U.S. DAIRY INGREDIENTS IN YOGURT AND YOGURT BEVERAGES

The popularity and consumption of conventional yogurt, higher protein yogurt and yogurt beverages continues to grow as people around the world enjoy the taste, creamy texture and convenience as well as recognize the health and wellness benefits associated with consuming these fermented dairy foods. U.S. dairy ingredients from milk and whey are well suited to provide nutrition, function and flavor attributes which enhance the value and cost effectiveness of all types of yogurt products. These benefits appeal to manufacturers, retailers and most importantly, consumers.

A wide variety of U.S. dairy ingredients are available for use in the manufacture of yogurt and yogurt beverages including: sweet whey powder (SWP), whey protein concentrate (WPC), whey protein isolate (WPI), modified WPC/WPIs, ultrafiltered (UF) milk, skim and whole milk powder (SMP, WMP), milk protein concentrate (MPC), milk protein isolate (MPI), micellar casein concentrate (MCC) and other dairy derived ingredients.

The potential benefits of formulating yogurt products with dairy ingredients include:

- Improved texture by increasing viscosity and firmness.
- Reduction of syneresis.
- Standardization of the protein content, which helps maintain product consistency.
- Replacement of non-dairy ingredients for a cleaner, more consumer-friendly label.
- Improved flavor, as compared to using non-dairy ingredients.
- Enhanced nutritional composition due to the addition of protein, minerals and other bioactive components.

Research suggests that proteins and bioactives in dairy can help stimulate the growth of probiotic bacteria (in the product and in the consumer's gut) by exerting a prebiotic effect; positively influence cardiovascular health; build muscle mass; prevent muscle loss; and promote optimal health.

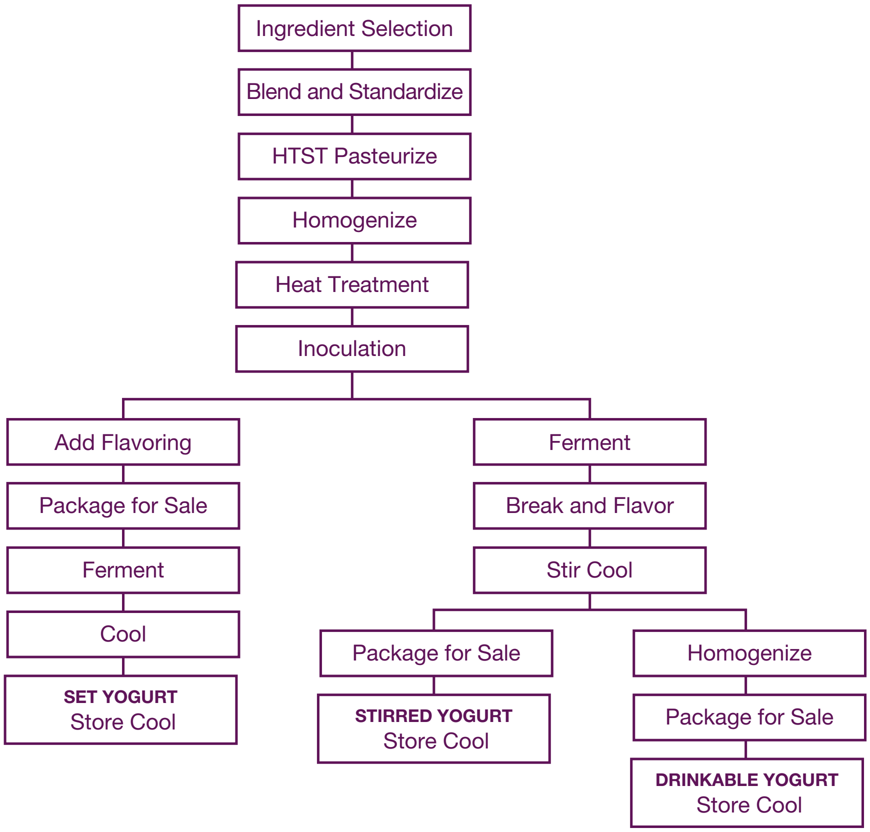



The Basis of What Constitutes Yogurt

Fermented milk products have been produced and consumed for centuries. To manufacture yogurt, milk is fermented at temp 40–45°C (104–113°F) by the required lactic acid producing bacteria *Lactobacillus delbrueckii* ssp. *bulgaricus* and *Streptococcus salivarius* ssp. *thermophilus*. It has become increasingly common to add a mixed starter culture that also includes various additional strains of *Lactobacillus* and *Bifidobacterium*. These latter bacteria can be considered probiotic microorganisms that can actively enhance the health of the consumer by improving the balance of microflora in the gut, when ingested in sufficient numbers.

There are three basic types of yogurt: set yogurt, stirred yogurt and drinkable yogurt. The processes commonly used to produce each of the three types are shown in Figure 1. Higher protein versions of these products may also be created through the addition of dairy protein ingredients and/or additional filtration/concentration steps.

FIGURE 1:
YOGURT PRODUCTION PROCESS



These potential health and wellness benefits complement the healthful image already surrounding yogurt and yogurt beverages, which includes being a source of calcium, vitamins, minerals, protein and probiotic cultures.

This monograph reviews the functional benefits associated with adding dairy ingredients to yogurt and yogurt beverages. It identifies which ingredients are best suited for developing innovative yogurt products for consumers in today's marketplace.

STIRRED/BLENDED CUP YOGURTS

Stirred/blended yogurts may also be referred to as Continental, French or Swiss-style. They can be produced with various textures by adding additional ingredients, including the fruit preparation or other inclusions. As the name suggests, stirred/blended yogurts have the fruit preparation and other added ingredients thoroughly blended into the yogurt after fermentation is complete.

Following the fermentation process, the initial gel formed during the process in the vat is broken by agitation. The yogurt is commonly cooled and pumped through a screen or a homogenizer valve without pressure. The objectives are to gently break the gel structure and achieve a uniform consistency with no lumps after flavors and fruits are mixed with the yogurt.

Stirred/blended yogurts with high-protein contents or added stabilizers, such as gelatin, may re-form a gel structure during storage. Alternatively, other yogurts are produced with the intent of preserving the thick, creamy texture that exists immediately after the initial gel is broken. Excessive stirring or pumping reduces the viscosity of the gel, which is only partially restored with time after the end of shearing.

Stabilizers may increase the viscosity of the stirred/blended product. Appropriate stabilizers include low-methoxyl pectin, gelatin, modified starch and WPC, or a combination of these depending on the desired product and label characteristics.

SET/FRUIT-ON-BOTTOM CUP YOGURTS

The fermentation of set/fruit-on-the-bottom yogurts occurs in the container in which it will be sold. These yogurts generally have a moderate-to-firm textured protein gel. The gel structure forms as acid is produced during fermentation of lactose.

Set yogurts can be plain or flavored and are often only slightly sweetened. Fruit-on-the-bottom set yogurts have exactly what the name suggests: fruit on the bottom of the container. Fruit and yogurt layers are mixed by the consumer. In this type of yogurt, a fruit preparation is deposited into the container before the inoculated, but not yet fermented, yogurt mix is poured on top of it. This minimizes the effect that the ingredients in the fruit base could have on the fermentation and gel properties of the yogurt. Fruit preparations typically include real fruit, flavor, color, sweetener, pectin (acting as a stabilizer) and food-grade acid for preservation.

