U.S. WHEY INGREDIENTS IN YOGURT AND YOGURT BEVERAGES

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The popularity and consumption of yogurt and yogurt beverages continues to grow as people around the world recognize the health and wellness benefits associated with consuming these fermented dairy foods.

Whey ingredients provide multiple nutritional, functional and cost benefits that enhance the value of all types of yogurt products. These all-natural, dairy-derived ingredients complement yogurt's flavor, texture and composition.

The use of dairy ingredients in dairy foods appeals to manufacturers, retailers and most importantly, to consumers.

A wide variety of U.S. whey 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), specialized WPCs, WPIs and other whey-derived ingredients and blends.

The potential benefits of formulating yogurt products with whey ingredients include: a cost reduction compared with skimmed milk powder (SMP); improved texture by increasing viscosity and firmness; reduction in wheying-off or syneresis; standardization of the protein content, which helps to maintain a consistent quality product; replacement of non-dairy ingredients for a cleaner, consumer-friendly label; improved flavor, as compared to using non-dairy ingredients; and enhanced nutritional composition due to the addition of whey proteins, minerals and other bioactive components.

Research suggests that the bioactive components and proteins in whey ingredients can: stimulate the growth of probiotic cultures (in the product and in the consumer's gut) by exerting a prebiotic effect; positively influence cardiovascular health; build muscle mass, as well as prevent muscle loss; and help promote optimal health. These potential health and wellness benefits complement the healthful image already surrounding yogurt and yogurt beverages, which include being a source of calcium and other vitamins and minerals, dairy proteins and probiotic cultures.

This monograph reviews the functional benefits associated with adding whey ingredients to yogurt and yogurt beverages. It identifies the whey ingredients that are best suited for the varying types of yogurt products in the marketplace today, as well as presents opportunities for innovative product development.

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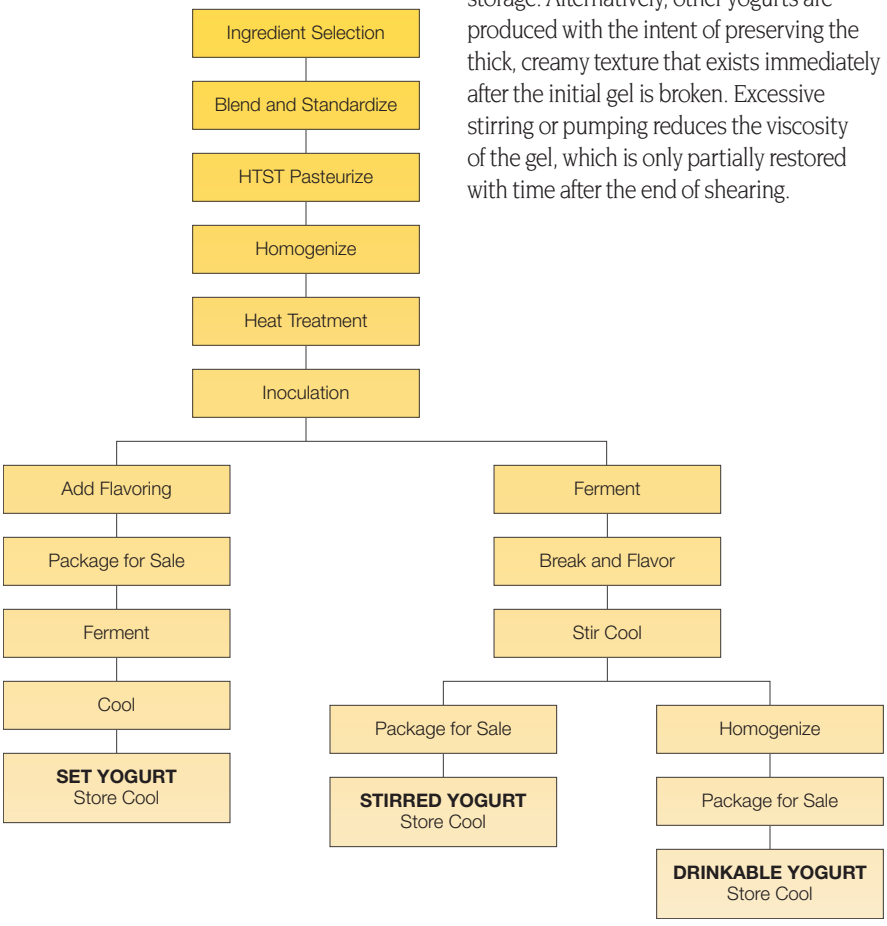
The Basis of What Constitutes Yogurt

Fermented milk products have been produced and consumed for centuries. To manufacture yogurt, milk is fermented at 40°C to 45°C by the lactic acid producing bacteria *Lactobacillus delbrueckii* ssp. *bulgaricus* and *Streptococcus thermophilus*. It has become increasingly common to add a mixed starter culture that also includes various strains of *Lactobacillus* and *Bifidobacterium*. These latter bacteria are probiotics, specifically selected 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.

