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FMC BioPolymer

Know how. It works.SM

Visit our website at www.fmcbiopolymer.com

FMC

FMC Microcrystalline Cellulose/Cellulose Gel

General Technology

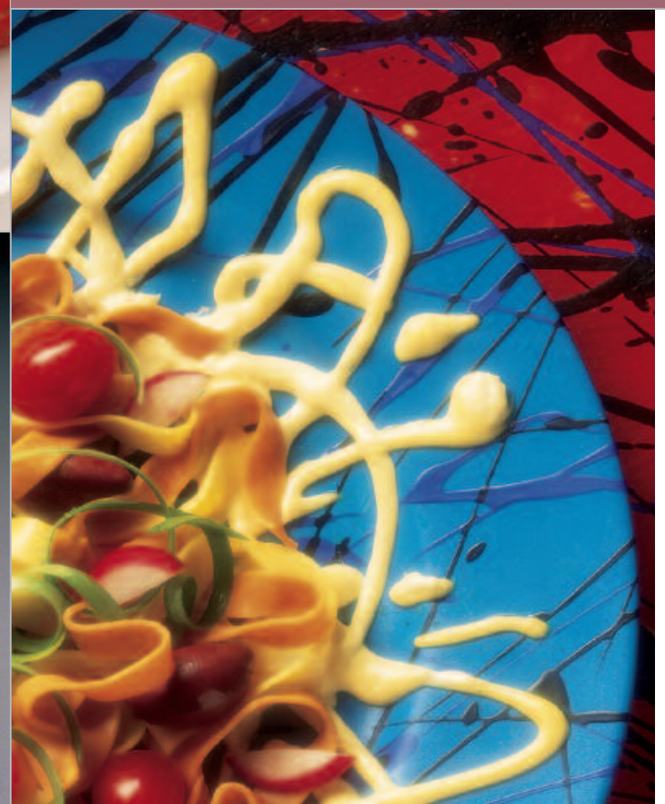
The Avicel Advantage

- AVICEL®
- AVICEL-PLUS®
- GELSTAR®
- NOVAGEL®

- LATTICE®
- NILYN®

FMC BioPolymer

Know how. It works.SM



Know how. It works.SM

With over 35 years of experience in the development and production of microcrystalline cellulose (cellulose gel) products, FMC BioPolymer is well prepared to serve you as a resourceful and reliable partner.

Working with a broad palette of microcrystalline cellulose and an even broader range of problem-solving skills, our know-how can help you add structure, texture and stability to achieve optimum results.

Our high quality microcrystalline cellulose is manufactured under the stringent requirements of ISO certification. And the customer service we provide, both before and after the sale, adds great value to our products. You can rely on us for the sound advice, formulation expertise, and processing problem-solving that can help you reach new levels of efficiency in your operation. You can also count on our family of Avicel® products—Avicel®, Avicel-plus®, Gelstar®, Lattice®, Nilyn® and Novagel® to help turn your innovative thinking into practical, profitable reality.

FMC BioPolymer. Adding structure, texture and stability– naturally.

FMC BioPolymer uses the terms microcrystalline cellulose (MCC) and cellulose gel interchangeably when referring to finished products. To simplify the content of this brochure, we will use the term MCC throughout.

Avicel *Avicel-plus* *Gelstar* *Novagel*

An Introduction to Avicel® Microcrystalline Cellulose

More than 40 years ago, FMC BioPolymer introduced Avicel MCC to the food, pharmaceutical and specialty industries which is the core to our technology. We continue to maintain a leadership position within the markets we serve by improving on existing technology and creating revolutionary breakthroughs that offer our customers even greater functionality.

FMC BioPolymer builds quality and performance into its family of Avicel products at three levels — raw material sourcing, the manufacture of Avicel, and tailoring the functional properties of each product. Today's Avicel product line has evolved into a family of highly functional products that offer optimum functionality to the food, specialty and pharmaceutical industries. FMC BioPolymer markets its Avicel products under six well-established trade names: Avicel, Avicel-plus®, Gelstar® and Novagel® are primarily designed to meet the needs of the food industry. The Lattice® and Nilyn® products are designed to meet the needs of the specialty (non-foods) industry.

All FMC BioPolymer manufacturing facilities maintain ISO certification on a global basis. ISO certification, along with a rigorous QA/QC program, assures highest quality products and functionality with every delivery.