The top layer may consist of only milk and cultures of *Lactobacillus delbrueckii* ssp. *bulgaricus* and *Streptococcus salivarius* ssp. *thermophilus*. However, it may also include additional dairy ingredients, stabilizers, sweeteners, flavors and colors.

After the container is sealed, it is incubated in a temperature-controlled warm room, usually between temp 40–42°C (104–107.6°F). Once the yogurt reaches the desired pH (~4.6), the containers are transferred to a refrigerated room or blast cooler for rapid cooling to cease any further fermentation.

Care must be taken to minimize handling of the warm cups as the gel is very fragile. Further, it is important to ensure that set yogurts are not physically disrupted or shaken during distribution and handling, as this too will cause the gel to break. Broken gels can result in syneresis. Including dairy proteins in the yogurt mix can help to minimize the amount of syneresis.

YOGURT DRINKS AND SMOOTHIES

Drinkable yogurts include yogurt as one of several ingredients. Products range in consistency from dilute, low-viscosity drinks to thick, viscous products.

During the manufacture of yogurt drinks, the gel is broken by high shear and never allowed to reset. Most products are made by shearing the yogurt post- fermentation. However, others may be made by dilution of yogurt with water or fruit juice. Flavors and other ingredients can also be added, prior to the post-fermentation homogenization step.

Whey proteins, such as WPC and WPI, can be used to fortify protein levels without added viscosity in drinkable yogurts or smoothies, especially if targeting higher levels of protein for meal replacement.

The post-fermentation homogenization step presents a significant challenge to most manufacturers, as it is crucial to obtain the appropriate product viscosity for a drink and to prevent syneresis and protein sedimentation during storage. Applied pressures of less than 500 psi (35 bar) using a single-stage homogenizer are typically sufficient. Helpful ingredients include viscosity-producing cultures (e.g. exopolysaccharides) and hydrocolloid stabilizers such as high-methoxyl pectin. The latter is negatively charged, so the pectin coats the casein molecules when at pH 4, and confers charge repulsion on these particles. Another option for controlling the viscosity of drinkable yogurt is to identify the optimum ratio of whey proteins to casein and the homogenization pressure to produce the desired viscosity for a drinkable beverage with minimum separation.

GREEK-STYLE YOGURT

Once most common in the Middle East and Europe, the popularity of Greek-style yogurt has expanded in the United States and around the world. Greek-style yogurts do not have a specific standard of identity in the United States but typically have a protein content that is two to three times higher than a conventional yogurt. They are characterized by a very viscous texture and a smooth mouthfeel. Greek-style yogurts can be found in plain, blended, fruit-on-the-bottom and drinkable varieties.

There are several ways to produce Greek-style yogurt.

- The more traditional method of Greek-style yogurt manufacture involves making the yogurt and then removing water, lactose and minerals through a physical separation method such as with cheese cloth by hand or using a Quark centrifugal separator on an industrial scale. The separated liquid is called Greek-style yogurt acid whey or often simply acid whey.
- Another process is to use membrane ultrafiltration to achieve a similar product composition. This method also presents the challenge of the production of Greek-style yogurt acid whey.
- A third method is recombination or reconstitution, starting with skim milk powder or nonfat dry milk as the starting base, followed by fermentation and typical yogurt production. One advantage is minimized whey production. However, it is important to control acidification, protect against protein damage caused by high temperature reconstitution and to allow adequate rehydration.
- Yet another method is to add MPC to fluid milk, prior to fermentation, to achieve the targeted composition of 8–10% protein (see sample formula on page 5). It does not require special equipment and has the advantage of no acid whey production. Adding WPC in addition to the MPC will add a smoother appearance and result

in less syneresis during storage. However, the added whey protein has more heat sensitivity and caution is needed to prevent graininess from whey protein denaturation with higher pasteurization temperatures.

Another key consideration when producing Greek-style yogurt is that the 8–10% protein level results in more buffering capacity than in a traditional yogurt with only 4–5% protein. That added buffering capacity means yogurt cultures must produce more acid to reach pH 4.6 which results in longer fermentation and processing times.

OTHER YOGURT STYLES

Aeration or cavitation processing may be used by dairy manufacturers to create more mousse or pudding-like yogurt products. These products are often positioned as a healthful dessert alternative, as they contain all the nutrition of milk, the benefits of the live and active cultures and often have fewer calories. These specialized yogurts can be successfully stabilized with the addition of dairy proteins.

Yogurts packaged in squeeze tubes have their own set of special requirements. For example, this form of yogurt has zero tolerance for syneresis, since the consumer uses this product by squeezing the tube. If the first thing to come out of the tube is liquid whey, the consumer may consider the product to be defective. Dairy proteins with higher protein levels have excellent water binding properties. They can improve the texture of the squeeze tube yogurt by increasing viscosity or firmness while at the same time decreasing the risk for syneresis.

Poised for growth is kefir, a popular cultured and fermented drinkable product fermented with kefir grains. Fermented milk products may also benefit from the addition of dairy ingredients. For example,

GREEK-STYLE YOGURT MADE USING MPC80 FORTIFICATION

INGREDIENTS

	Usage Levels (%)
Skim milk	86.64
MPC80	8.29
Cream	4.89
Pectin	0.18
Total	**100.0**

PROCEDURE

1. Mix MPC80 into skim milk with a high speed mixer. Add cream and pectin. Allow to hydrate with slow agitation and warm in steam-jacketed tank to 60°C (140°F) so solution is at 22°C (150°F) for a minimum of an hour to achieve full hydration of the MPC and best functionality.
2. Homogenize mix 60°C (140°F) at 2000 psi/500 psi (138 bar/34 bar).
3. Pasteurize by batch pasteurization at 85°C (185°F) for 30 minutes or HTST at 95°C (203°F) for 5–7 minutes to achieve the maximum viscosity. Reduce the temperature if less viscosity is desired.
4. Cool to 43°C (109.4°F) and add culture at recommended levels by the manufacturer.
5. Incubate at 43°C (109.4°F) for 8–10 hours to achieve pH 4.6.
6. Package as desired.

NUTRITIONAL CONTENT

U.S. Label

Nutrition Facts

Serving Size 1 Cup (285g)
Servings Per Container

Amount Per Serving	
Calories 220	Calories from Fat 50
	% Daily Value*
Total Fat 5g	**8%**
Saturated Fat 3.5g	**18%**
Trans Fat 0g	
Cholesterol 35mg	**12%**
Sodium 150mg	**6%**
Total Carbohydrate 15g	**5%**
Dietary Fiber 0g	**0%**
Sugars 14g	
Protein 28g	
Vitamin A 4%	• Vitamin C 0%
Calcium 80%	• Iron 0%

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

		2,000	2,500
	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Saturated Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

per 100 g

Calories	80 kcal
Total Fat	2 g
Saturated Fat	1 g
Trans Fat	0 g
Cholesterol	10 mg
Total Carbohydrates	5 g
Dietary Fiber	0 g
Sugars	5 g
Protein	10 g
Calcium	250 mg
Sodium	50 mg
Iron	0 mg
Vitamin A	100 IU
Vitamin C	0 mg

Developed at the Wisconsin Center for Dairy Research, University of Wisconsin-Madison.

liquid probiotic whey shots can provide consumers additional nutritional value by providing a source of high-quality, branched chain amino acids for muscle recovery.