Figure 1.
Yogurt Production Process



STIRRED/BLENDED CUP YOGURTS

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

Following the fermentation process, the initial gel formed during the process in the vat is broken. 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 to 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 increase the viscosity of the stirred/blended product. Appropriate stabilizers include low-methoxyl pectin, gelatin, modified starch and WPC, or a combination of these.

SET/FRUIT-ON-BOTTOM CUP YOGURTS

The fermentation of set/fruit-on-bottom yogurts occurs in the cup or 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 by the fermentation of lactose and possibly other added dairy ingredients. With set/fruit-on-bottom yogurts, the consumer expects to break the original gel structure.

Set yogurts can be plain, or flavored and slightly sweetened. Fruit-on-bottom set yogurts have exactly what the name suggests: fruit on the bottom of the container. For consumption, the 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 thermophilus*. It can also include whey ingredients, stabilizers, sweeteners, flavors and colors.

After the container is sealed, it is incubated in a temperature-controlled warm room. Once the yogurt reaches the desired temperature (usually 40-42°C) and 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 gels are very fragile. Further, it is important to ensure that set yogurts are not physically abused or shaken during distribution and handling, as this too will cause the gels to break. Broken gels can result in syneresis. Including whey proteins in the yogurt mix can help minimize syneresis.

YOGURT DRINKS AND SMOOTHIES

Drinkable yogurts include yogurt as one of many 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 such shearing of the yogurt post-fermentation. However, others are made by dilution of yogurt with water or fruit juice. Flavors and other ingredients can also be added immediately prior to the post-fermentation homogenization step.

Whey proteins, such as WPC and WPI, can be used to fortify protein levels in drinkable yogurts or smoothies. Because smoothies are viscous, processors can fortify these products with high levels of whey protein, especially if they are targeting a meal replacement product.

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.

OTHER YOGURT-STYLE PRODUCTS

In most countries the regulations related to the composition and ingredients in yogurt beverages and smoothies are more flexible than the traditional set or stirred yogurt products.

Using an aeration process similar to whipping cream or introducing overrun to ice cream mix, dairy manufacturers have created mousse-style yogurt products. These products are often positioned as a healthful dessert alternative, as they contain all the goodness of milk and the benefits of the live and active cultures, often with fewer calories and less fat than traditional mousse. In these aerated yogurts, whey proteins can successfully stabilize the air cells, preventing the yogurt product from collapsing.

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. The proteins in whey ingredients are excellent at binding water. This improves the texture of the squeeze tube yogurt and increases its viscosity, or firmness at the same time it decreases any whey-off or syneresis.

There are other fermented milk products that will benefit from the addition of whey ingredients. For example, liquid probiotic whey shots can provide consumers additional value by being a source of high-quality protein through the addition of whey protein.

Greek-Style, concentrated, or strained yogurt is a common variety produced in the Middle East, popular in European countries and gaining popularity in the United States. A combination of whole milk standardized with cream to 7% fat is most often used as the base for Greek yogurt but nonfat versions are also commercially available. The traditional process includes fermentation of the yogurt base to pH 4.6 followed by straining the yogurt through a cheese cloth at 4°C overnight. Whey drains through the cheese cloth, increasing the total solids from 14% to 21-23%. The resulting texture is very thick and viscous. Straining the yogurt increases the protein content to approximately 6-7% and the fat content to 10%. The traditional method is not very practical for large scale production so mechanical separation using a Quarg centrifugal separator is an alternative method of whey separation.

Others have used ultrafiltration of the milk to achieve the desired composition or formula modifications to achieve the fat and total solids desired.

Yogurt Packaging

Yogurt can be sold in plastic, glass or terra cotta cup or in a squeeze tube, with the latter considered an interactive product that is usually targeted to children. Yogurt drinks are most often sold in single-serve packages – carton or bottle – but can also be found in larger, multi-serve, family-size containers.

