on packages. A strategy moving forward may be to register a few formulations per product with the European Food and Safety Authority (EFSA), then switch back and forth between these formulations as ingredient availability fluctuates. Labels could also contain a QR code that could be scanned by the consumer to provide instant information. Consumers would like more transparency, and this technology could start to fill consumer knowledge gaps.

Shortages, long transit times, and raw material shortages are having a massive effect on the supply chain. Unfortunately, it is too late to get prepared. However, the current situation is an opportunity to evaluate formulations and ingredients and form strategies to deal with these difficulties now and in the future. ▼

› *Pectin and CMC can help protect protein from denaturing and precipitating in plant-based dairy alternatives.*

Nesha Zalesny is a hydrocolloids technical consultant and co-author of *The Quarterly Review of Food Hydrocolloids* produced by IMR International since 1991.