Manufacturing

Microcrystalline cellulose (MCC) is derived from naturally occurring cellulose similar to that found in fruits and vegetables. From this natural source, FMC BioPolymer develops and customizes Avicel products, through various unique co-processing techniques. These help us standardize products to meet specific viscosity, gelling, suspension and stabilizing properties.

The raw material for Avicel is purified plant fiber, or alpha cellulose, and it is composed of millions of microfibrils. Each microfibril is composed of two areas (**Figure 1**).

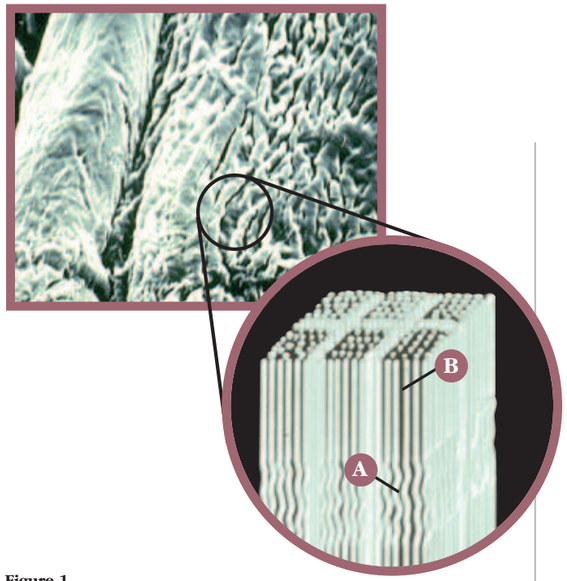
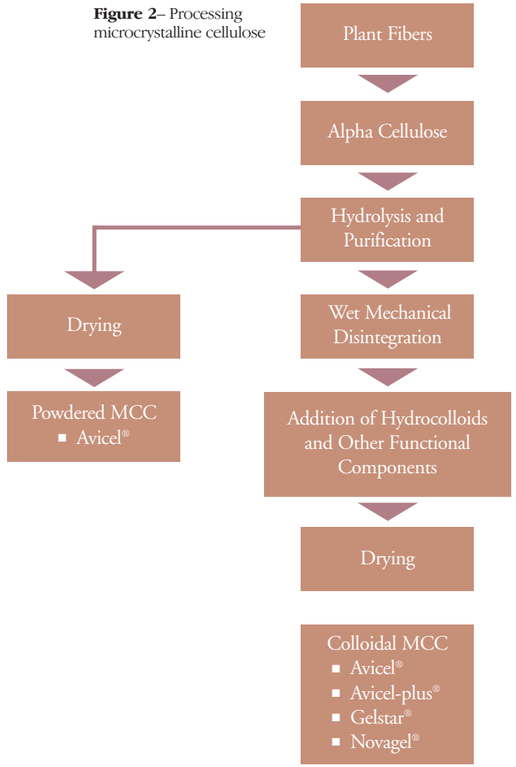


Figure 1
A. The **paracrystalline region**, an amorphous flexible mass of cellulose chains, and
B. The crystalline region, which is composed of tight **bundles of microfibrils** in a rigid linear arrangement.

During processing, the fibrous material is hydrolyzed (depolymerized) to remove the amorphous regions, leaving only the crystalline bundles. The resulting cellulose gel can be processed by two methods, to produce either Avicel powdered or Avicel colloidal MCC (see **Figure 2**, next page).

Figure 2– Processing microcrystalline cellulose



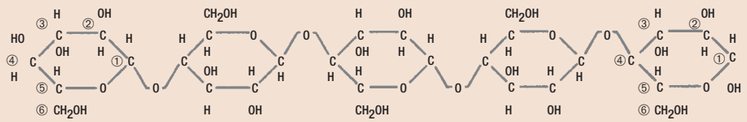
Powdered Grades

Drying the crystalline bundles results in aggregates of very porous particles, which are 100% MCC. This porosity allows the particles to absorb large amounts of water or oil onto the surface.

Powdered grades of Avicel MCC are ideally suited as:

- Source of dietary fiber
- Non-caloric bulking agents
- Opacifiers
- Carriers
- Anti-caking agents
- Extrusion aids
- Tableting aids

Figure 3– The cellulose molecular chain — β —1,4 glycosidic linkages between anhydro glucose units.



Colloidal Grades

Avicel colloidal MCC is processed by wet mechanical disintegration (attrition) which breaks up the cellulose aggregates to release the microcrystals. Traditionally, the microcrystals are then co-processed with a hydrophilic barrier dispersant, to keep the microcrystals from reaggregating during the drying process. The dispersants used have included water soluble hydrocolloids such as carboxymethylcellulose, alginate, guar gum or pectin.