Additional niche yogurt varieties are continually being introduced into the marketplace. Icelandic Skyr, for instance, has experienced rapid growth as consumers discover its creamy texture and high protein content. Australian and full-fat yogurt varieties are also particularly popular with consumers looking to indulge in a delicious treat which also offers nutritional benefits.

No matter the yogurt variety (traditional, Greek-style, Skyr, drinkable, etc.) or production method, product packaging and positioning are vital to its success. Yogurt can be marketed as a healthy indulgence or dessert with sweet flavors such as caramel and chocolate. It can be packaged with separate inclusions such as granola, nuts or chocolate for added texture and consumer interaction with the product. Packaging differentiation can help yogurt target men, children or weight conscious consumers (100-calorie packs). Overall, yogurt production options result in an extremely versatile product, meeting many consumer needs throughout the day and through all life stages.

Dairy Ingredients Used in Yogurt

Most commercial yogurt in the United States and Europe is produced with cow's milk. Fresh whole milk and fresh skim milk are still the primary ingredients; however, powdered and condensed dairy ingredients are increasingly important when formulating yogurts with specific texture, flavor and nutritional properties. A variety of dairy ingredients are available for yogurt production.

SWEET WHEY POWDER

SWP is an ingredient of economic interest to yogurt manufacturers and can be used successfully to replace skim milk powder (SMP) at levels of 2.0–5.2%. Regulations in the United States and in many other countries approve the addition of SWP to increase the milk-solids-non-fat (MSNF) content of the yogurt; however, the regulations may include a stipulation relative to maintaining a minimum ratio of protein to total nonfat solids in the final yogurt. Factors that limit the usage level of SWP in yogurt include: the possible detection of a whey flavor note; the potential to develop a slight yellow color due to Maillard-type reactions during storage of the whey powder; and the low-protein content but relatively high concentrations of lactose and mineral salts.

WHEY PROTEIN CONCENTRATES

WPCs are made in a range of protein levels typically from 34–89%. WPC is the most widely used whey ingredient in yogurt products. The addition of 0.7% to 2.0% WPC34 (or 0.5% to 0.8% WPC80) has been used for the fortification of stirred yogurt; higher levels may lead to some negative attributes. In practice, up to 25–35% of the MSNF content, derived by the addition of SMP to fortify the solids content of the yogurt mix, has been replaced with WPC34. Replacing SMP with

WPC generally results in increased gel strength in set yogurt, increased viscosity in stirred yogurt and reduced syneresis in both types of yogurt. The addition of WPC34 allows the manufacturer to maintain the ratio of protein-to-MSNF and increase the ratio of whey proteins-to-casein in the yogurt. WPC80 allows the manufacturer to easily increase the ratio of protein-to-MSNF, increase the ratio of whey proteins-to-casein, increase the total protein content and reduce the carbohydrate (lactose) content.

Blends of WPC and caseinate are used commercially in various parts of the world and some ingredient companies market these blends as yogurt stabilizers. When added on a constant protein level, sodium caseinate gives higher yogurt viscosities than whey protein-enriched products. Milk protein concentrate (MPC) can also be used as a way of increasing yogurt stability.

Compared to WPC, MPC will contribute a firmer texture and more brittle gel. Use of MPC requires more hydration time than WPC, which adds to processing time. Manufacturers will also have a longer fermentation time using MPC due to the higher calcium content than WPC as both protein and calcium provide buffering capacity.

WHEY PROTEIN ISOLATE

WPI is the dairy ingredient with the highest whey protein concentration (i.e. no less than 90% protein), and it contains only small amounts of lactose, milk minerals and milkfat. WPI is added to yogurt products for special nutritional, textural and flavor attributes. It is also used in some low-lactose or reduced/low-sugar yogurt and smoothie products. Numerous fruit-flavored yogurt drinks and smoothies featuring WPC80 and WPI have been introduced in both the United States and international markets.

DEMINERALIZED AND HYDROLYZED WHEY

The mineral content of whey influences the denaturation of whey proteins. Phosphates, for example, contribute to the buffering of milk products. Thus, a reduction in minerals should assist in faster acidification of yogurt mixes and a reduction in fermentation time.

The lower protein content of demineralized whey compared with SMP results in weaker gels when it is used as a substitute for SMP. The addition of milk protein hydrolysates to yogurt enhances the acidification rate and reduces the fermentation time by supplying growth factors for the starter culture. Hydrolysates may also stimulate the growth of probiotic cultures.

MILKFAT

Fresh cream and whole milk powder (WMP) can be sources of added milkfat in yogurt products. Whey products can be a highly economical source of milkfat. The milkfat in whey ingredients needs to be taken into account when considering final milkfat targets in yogurt products. Whatever the milkfat source, the ingredient should be blended with the other dairy ingredients and the total blend should be homogenized before the product is heat treated, inoculated and fermented.

Milkfat has a significant effect on the properties of the final yogurt. It imparts flavor, mouthfeel and richness to the product. The milkfat also impacts the final structure and stability of the yogurt. Increases in viscosity and a reduction in syneresis are directly related to yogurt's fat content. Of course, nutritional composition is also altered and care must be taken to ensure nutritional targets are met.

Pre-inoculation homogenization of fat-containing yogurt mixes is critical in preventing a cream layer from forming on the top surface of the finished product. Homogenization breaks down the fat globules and produces smaller fat globules with a greatly increased surface area.

Casein and whey protein-rich membranes form on the new fat globules. The milk proteins on the new fat globule membrane interact with the milk proteins in the serum during acidification causing the fat globules to become an integral component of the gel structure.

Changing Nutritional Perspectives on Milkfat

Milkfat is one of the most complex dietary fats with a unique fatty acid profile. Because 65-70% of the fats in milkfat are saturated fatty acids, low or no-fat dairy products may be perceived as healthier than full-fat dairy products varieties. Yet, there is growing research in areas such as cardiovascular disease, obesity and diabetes suggesting that consumption of dairy foods—regardless of fat content—may play a positive role in healthful dietary patterns. For more information, visit ThinkUSAdairy.org *and download* Technical Report: Milkfat and Related Ingredients Serving Today's Marketplace*.*

TYPICAL COMPOSITION OF DRY DAIRY INGREDIENT SOURCES OF MILK SOLIDS

INGREDIENT	PROTEIN (%)	LACTOSE (%)	FAT (%)	ASH (%)	MOISTURE (%)
Whole Milk Powder	24.5–27.0	36.0–38.5	26.6–40.0	5.5–6.5	2.0–4.5
Skim Milk Powder	34.0–37.0	49.5–52.0	0.6–1.25	8.2–8.6	3.0–4.0
UF Skim Milk	10.0–12.0	2.5–3.5	0.0–0.5	0–2.5	80.0–85.0
Milk Protein Concentrate 42	40.0–43.0	45.0–47.0	0.5–1.5	7.0–8.0	3.5–5.0
Milk Protein Concentrate 80	79.0–83.0	4.0–6.0	1.0–2.0	7.0–8.0	3.5–5.0
Micellar Casein Concentrate 85	85.0–87.0	1.0–3.0	1.0–3.0	4.0–6.0	4.0–6.0
Milk Protein Isolate	87.0–89.0	1.0–2.0	1.0–2.0	3.5–6.0	3.5–5.0
Sweet Whey Powder	11.0–14.5	63.0–75.0	1.0–1.5	8.2–8.8	3.5–5.0
Whey Protein Concentrate 34	34.0–36.0	48.0–52.0	3.0–4.5	6.5–8.0	3.0–4.5
Whey Protein Concentrate 80	80.0–82.0	4.0–8.0	4.0–8.0	3.0–4.0	3.5–4.5
Whey Protein Isolate	90.0–92.0	0.5–1.0	0.5–1.0	2.0–3.0	3.5–5.0

MILK POWDERS

SMP is commonly used to fortify the MSNF and protein content of yogurt to improve the texture and stability of the gel. It can also be recombined with water to replace fresh fluid skim milk or whole milk. Low-heat SMP with a whey protein nitrogen content greater than or equal to 6 mg/g is often preferred. This allows the whey proteins to be more reactive during the heat treatment of the yogurt base before the culture is added. Higher heat-processed WMP is also commonly used. The higher heat treatment inactivates lipase and reduces the potential for flavor problems associated with lipolysis, which may develop in the powder during storage.