Plastic cups, from single-serving to multi-serving containers, are used in most countries for all types of cup yogurt. These plastic containers may or may not have an inner seal made of plastic, plastic-coated paper or foil. If there is a seal, some cups may not have a lid while other cups may have a plastic lid. Multi-packs of attached miniature cups are also available. These almost always are sold in packs of four or six cups with a foil seal to connect the cups.

Fruit-on-bottom set yogurts are also sold in glass pots; however, advancements in plastics technology are enabling the use of clear plastic containers. The advantage of these clear containers is that consumers can see the layered product, which may help convey the health and wellness benefits of consuming yogurt.

Effects of Using of Whey Ingredients in Yogurt Include:

- Decreasing the ratio of casein to whey protein results in:
  – Increased firmness/viscosity
  – Reduced whey separation
- Reduction in buffering by whey proteins (compared with caseins) resulting in faster acidification
- Stimulation of the growth of yogurt bacteria (depends on protein and mineral contents)
- Increased gelation pH/shorter gelation time which can result in a shorter manufacturing time

WHEY INGREDIENTS USED IN YOGURT

Most commercial yogurt is produced with cow's milk. Fresh milk and fresh skimmed milk are still the primary ingredients; however, powdered and condensed milk fractions are increasingly important in formulating yogurts with the composition needed for the desired texture, flavor and nutritional and health properties. The variety of dairy ingredients available for yogurt production and knowledge of the benefits that they can provide continues to increase, as does the trend towards including whey ingredients.

A range of different types of whey ingredients, including SWP, WPC, WPI, deproteinized, demineralized and hydrolyzed whey, can successfully be used in the manufacture of yogurt products.

Sweet Whey Powder

SWP is an ingredient of economic interest to yogurt manufacturers and can be used successfully to replace SMP at levels of 2.0% to 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% to 89%. WPC is the most widely used whey ingredient in yogurt products. The addition of 0.7% to 2.0% WPC 34 (or 0.5% to 0.8% WPC 80) has been used for the fortification of stirred yogurt; much higher levels may lead to some

negative attributes. In practice, up to 25% to 35% of the MSNF content, derived by the addition of SMP to fortify the solids content of the yogurt mix, has been replaced with WPC 34. 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 WPC 34 allows the manufacturer to maintain the ratio of protein-to-MSNF and increase the ratio of whey proteins-to-casein in the yogurt. WPC 80 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.

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 milk fat. WPI is added to yogurt products for special nutritional or texture benefits. It is also used in some of the new-generation, low-lactose or reduced/low-sugar yogurt and smoothie products. Numerous fruit-flavored yogurt drinks and smoothies featuring WPC 80 and WPI have been introduced in both U.S. 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 hydrolyzates to yogurt enhances the acidification rate and reduces the fermentation time by supplying growth factors for the starter culture. Hydrolyzates may also stimulate the growth of probiotic cultures.

Whey Protein Crisps

Whey proteins can now be added to yogurt in a new form. Whey protein crisps are puff extruded, light and crisp particles produced with WPC or WPI and starch. They are available in varying protein concentrations (20% to 80%), sizes, shapes, flavors and colors. Whey protein crisps provide a great opportunity to add more nutrition, a unique texture and even fun to a yogurt product.

OTHER DAIRY INGREDIENTS USED IN YOGURT

Milk Fat

Fresh cream and anhydrous milk fat are common sources of added milk fat in yogurts. Whole milk powder (WMP) can also be a source of milk fat in yogurt products. Whey products can be a highly economical source of milk fat. The milk fat in whey ingredients needs to be taken into account when considering final milk fat targets in yogurt products. Whatever the milk fat 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.

Milk fat has a significant effect on the properties of the final yogurt. It imparts flavor, mouthfeel and richness to the product. The milk fat also impacts the final structure and stability of the yogurt. Both viscosity and a reduction in whey separation are directly related to yogurt's fat content.

Homogenizing the milk with fat before inoculation is critical in preventing a cream layer from forming in 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.

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 skimmed 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

Milk protein concentrate (MPC) can be rehydrated to substitute for skimmed milk or it can be used to fortify the protein content of the yogurt base. The protein content of MPC powders typically range from between 42% to 85%. Milk protein isolate (MPI) will have a protein level of at least 90%. There is little difference in texture or whey separation when MPC is used to replace SMP in yogurts made at a constant protein level.