The unique functional properties of fully dispersed Avicel colloidal MCC will greatly improve the mouthfeel and impart or enhance fat-like properties in food products. It also imparts emulsion stability, opacity and suspension in a variety of products.

The line of Avicel products began to evolve in the late 1980s and early 1990s, when FMC BioPolymer patented its process of producing Novagel MCC. The Novagel MCC line of products consists of MCC and guar. They mimic the rheological properties of fat and provide exceptional fat-like eating qualities in processed foods.

More recently, FMC BioPolymer has perfected processing technology that allows the microcrystals to be co-dried with other functional ingredients, such as calcium and surfactants. These Avicel-plus products are unlike the traditional Avicel MCC in that they offer other unique properties, such as improved rheological properties, minimal viscosity with excellent suspension, calcium fortification, enhanced sensory properties and positive modification in the overall flavor profile of the finished product. These properties can be further enhanced with the use of a traditional Avicel MCC.

Colloidal Grades

Avicel® colloidal MCC is specially dried, to form distinct microcrystalline particles. The functionality of colloidal Avicel MCC is due to the properties imparted by these particles when properly dispersed in water or a liquid medium.

Colloidal MCC - Avicel, Avicel-plus®, Gelstar® and Novagel®: Properties and Functionality

Properly dispersed colloidal MCC sets up into a 3-dimensional network of these colloidal particles which imparts stability in the finished product; the system is held together by weak hydrogen bonding.

These colloidal grade product dispersions bind or entrap water to a much lesser extent than soluble hydrocolloids (although some water is bound to the soluble hydrocolloid associated with Avicel, e.g. CMC), as shown in **Figure 4**. The formation of this insoluble 3-dimensional matrix creates a physical network that affects the movement of moisture and gives the colloidal grades of MCC their functional properties.

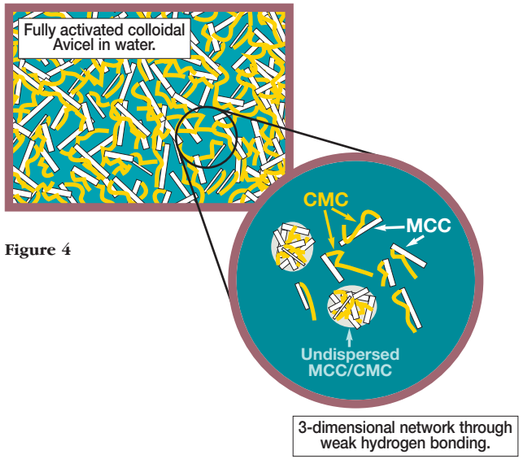


Figure 4

The Functional Properties of Colloidal MCC

The gel network formed with colloidal MCC offers the following properties:

Thixotropy– gels made with colloidal MCC readily break down with shear; when the shear is removed, the gel will reform over time with minimal loss to viscosity.

Foam Stability– colloidal MCC is a premier foam stabilizer. The microcrystalline network thickens the water phase between air cells and acts as a physical barrier to maintain the air cells in suspension. Although colloidal MCC does not have significant film forming properties, it does work to increase the film strength (**Figures 5A and 5B**).

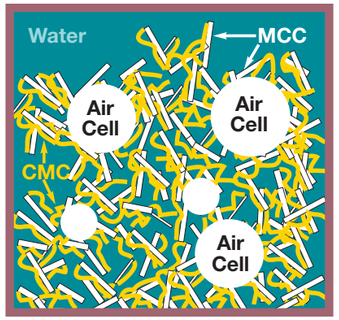


Figure 5A– Colloidal MCC locates in aqueous phase and increases film strength.

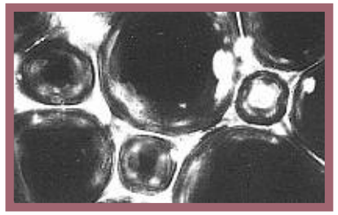


Figure 5B– Stabilizes foam

Stabilize Emulsions– colloidal MCC forms a 3-dimensional network of particles when properly dispersed in water. This colloidal network sets up at the oil-water interface to physically prevent the oil globules from coalescing (**Figures 6 and 7**). Hence the colloidal MCC acts to stabilize the emulsion as well as thicken the water phase.