MILK PROTEIN CONCENTRATE

MPC can be rehydrated to substitute for skim milk or it can be used to fortify the protein content of the yogurt base. The protein content of MPC powders typically range from 42-85%. Milk protein isolate (MPI) has a protein level of at least 87.1%. There is little difference in texture or whey separation when MPC is used to replace SMP in yogurts made at a constant protein level. However, proper hydration must take place prior to heat processing to prevent grainy or chalky mouthfeel.

Functional Properties of Dairy Proteins in Yogurt

The functional properties of dairy ingredients come primarily from the protein; however, the other components must also be considered in product formulations. These include lactose, fat, moisture and ash which encompasses vitamins and minerals. What makes dairy ingredients so appealing to yogurt product manufacturers is the compatibility between ingredient and product: both come from cow's milk and complement each other in color, flavor and nutritional profile. Dairy protein ingredients also enhance the nutritional profile of the milk being fermented into yogurt. Additionally, dairy ingredients can positively impact yogurt formulations by improving texture, flavor, appearance and other physical characteristics.

HYDRATION

To obtain the best results it is crucial to allow sufficient time for the ingredients to become rehydrated before heat processing. Much of the literature reported on the use of dried dairy ingredients in yogurt includes a range of time and temperatures for hydration prior to heat processing of the mix with the extreme example of allowing no time for hydration.[1]

Whey protein ingredients typically require 20-30 minutes of hydration time at ambient temperatures in water with slow agitation to obtain good solubility.[2]

Milk protein ingredients are much slower to hydrate and will contribute to a grainy, chalky texture in high protein yogurts if they are not well hydrated. Many researchers have evaluated the hydration characteristics of milk protein concentrates and isolates.[3]

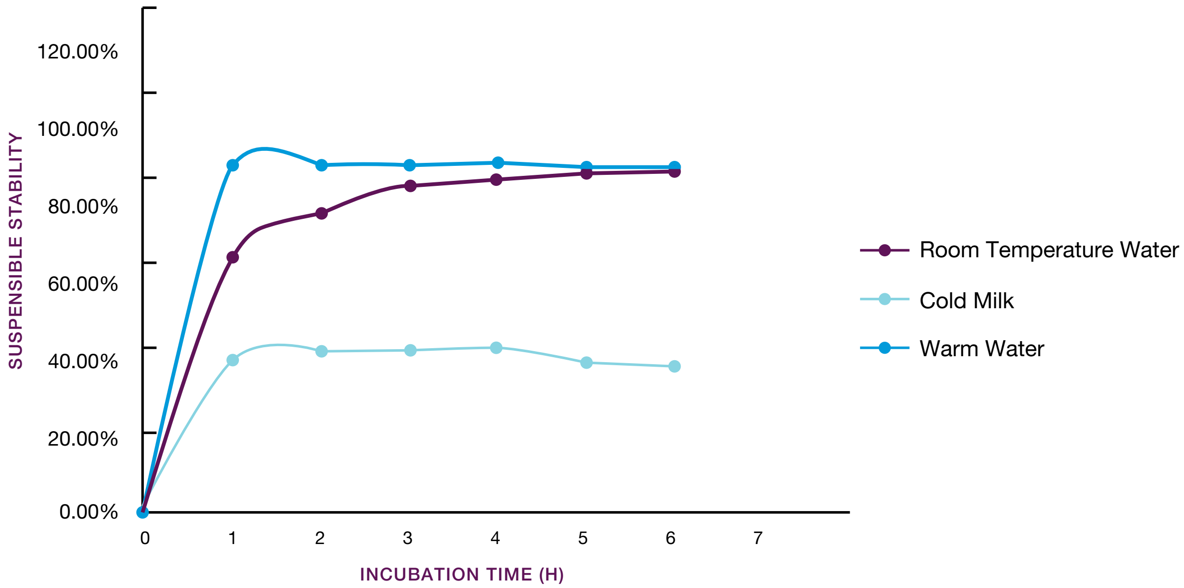
Below is a table that compares the solubility (hydration level) of 5% solutions of MPC85 in room temperature water (RT, 25°C [77°F]), cold milk (CM, 5°C [41°F]) and warm water (WW, 50°C [122°F]) (Figure 2). The solutions were stirred continuously over a six-hour period with temperature control. The fastest hydration occurs in warm water while the slowest is in cold milk. Even after six hours of hydration, the MPC85 solution in cold milk is not fully solubilized. Published studies have confirmed this issue of poor re-hydration properties with high protein MPC ingredients at 70% protein and above.[4] This slow hydration in cold milk is an issue for high protein yogurt manufacture since most of the time the MPC will be added to cold milk.

Warming the milk during the hydration time will help achieve better solubility in a shorter time period given that water at a temperature of 50°C (122°F) provides the highest solubility for MPC85 after only one hour. Batch pasteurization may work better for hydration of MPC, once it is added to cold milk, because it takes time to warm a tank of milk to reach temp 85°C (185°F) (or above) and be held for up to 30 minutes while a high temperature, short time process (temp 95°C [203°F] for 5-7 minutes) is much shorter.

Hydration studies done using micellar casein concentrate (MCC) showed that powder solubility increased from 17% after five minutes to about 70% after 15 hours of rehydration at temp 20°C (68°F).[6]

Additional studies using MCC containing 58% and 88% protein were evaluated in yogurts with 9.8% protein. The MCC ingredients were allowed to hydrate for 18 hours at temp 4°C (39.2°F) to ensure good hydration prior to manufacture of the yogurt.[7] When compared to a strained Greek-style yogurt, yogurt made with the MCC with 58% protein was the most similar in texture and flavor.

FIGURE 2:
HYDRATION CHARACTERISTICS OF MPC85



(Testing done by The Wisconsin Center for Dairy Research according to the method of Sikand et al.)[5]

TEXTURE

Dairy proteins bind water through physical and chemical means. They can improve the texture of yogurt products by increasing viscosity or improving firmness, as well as decreasing any whey-off or syneresis. For example, previously denatured whey proteins in traditional yogurts can improve yogurt firmness and viscosity; presumably because these complexes can bridge with denatured whey proteins already on the micelle surface.

Yet in Greek-style products, texture/viscosity is even more crucial for final product acceptability. Whey proteins or milk proteins may be used to make a Greek-style yogurt but the procedures may need to be modified for each. Additionally, the characteristics of the final yogurts may be very different.