Interest in protein concentrates has increased in response to consumer interest in lower carbohydrate and reduced calorie yogurts. However, yogurts with protein content greater than 5.6% were considered to be too firm in body and they may appear grainy in texture. Additionally, yogurts with low-lactose concentrations can be bland in taste due to a reduction in the acid content and other flavor compounds.

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
Skimmed Milk Powder	34.0-37.0	49.5-52.0	0.6-1.25	8.2-8.6	3.0-4.0
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
Milk Protein Isolate	85.0-88.0	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	4.5

FUNCTIONAL PROPERTIES OF WHEY PROTEINS

The functional properties of whey 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 whey 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. Whey ingredients enhance the goodness of the milk being fermented into yogurt.

The functional properties of whey ingredients positively impact yogurt formulations by helping to improve both texture and flavor. The addition of whey proteins has also been shown to improve the water holding capacity of yogurt. The effectiveness of the added whey protein in improving texture and reducing whey separation depends on the processing conditions including the milk heat treatment conditions (time, temperature and pH), protein and mineral contents of the whey product, and fermentation conditions used for yogurt manufacture.

Specialty products such as aerated yogurts, smoothie-type yogurt drinks and squeeze-tube yogurts also benefit from the functional properties of whey proteins including emulsification, gelation, visual appeal and whipping ability/foaming. In addition, whey proteins are highly soluble and assist with the dispersion of other ingredients in yogurt formulations, such as flavors, sweeteners, vitamins and minerals.

To obtain the best results it is crucial to allow sufficient time for the ingredients to become rehydrated before processing.

Texture

Whey proteins bind water through physical and chemical means. This improves the texture of yogurt products by increasing viscosity or improving firmness, as well as decreasing any whey-off or syneresis. The use of previously denatured whey proteins as an ingredient in yogurt can still improve yogurt firmness and viscosity; presumably these complexes can bridge with denatured whey proteins already on the micelle surface.

In some formulations, whey ingredients can be used as low-cost solids, bulking agents and fat replacers. Whey proteins contribute to a smooth and creamy mouthfeel in the finished product.

Flavor

Unlike non-dairy-derived ingredients, whey ingredients have a very mild, sweet dairy flavor profile that complements yogurt products.

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 70°C 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.

Visual Appeal

Depending on the yogurt product, whey ingredients can add opacity and whiteness to finished products.

Emulsification

Whey 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. Whey proteins help stabilize and strengthen air cells.

Solubility

Undenatured whey proteins are highly soluble; they show excellent solubility 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.

Dispersibility

Whey ingredients have good dispersibility. Instantized forms of WPC and WPI are available for applications that require whey 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.

Stirred Yogurt with Fruit

Yogurt Base

Ingredients	Usage Level (%)
Fresh milk (3.5% fat, 9.1% MSNF)	84.75%
Sugar	7.50%
Culture	3.00%
WPC 34	2.00%
Anhydrous milk fat	0.90%
Modified food starch	0.90%
Skimmed milk powder	0.70%
Kosher gelatin	0.25%
Total	**100.00%**

Final Stirred Yogurt

Ingredients	Usage Level (%)
Yogurt base	88.00%
Stabilized fruit base	12.00%
Flavor and color	variable
Total	**100.00%**

Procedure:

Yogurt Base

1. Add dry ingredients into fresh milk and allow to hydrate.
2. Warm to 60°C and add anhydrous milk fat.
3. HTST pasteurize and homogenize.
4. Heat to 85°C and hold for 30 minutes with slow mixing.
5. Cool to 42°C and mix in culture.
6. Incubate at 42°C until pH reaches 4.6.
7. Break the gel and pump yogurt through a screen into the mix tank.

Final Stirred Yogurt

1. Add heat processed fruit base (aseptically packaged if available) to yogurt base at an 88:12 ratio.
2. Add flavor and color if desired.
3. Gently mix to obtain a uniform blend.
4. Package and store at 0-4°C

Nutritional Content per 100 grams

Calories	130 kcal
Total Fat	3.5 g
Saturated Fat	2 g
Trans Fat	0 g
Cholesterol	15 mg
Sodium	45 mg
Total Carbohydrate	21 g
Dietary Fiber	0 g
Sugars	19 g
Protein	4 g

Formula courtesy of Hugunin & Associates, USA

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 though 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, WPC 80, MPC 80 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 WPC 80 or WPI reduces the quantity of whey powder needed as these ingredients are concentrated sources of whey protein. They also have reduced ash/mineral content, which could reduce the overall fermentation time by reducing the buffering capacity of the yogurt mix.