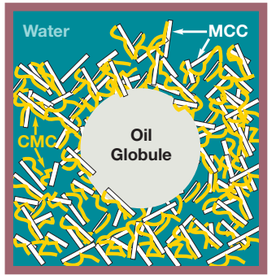


Figure 6– Representation of 3-dimensional structure formed with colloidal MCC

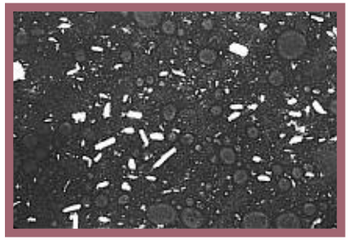


Figure 7– Colloidal MCC stabilizes emulsions for added shelf-life

Heat Stability– temperature changes have little or no effect on the functionality and viscosity of a colloidal dispersion. This property is extremely important in the preparation of heat stable products, particularly when acids are present. Colloidal MCC products will hold up during heat processing, including baking, retorting, HTST, UHT processing and microwave heating with minimal loss in viscosity.

Shorten Textures– colloidal MCC can be used to modify textures– it can shorten textures or add body without creating a gummy or pasty texture. In food systems this quality results in a cleaner mouthfeel and excellent flavor release.

Suspend Particles– the stability and thixotropic rheology of colloidal MCC makes it a useful suspension aid. In an aqueous system, the 3-dimensional matrix sets-up at low use levels to effectively suspend particulates.

Replace Fats and Oils– colloidal MCC can be used to replace some or all of the oil in emulsion type products. The Avicel mimics many of the rheological properties associated with full oil emulsions (**Figures 8 and 9**).

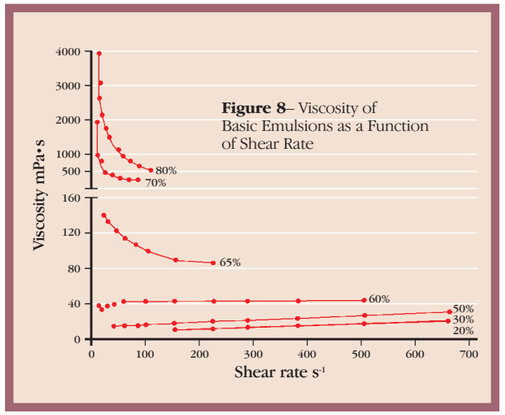


Figure 8– Viscosity of Basic Emulsions as a Function of Shear Rate

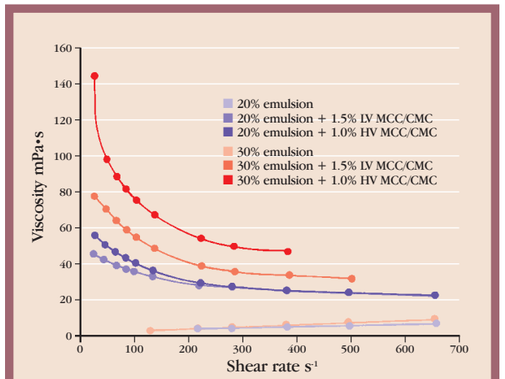


Figure 9– Low Oil/ Emulsions Containing colloidal MCC
These levels are indicative of base oil in water emulsion systems. Use levels are lower in finished food products.

Control Ice Crystal Growth– the 3-dimensional matrix created with dispersed colloidal MCC and the surface area of the microcrystals create a stabilizing system that maintains a homogeneous state during freeze/thaw cycles. Colloidal MCC helps prevent moisture migration and inhibits the aggregation of protein and other solids. The 3-dimensional network formed is extremely effective in maintaining the three-phase system of water/fat/air.

Extend Starches– using a ratio of 4 parts starch/1 part colloidal MCC allows processors to reduce the amount of starch thickener required by as much as 25%. The MCC will also improve heat and shear stability over prolonged process cycles.

(**Figures 10 and 11**)

Figure 10– Colloidal MCC Improves Cling

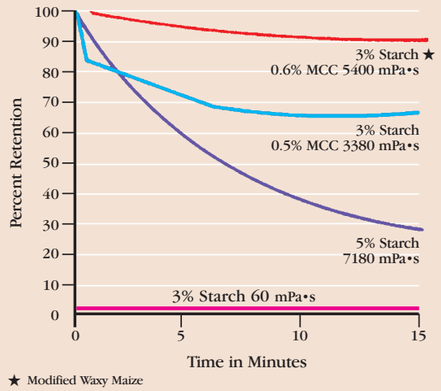
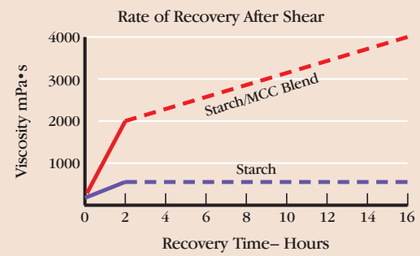


Figure 11– Colloidal MCC is Shear Stable



Opacity– insoluble cellulose crystallites act as opacifiers and can add whiteness to products.