Yogurts were made comparing WPC80 and MPC85 at 6%, 8% and 10% protein (Figure 3), heat processed at two different temperature conditions, temp 85°C (185°F) for 15 minutes and temp 68°C (154.4°F) for 15 minutes.

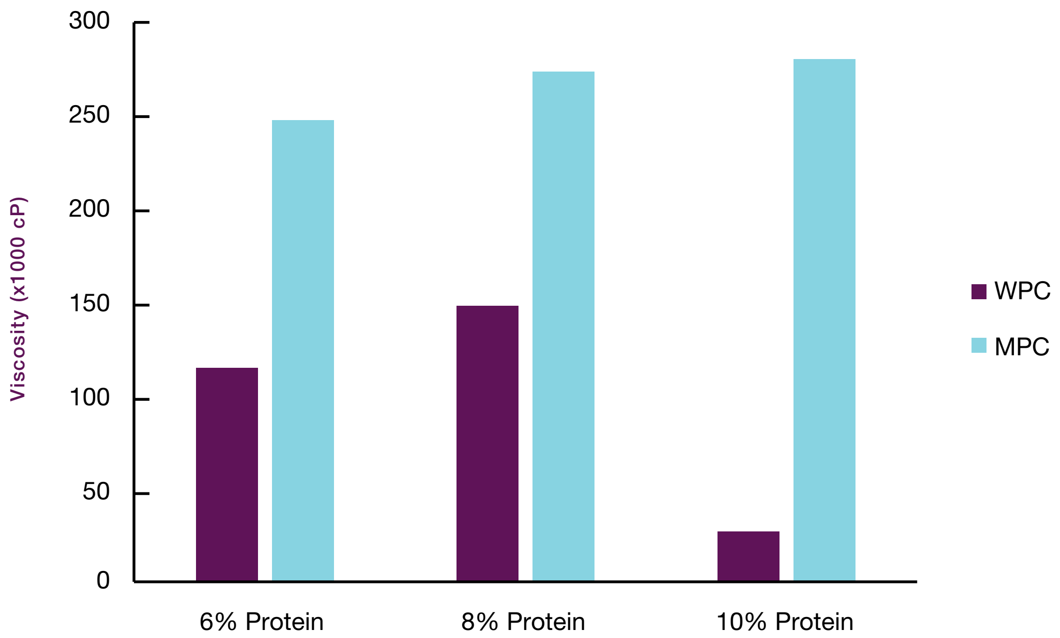
The procedures for making the yogurts were as follows:

1. Mix and blend the dry ingredients with milk and hydrate for one hour with slow agitation.
2. Heat the milk mixture to 68°C (154.4°F) for 15 minutes and then heat at 68°C (154.4°F) or 85°C (185°F) for an additional 15 minutes.
3. Cool the mixture to about temp 43°C (109.4°F).
4. Add 0.01–0.02% culture to the mix.
5. Incubate the mixture at 43°C (109.4°F) to pH 4.6.

Two different heat treatment temperatures were used because whey proteins tend to be more susceptible to coagulation during heating.

MPC85-fortified yogurts had a much higher viscosity at each level of protein. Casein, the predominant protein in MPC85, is the primary protein which forms the gel structure of yogurt. Whey proteins will denature and interact with casein during the heating process but they do not gel during the acidification process.

FIGURE 3:
VISCOSITY OF YOGURTS WITH WPC AND MPC AT DIFFERENT PROTEIN LEVELS (68°C [154.4°F] FOR 15 MINUTES)



Note: Yogurt mixes fortified with WPC80 at 8% and 10% protein coagulated at temp 85°C (185°F) for 15 minutes.

If you compare all the yogurts made with MPC85 at the three levels of protein, the yogurts heat treated at 85°C (185°F) had a much higher viscosity than the yogurts heat treated at temp 68°C (154.4°F) (Figure 4). This difference is expected since higher heat treatments will denature more of the whey protein and create a firmer texture. It is also possible that the yogurts heated to the higher temperature would have taken longer to warm up which helped the MPC85 to have more time to hydrate.

Depending on desired texture and protein targets, formulators may choose different sources of dairy protein. For example, if producing drinkable yogurts, formulators may choose WPC80 for fortifications to ensure a less viscous, more drinkable yogurt.

Differences in incubation time were also found between the WPC80 and MPC85-fortified yogurts. The WPC fortified yogurts with 6% and 8% protein took five hours to reach pH 4.6 versus the MPC85 fortified yogurts which took 6–8 hours respectively. At the 10% protein level, WPC fortified yogurt took eight hours to reach pH 4.6 and the MPC fortified yogurt took nine hours. Overall, yogurts fortified with higher levels of protein have a longer incubation times.

Protein increases the buffering capacity of the yogurt resulting in the need for more acid production or longer fermentation times to reach the target pH of 4.6. Higher calcium content also contributes to a higher buffering capacity which explains why incubation times for MPCs is longer versus WPC at the same level of protein.

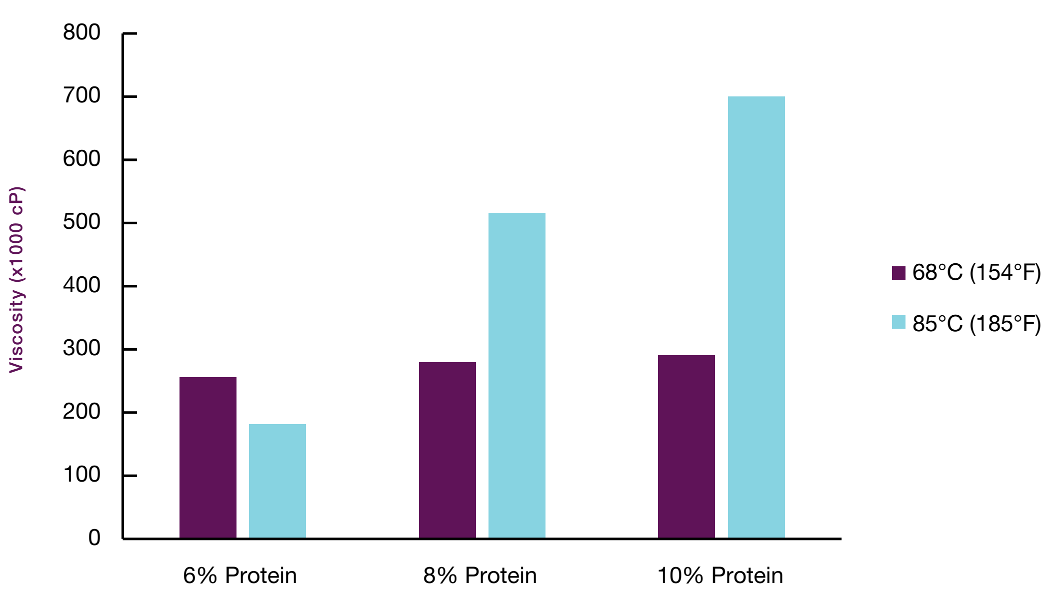
FLAVOR

Unlike non-dairy-derived ingredients, dairy ingredients have a very mild, sweet milky flavor profile that complements yogurt products. However, when making Greek-style products, the higher levels of protein may influence the astringency of the finished yogurt product.