Nutritional Benefits

Microcrystalline cellulose is a good source of dietary fiber, yet contributes no, or very little calories in food systems. Some colloidal grades provide caloric content due to the soluble hydrocolloids used during co-processing with the MCC.

MCC is virtually inert and will not interfere or interact with other nutrients added to the foods for fortification, such as vitamins and minerals. Actually, colloidal MCC is an excellent suspending agent and can provide stable suspension of even very heavy particulates like ferrous fumarate or other minerals.

Our technologists continue to develop innovative products based on colloidal MCC that offer, enhanced functionalities and nutritional benefits.

Typical Nutritional Content of Avicel Microcrystalline Cellulose (per 100 grams):

Parameter	Colloidal Avicel	Powdered Avicel
Total Calories	20 cal	0 cal
Total Fat	ND*	0
Total Dietary Fiber	93 g	98 g
Soluble Dietary Fiber	5 g	0 g
Sugar	ND**	ND
Protein	ND***	ND
Vitamin A	NDE	ND
Vitamin C	NDE	ND
Sodium	934 mg	4 mg
Iron	0.5 mg	0.24 mg
Calcium	2.0 mg	0.1 mg
Ash	2 g	1 g

ND* = Not Detectable (<0.1%)
ND** = Not Detectable (<0.2%)
ND*** = Not Detectable (0.1%)
NDE = Not Determined

Note: These are typical values. Values may vary slightly when analysis are performed in other laboratories.

Proper Dispersion of Colloidal MCC

Proper dispersion of colloidal MCC is the key to obtaining optimum functionality. As the colloidal MCC is dispersed in water with appropriate shear, the hydrophilic portion is hydrated. This allows the cellulose microcrystals to be released and activated, resulting in a stable colloidal network. Critical factors to consider when dispersing the remaining ingredients include:

Order of Addition– colloidal MCC should ideally be hydrated in water **before** other ingredients are added. Colloidal MCC does not chemically bind water and will not interfere with the subsequent addition of the remaining ingredients.

Type of Shear– the grade or type of colloidal MCC you select depends on the amount of shear available in your process.

pH of Systems– a protective colloid is recommended to prevent flocculation if the pH of your system is less than 3.8. Suggested protective colloids are xanthan gum, carboxymethylcellulose and methylcellulose. The protective colloid is generally used at 10% of the microcrystalline cellulose level.

Hard Water/Electrolytes– a high level of electrolytes present in the system before the addition of colloidal MCC may inhibit proper dispersion and require higher shear for good activation.

Methods of Dispersion

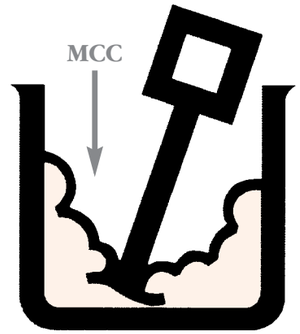


Figure 12–
Dispersion in Water

Batch Tank with High Speed Mixer

- Add microcrystalline cellulose to water while agitating
- Add protective colloid if pH of system is less than 3.8
- Agitate in a high speed mixer for 5 to 15 minutes (length of dispersion time is dependent on the equipment)
- Add the other ingredients
- Hold the salts and acids until last

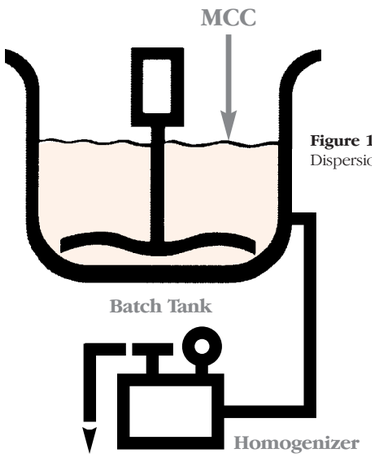


Figure 13–
Dispersion in Milk

Homogenization

- Follow steps as for water dispersion (above)
- Best to use homogenization at greater than 2000 psi (138 bar)

Checking Your Dispersion of Avicel® Colloidal MCC

A polarized microscope will allow you to see if your microcrystalline cellulose is properly dispersed. Full functionality is only obtained after proper dispersion (see **Figures 14, 15 and 16**).