GELATION

Whey proteins form thermo-irreversible gels. Gel characteristics depend on the protein concentration, the pH of the solution and the calcium and sodium ion concentration. Heating whey proteins to temperatures above temp 70°C (158°F) can cause denaturation and polymerization, resulting in gel formation. Whey proteins form irreversible gels by restructuring into extended three-dimensional networks that have the capability to entrap fat and water. A strong gel network helps hold this water and prevents moisture loss, which assists in controlling syneresis.

FIGURE 4:
VISCOSITY OF YOGURTS WITH MPC85 AT DIFFERENT PROTEIN LEVELS AND HEAT TREATMENTS



VISUAL APPEAL

Depending on the yogurt product, dairy ingredients can add opacity and whiteness to finished products. Using higher levels of WPC80 (up to 8–10% protein) will give the yogurt an off-white to tan color while yogurt made with MPC85 at the same levels will be very white.

EMULSIFICATION

Dairy proteins are widely used in the food industry to stabilize oil-in-water emulsions. Whey proteins have both hydrophilic and hydrophobic groups, which allow the proteins to adsorb and unfold rapidly at the oil-water interface and form a layer that stabilizes the oil droplets and prevents flocculation and/or coalescence. The hydrophilic sites of the whey protein molecule bind water while the hydrophobic sites encapsulate the fat, resulting in stabilization of the system. They can be used to totally or partially replace chemical emulsifiers in specialty yogurt products. Additionally, the bound fat in whey ingredients is relatively high in phospholipids (i.e. lecithin), which adds to their emulsification capacity.

WHIPPING & FOAMING

The whipping ability and foaming function assists in the formulation of specialty yogurt products, such as those resembling mousse, as well as thick, shake-style yogurt drinks. Dairy proteins can help stabilize and strengthen air cells.

SOLUBILITY

Dairy proteins are soluble. Undenatured whey proteins are highly soluble over the entire pH range (pH 2 to 10). However, heat may reduce the solubility of whey proteins and render them sensitive to precipitation, especially between pH 3.5 to 6. Minimizing mineral content when processing milk protein powders is also important to maintaining their solubility over time.

DISPERSIBILITY

Dairy ingredients are dispersible. Instantized forms of WPC and WPI are available for applications that require the ingredients to dissolve quickly and without an excessive amount of agitation. The process of instantizing involves the use of a unique spray-drying method, which produces agglomerates with improved wetability, sinkability and dispersibility.

Factors to Consider When Adding Dairy Ingredients to Yogurt Product Formulations

Flavor

The effect of replacing SMP with SWP or WPC on yogurt flavor varies by product type. While some studies have shown that casein exhibits good flavor-masking properties, yogurt processors frequently comment that fruit and other added flavors are enhanced in the formulas when whey proteins have been used to partially replace casein. Dairy ingredients used for the fortification of yogurt should be bland and not contain off-flavors which could be carried through to the yogurt. In strongly flavored and sweetened yogurt such off flavors are less of a concern than in plain yogurt.

Lactose Concentration

High-lactose levels may increase the risk of post-acidification. Thus, high-protein powders such as WPI, WPC80, MPC80 and MPI may reduce the risk of this defect. Lower lactose also reduces the sugar content of yogurt, which some consumers find appealing. A low-lactose, high-protein powder such as WPC80 or WPI reduces the quantity of whey powder needed as these ingredients are concentrated sources of whey protein.

Usage Level

In determining the best addition/substitution level it is important to consider:

- Unwanted textural defects may occur with excessively high usage levels (e.g. lumpiness from too high a substitution of SMP with WPC).
- Coagulation can occur during the heat processing of the yogurt mix if the whey protein content is very high. Thus, depending on the type of WPC used, addition of more than 4% whey protein to a yogurt mix is not recommended.
- WPC made from acid whey is more sensitive to heat coagulation than WPC made from sweet whey due to the higher mineral content in acid whey. Mineral fortification of the yogurt mix also impacts the heat sensitivity of the proteins.
- The texture-building ability per gram of protein differs depending on the type of milk protein and the aggregation state of the milk protein.

Variability

Manufacturers are encouraged to discuss the type and usage level of dairy protein ingredients with their U.S. supplier to achieve the desired finished product characteristics. Several types of WPC and MPC that differ in protein level and functional performance are available. Modified products, e.g. with improved gelation characteristics, are also available.

Compositional Standards

YOGURTS

Yogurt products come in a range of fat contents, from full-fat, which is made with whole milk, to fat-free. Regulations on the identity and composition of yogurts differ by country.

In the United States, yogurts with three different fat contents are legally defined. Yogurt (full-fat) must contain not less than 3.25% milk fat and not less than 8.25% MSNF before flavors are added. Low-fat yogurt must contain not less than 0.5% nor more than 2% milkfat and not less than 8.25% MSNF before flavors are added. Nonfat or fat-free yogurt must contain less than 0.5% milk fat, have no added fat and contain not less than 8.25% MSNF before flavors are added.

There are noteworthy differences in yogurt products from around the world. Most yogurt products produced in the United States include sweeteners and stabilizers in their formulas. The stabilizers aid in controlling the texture and minimizing whey separation. Modified starch, gelatin and pectin are commonly used while guar gum and agar are used on occasion.

Cup yogurt products come unflavored, sometimes with a bit of sweetener, as well as flavored and sweetened. Tubes and drinks are almost always flavored and sweetened. Sweeteners range from standard natural sugar to high-intensity, non-nutritive sweeteners.

Yogurts with reduced sugar and/or calorie contents have become popular in the United States. Although not defined by regulations, these products typically include dairy ingredients with higher protein-to-solids ratios and high-intensity sweeteners.

In countries outside the United States, yogurt products are often less sweet and many do not include, or even allow, added stabilizers. Rather, the types of cultures, increasing the milk protein concentration and altering process variables are used to control texture and minimize whey separation in these products.

Savory versions of many yogurts and drinkable yogurts are also garnering consumer interest globally.

FERMENTED MILKS

Yogurt goes by a different name in many parts of the world, a name that is not legally regulated or defined. Categorized simply as fermented milk, these products are a part of many countries' cultures and have been around for centuries.

International standards for fermented milks, including yogurt, can be found in the Codex Alimentarius, standard 243, which was revised and adopted in 2003. The standard specifies that the milk for yogurt may have been manufactured from products obtained from milk with or without compositional modification as limited by these provisions: milk protein must be a minimum of 2.7%; milkfat must be less than 15%; titratable acidity must be a minimum of 0.6%; and the product shall contain symbiotic cultures of *Streptococcus salivarius* ssp. *thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus*. These starter cultures must be present at a total minimum level of 10^7 per gram and labeled

Selection of Dairy Ingredients

Selecting the proper amount and type of dairy ingredients for a specific application is crucial to the success of a product. The variety of U.S. dairy ingredients is growing as specialty and customized dairy products and blends are being offered. Please consult with your U.S. dairy ingredient supplier during the product development phase as they may be able to provide assistance and recommend the best dairy ingredients to meet your objectives. Selection of dairy ingredients may be based on the following considerations:

Economics

Dairy ingredients add protein and bind water in yogurt products. They have the potential to play a significant role in reducing ingredient costs and improving finished product yields.

Nutrition Labeling Claims

If specific health, structure/function or nutrient content claims are made, yogurt products must be formulated to comply. Dairy products are significant sources of high-quality protein and dairy minerals such as calcium and phosphorous. Additionally, WPCs, WPIs, MPCs and MPIs may offer an indirect functional benefit in formulas where fat and/or sugar is being reduced.