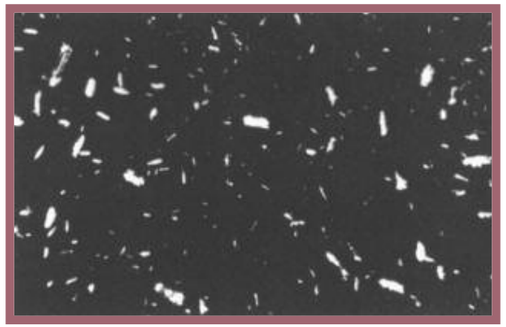


Figure 14– Fully Dispersed 100x Polarized Light
Dispersed Avicel MCC appears as an even, crystalline pattern under polarized light.

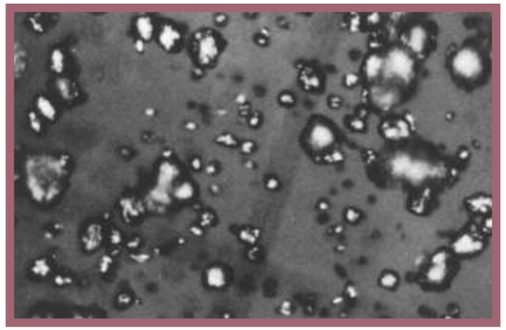


Figure 15– Undispersed 100x Polarized Light
Undispersed Avicel MCC appears as aggregates of powder.

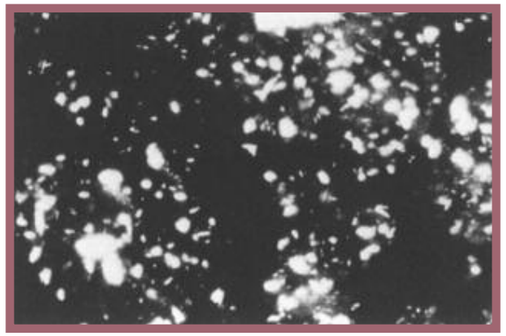


Figure 16– Flocculated 100x Polarized Light
Flocculated Avicel MCC will have areas with gaps, where no microcrystals are present.

Main Applications, Functions and Benefits

The combination of properties discussed in this brochure allows Avicel® MCC to function in a variety of systems, as summarized below.

FOOD SYSTEMS

Application	Type of Avicel MCC	Functions and Benefits
Bar Mixes	Colloidal	▪ Adds creaminess and pulpiness; stabilizes emulsion; suspends solids; adds opacity
Batters & Breadings	Colloidal	▪ Improves cling; reduces drying time; reduces fat absorption during frying; reduces sogginess if finished product stored under heat lamps
Chocolate Drinks	Colloidal	▪ Adds creaminess; suspends solids; stable under high temperature processing; adds opacity
Confections	Powdered	▪ Controls moisture absorption; non-nutritive bulk filler
Dressings	Colloidal	▪ Enhances the mouthfeel characteristics; mimics the mouthfeel of oil; stabilizes emulsions; suspends solids; improves cling; opacifier
Fillings	Colloidal	▪ Prevents boil-out; improves texture and flavor release
Food Service	Colloidal	▪ Stabilizes microwave sauces; reduces skinning on sauces held on steam table; helps keep fried foods crisp under heat lamps; reduces fat pick up during frying
High Fiber Drinks	Powdered or Colloidal	▪ Increases dietary fiber; adds body and creaminess; suspends solids
Icings	Colloidal	▪ Controls flow and moisture migration; imparts stability; increases creaminess
Ice Cream	Colloidal	▪ Ice crystal control; fat and MSNF replacement; enhanced body and texture
Lowfat Sour Cream	Colloidal	▪ Imparts full-fat mouthfeel; stabilizes the system
Puffed Snacks	Powdered	▪ Aids in extrusion process; increases uniformity; promotes finer air cell structure
Sauces	Colloidal	▪ Shear stability allows pumping without viscosity loss; stabilizes emulsions; improves cling; adds body and creaminess; prevents boil-out; adds opacity
Whipped Toppings	Colloidal	▪ Foam stabilizer; syneresis control