Processing Conditions

Care should be taken in the handling and addition of dairy ingredients to ensure full and complete hydration and functionality. Additionally, desired viscosity and protein targets may dictate whether you use milk or whey proteins and what fermentation/processing times are most appropriate.

microorganisms shall be present at a minimum of 10^6 per gram. Starter microorganisms shall be viable, active and abundant in the product to the expected end of the shelf life (if stored appropriately).

Pasteurizing yogurt products may necessitate a labeling notice that cultures have been destroyed. In the United States, current regulations allow heat-treated yogurt to be called yogurt while in many parts of the world this product would have to be called heat-treated fermented milk or another related term other than yogurt.

To review the complete Codex Alimentarius standard, visit www.codexalimentarius.net.

Ensuring the Quality of Yogurt Products

Manufacturers with well-designed sanitation and quality assurance programs produce yogurt products with a 45–60 day shelf life, providing the product is properly refrigerated (0–4°C [32–39.2°F]) during storage and distribution. Compared to many other foods, yogurt products have fewer microbiological problems because of the high heat treatment the milk receives, the low pH of the product and the subsequent high lactic acid concentration.

Fruit or puree may contaminate the product if these flavoring systems are not adequately processed and stored. The same is true for all ingredients added to yogurt products. Good manufacturing practices are of significant importance.

Many consumers like to pack a yogurt product for on-the-go consumption later in the day. The good news is that both the acidic environment and the active cultures help protect the quality and safety of yogurt products when refrigeration isn't available immediately before consumption.

SOME COMMON DEFECTS IN YOGURT AND POTENTIAL REMEDIES

DEFECT	POSSIBLE CAUSES	REMEDY
Syneresis (whey separation)	• Low protein or fat content	• Increase protein and/or fat content
	• Insufficient heat treatment or homogenization of milk	• Increase heat treatment and homogenization pressure
	• Too high an incubation temperature	• Reduce incubation temperature to 40–42°C (104–107.6°F)
	• Low acidity	• Ensure pH is around 4.4
	• Disturbance of coagulum prior to cooling (e.g. shaking or vibration)	• Reduce vibration and have adequate cooling
	• Improper handling of set-yogurts in the distribution chain	• Reduce abuse during storage
	• Unspecified	• Add stabilizer, change culture type, add an exopolysaccharide producing culture along with the starter culture
Granular/Sandy (nodular)	• Poor mixing/hydration of powders	• Adjust process conditions
	• Agitation prior to cooling	• Adequate cooling
	• Precipitation of calcium salt and/or whey proteins	• Adjust process conditions
	• Too high an incubation temperature	• Reduce incubation temperature 42°C (107.6°F)
	• Too low an inoculation rate	• Alter inoculation rate or culture type
	• Too high addition of stabilizer(s)	• Reduce dosage rate
	• Too high whey protein-to-casein ratio	• Decrease whey protein-to-casein ratio
	• Inadequate breakdown of large protein clusters during mixing for stirred yogurt	• Use of a screen or mesh to break up lumps
Low Viscosity	• Low protein or fat content	• Increase protein and/or fat content
	• Insufficient heat treatment or homogenization of milk	• Increase heat treatment and homogenization pressure
	• Too high an incubation temperature	• Reduce incubation temperature to 40–42°C (104–107.6°F)
	• Too low an inoculation rate	• Alter inoculation rate or culture type
	• Excessive shearing of yogurt during cooling	• Adjust process conditions

(Derived from Tamime and Robinson, 2007)[8]

Sample Yogurt Formulations

The formulations in this section are provided as a starting point for product development purposes. Adjustments may be necessary, depending upon the exact nature of ingredients used, processing and storage variables, local regulations and target consumer preferences in each market. Please consult your U.S. dairy ingredient supplier for additional information. Also check local regulations for use of additives and labeling requirements.

SAVORY GREEK-STYLE YOGURT

INGREDIENTS

	Usage Levels (%)
Yogurt, nonfat Greek	97.96
Green bell peppers, freeze-dried, chopped	0.49
Red bell peppers, freeze-dried, chopped	0.49
Cucumbers, freeze-dried, chopped	0.30
Shallots, freeze-dried, chopped	0.30
Garlic, freeze-dried, chopped	0.29
Salt	0.07
Basil, dried	0.06
Dill, dried	0.02
Ground black pepper	0.01
Paprika	0.01
Total	**100.00**

PROCEDURE

1. Mix together yogurt, freeze-dried vegetables, herbs, salt and spices.
2. Let product hydrate 24 hours at refrigeration temperature.
3. Stir before consuming.
4. Optional—serve in a tart cup or with crackers.

NUTRITIONAL CONTENT

U.S. Label

Nutrition Facts
Serving Size 1 Cup (225g)

Amount Per Serving

Calories 130	Calories from Fat 0
	% Daily Value*
Total Fat 0g	**0%**
Saturated Fat 0g	**0%**
Trans Fat 0g	
Cholesterol 15mg	**5%**
Sodium 150mg	**6%**
Potassium 330mg	**9%**
Total Carbohydrate 12g	**4%**
Dietary Fiber 1g	**4%**
Sugars 10g	
Protein 22g	**42%**

Vitamin A 10%	Vitamin C 45%
Calcium 25%	Iron 2%
Thiamin 6%	Riboflavin 0%
Phosphorus 30%	

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Saturated Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Potassium		3,500 mg	3,500 mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g
Protein		50g	65g

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

per 100 g

Total Fat	0 g
Saturated Fat	0 g
Trans Fat	0 g
Cholesterol	7 mg
Total Carbohydrates	5 g
Dietary Fiber	0 g
Sugars	4 g
Protein	10 g
Calcium	111 mg
Phosphorus	133 mg
Potassium	147 mg
Sodium	67 mg
Iron	0 mg
Vitamin A	222 IU
Vitamin C	12 mg

Developed at the Dairy Products Technology Center, California Polytechnic State University.

LOW-FAT STIRRED YOGURT

INGREDIENTS

	Usage Levels (%)
Skim milk	75.46
Milk, 1% fat	18.87
Cream, 40% fat	2.98
Skim milk powder	1.99
Stabilizer	0.70
Culture	per supplier recommendation
Total	**100.00**

PROCEDURE

1. Mix all ingredients, except culture.
2. Pasteurize at 85–90°C (185–194°F) for 15 seconds or 80–82°C (176–180°F) for 30 minutes. Homogenize at 10–14 MPa (1450–2030 psi).
3. Cool to 34–41°C (93–106°F). Inoculate with yogurt cultures until pH is 4.20–4.65.
4. Cool to less than 15°C (59°F).
5. Stir.
6. Package.
7. Store refrigerated.

NUTRITIONAL CONTENT

U.S. Label

Nutrition Facts

Serving Size 1 Cup (245g)
Servings Per Container

Amount Per Serving

Calories 190 Calories from Fat 40

	% Daily Value*
Total Fat 4.5g	**7%**
Saturated Fat 3g	**15%**
Trans Fat 0g	
Cholesterol 30mg	**10%**
Sodium 125mg	**5%**
Total Carbohydrate 13g	**4%**
Dietary Fiber 0g	**0%**
Sugars 12g	
Protein 24g	

Vitamin A 4% • Vitamin C 0%
Calcium 70% • Iron 0%

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Saturated Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram
Fat 9 • Carbohydrate 4 • Protein 4

per 100 g

Calories	50 kcal
Total Fat	1.5 g
Saturated Fat	1 g
Trans Fat	0 g
Cholesterol	6 mg
Total Carbohydrates	5 g
Dietary Fiber	0 g
Sugars	5 g
Protein	3 g
Calcium	120 mg
Magnesium	11 mg
Phosphorus	98 mg
Potassium	151 mg
Sodium	50 mg
Iron	0 mg
Vitamin A	237 IU
Vitamin C	0 mg

Developed at the Wisconsin Center for Dairy Research, University of Wisconsin-Madison.

CUCUMBER LEMON YOGURT DRINK

INGREDIENTS

	Usage Levels (%)
Milk, reduced-fat	90.21
Milk permeate (dairy product solids)	6.49
Nonfat dry milk	0.92
Cucumber puree	2.20
Natural lemon flavor	0.15
Yogurt culture (CHR Hansen YCX11)	0.02
Probiotics (CHR Hansen F-DVSABC)	0.01
Total	**100.0**

PROCEDURE

1. Blend permeate and nonfat dry milk into milk with high-speed mixer. Allow to hydrate for 30 minutes.
2. Warm mix to 60°C (140°F) and homogenize at 2,500/700 psi.
3. Pasteurize mix at 85°C (185°F) for 30 minutes.
4. Cool to 42°C (107.6°F).
5. Inoculate with culture and add probiotics.
6. Incubate at 42°C (107.6°F) for 4–5 hours until pH reaches 4.2.
7. Mix in cucumber puree and lemon flavor.
8. Cool to 4°C (39.2°F) and store at refrigeration temperatures.

NUTRITIONAL CONTENT

U.S. Label

Nutrition Facts

Serving Size 1 cup (240 ml) (227g)
Servings Per Container

Amount Per Serving

Calories 160	Calories from Fat 35
	% Daily Value*
Total Fat 4g	**6%**
Saturated Fat 2g	**10%**
Trans Fat 0g	
Cholesterol 15mg	**5%**
Sodium 130mg	**5%**
Total Carbohydrate 24g	**8%**
Dietary Fiber 0g	**0%**
Sugars 24g	
Protein 8g	**16%**

Vitamin A 8% • Vitamin C 2%
Calcium 50% • Iron 0%

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.

	Calories	2,000	2,500
Total Fat	Less than	65g	80g
Saturated Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g
Protein		50g	65g

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

per 100 g

Calories	70 kcal
Total Fat	2 g
Saturated Fat	1 g
Trans Fat	0 g
Cholesterol	7 mg
Total Carbohydrates	11 g
Dietary Fiber	0 g
Sugars	11 g
Protein	4 g
Calcium	220 mg
Sodium	57 mg
Iron	0 mg
Vitamin A	176 IU
Vitamin C	1 mg

Developed at the Wisconsin Center for Dairy Research, University of Wisconsin-Madison.

Q&A

Q: Which whey ingredients produce the firmest yogurt gels?

A: Since it is primarily the r3-lactoglobulin component of whey ingredients that is involved in modifying yogurt texture, a higher-protein WPC (i.e. WPC80) or WPI will provide greater textural benefits than lower-protein products (i.e. SWP and WPC34) when used at the same level. Modified WPC products enriched with r3-lactoglobulin are likely to produce yogurt gels with higher firmness/viscosity than unmodified WPC/WPI products when used at the same protein level.

Q: What happens when the ratio of casein-to-whey proteins is decreased in yogurt formulations?

A: Decreasing the ratio of casein-to-whey proteins results in increased firmness and viscosity. This may or may not be desirable based on the yogurt product's positioning in the marketplace. However, the decrease will also reduce whey separation, which is usually desirable in all yogurts.

Q: What happens if too much dairy protein is added to yogurt mix?

A: Excessive protein addition or lack of proper hydration can lead to graininess, lumpiness, yellow color development and a short, brittle texture.

Q: How can the protein content of yogurt drinks be increased without impacting viscosity?

A: The protein content of yogurt drinks can be increased by mixing a pasteurized solution of WPC80 or WPI with the yogurt component of the beverage. Soluble (undenatured) WPI increases protein content without increasing viscosity as long as the WPI remains undenatured (i.e. added after the heat treatment or directly to the fermented products).

Q: How can dairy ingredients assist with producing consistent viscosity from batch to batch?

A: Variation in the composition and the processing of the dairy ingredients and inconsistencies in the yogurt production process can result in inconsistent gel strength and viscosity in yogurt. Variations in the type and source of all milk solids, the heat treatment of the milk, the pH of the milk when heat treated, the starter culture, the incubation temperature and shear on the product after fermentation can affect gel strength and viscosity. All should be considered in identifying the cause of inconsistent viscosity. Many have recognized that including high-quality dairy proteins can help overcome inconsistencies.

Q: How does WPC reduce syneresis in cup yogurt?

A: Most research, as well as industry experience, identifies a direct relationship between including whey proteins in yogurt formulas and minimizing syneresis.

However, high incubation temperature and physical abuse (i.e. shaking) can cause stress on the gels that lead to syneresis. Stabilizer systems, such as modified food starch, can provide additional protection, and they are generally considered necessary in stirred yogurts and yogurts that will undergo the rigors of national and international distribution systems. A disadvantage of starch is its effect on flavor. Minimizing the concentration of added starch is desirable and that can be accomplished by including WPC and other stabilizers, such as gelatin or low methoxyl pectin, in the formula. Minimizing shear damage to starch granules after they have been swelled by the high-heat treatment of the milk also permits lower starch levels.

Q: How can I safely heat-treat yogurt beverages?

A: The pH range of yogurts is the most unstable for caseins and whey proteins. Aggregation of proteins resulting in grainy texture and separation are concerns. If the yogurt beverage is to be pasteurized after fermentation, a solution of high methoxyl pectin is mixed with the yogurt and any post-fermentation added WPC or WPI. In the pH range of 3.8–4.4 that is typical for yogurt drinks, the high methoxyl pectin has a negative charge. Its absorption to the whey proteins and caseins helps to prevent heat coagulation by enhancing the electrostatic repulsion between protein molecules. Minimum temperature and hold times plus adding turbulent flow during heating will help minimize heat coagulation. Working with suppliers to obtain the WPC/WPI that is most stable to heat under these conditions is very important.

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About the U.S. Dairy Industry

As the world's largest single-country producer of cow's milk with an ample, rising milk supply and a competitive, evolving product portfolio, the U.S. dairy industry is well positioned to satisfy the world's growing appetite for dairy. Continuous investments in research and innovation combine with a long, rich heritage of skilled craftsmanship to support the United States' emergence as a leading global supplier of quality dairy products and ingredients. The entire U.S. dairy supply chain—farm families, milk processors, product and ingredient manufacturers and dairy institutions—works together to provide high-quality, nutritious products to fulfill customers' needs and drive their businesses forward.

GET IN TOUCH

USDEC Southeast Asia
20 Martin Road,
Seng Kee Building, #08-00
Singapore 239070

ThinkUSAdairy.org
Tel. +65 6230 8550
Fax. +65 6235 5143

*To learn more and contact a USDEC Southeast Asia representative, go to **USdairyexcellence.org** or email **info@usdecsg.org***

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