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 will also impact 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 of WPC or other dairy ingredient and usage level with their U.S. supplier to achieve the desired finished product characteristics. Several types of WPC are available differing in protein level and functional performance. Specifically 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% milk fat 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 yogurts products from around the world. Most yogurts produced in the United States include sweeteners and stabilizers in their formulas. The stabilizers aid in controlling the texture and 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, and 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 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.

Fermented Milks

Yogurt goes by a different name in many parts of the world, a name that is not regulated or defined. Categorized simply as fermented milk, these products are a part of the country's culture 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%; milk fat must be less than 15%, titratable acidity must be a minimum of 0.6%; and the product shall contain symbiotic cultures of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus*. These starter cultures must be present at a minimum level of 107 and labeled microorganisms shall be present at a minimum of 106. 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.

Fat-Free, Calcium Fortified Stirred Yogurt

Ingredients	Usage Level (%)
Fresh skimmed milk (0.2% fat, 9.0% MSNF)	92.46
Culture	3.00
WPC 80	1.80
Fructose	1.00
Modified food starch	1.00
Milk calcium	0.43
Kosher gelatin	0.30
Sucralose	0.01
Flavor and color	Variable
Total	**100.00**

Procedure:

1. Blend dry ingredients into skimmed milk.
2. HTST pasteurize and homogenize.
3. Heat to 85°C and hold for 30 minutes with slow mixing.
4. Cool to 42°C and mix in flavor, color and culture.
5. Package in cups.
6. Transfer cups to 42°C incubator.
7. Incubate until pH reaches 4.6.
8. Transfer cups to 0-4°C storage and cool.
9. Store and distribute at 0-4°C.

Nutritional Content per 100 grams

Calories	50 kcal
Total Fat	0 g
Saturated Fat	0 g
Trans Fat	0 g
Cholesterol	0 mg
Sodium	50 mg
Total Carbohydrate	7 g
Dietary Fiber	0 g
Sugars	6 g
Protein	5 g

Formula courtesy of Hugunin & Associates, USA

Selection of Whey Ingredients

Selecting the proper amount and type of whey ingredients for a specific application is crucial to the success of a product. The variety of U.S. whey ingredients is growing as new specialty and customized whey products and blends are being offered. Please consult with your U.S. whey ingredient supplier during the product development phase as they may be able to provide assistance, share expertise and recommend the best whey ingredient for your objectives.

Selection of whey ingredients may be based on the following considerations:

Economics

Whey products 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. Whey products are significant sources of high-quality protein and dairy minerals such as calcium and phosphorous. Additionally, WPCs and WPIs offer an indirect functional benefit in formulas where fat and/or sugar is being reduced.

Processing Conditions

The use of whey ingredients does not significantly change the processing or the conditions under which yogurt products are manufactured. Care should be taken in the handling and addition of whey ingredients to ensure full and complete hydration and functionality.

Low-Fat Yogurt Smoothie

Yogurt Base

Ingredients	Usage Level (%)
Low-fat milk (2% fat, 10% MSNF)	75.0
Skimmed milk (0.2% fat, 9% MSNF)	14.3
Sugar	5.0
Culture	3.0
WPC 80	1.4
Modified food starch	0.9
Kosher gelatin	0.4
Total	**100.0**

Flavor Solution

Ingredients	Usage Level (%)
Water	81.6
Sugar	12.5
Fruit juice concentrate (3:1)	5.0
Modified food starch	0.9
Flavor and color	Variable
Total	**100.0**

Yogurt Smoothie

Yogurt base	60.0
Flavor solution	40.0
Total	**100.0**

Procedure:

Yogurt Base

1. Mix WPC 80 into low-fat and skimmed milk.
2. Mix modified food starch and gelatin with sugar and add to milk.
3. HTST pasteurize and homogenize.
4. Heat to 85°C and hold for 30 minutes with slow mixing.
5. Cool to 42°C and mix in culture.
6. Incubate at 42°C until pH reaches 4.5.
7. Break the gel and cool to 18-20°C.

Flavor Solution

1. Mix modified food starch with sugar and add to water.
2. Mix in fruit juice concentrate.
3. Pasteurize at 90°C, hold 15-30 seconds.
4. Cool to 18-20°C.

Final Yogurt Smoothie

1. Mix yogurt base and flavor solution at 60:40 ratio.
2. Homogenize at low pressure (<35 bar).
3. Bottle and store at 0-4°C.

Nutritional Content per 100 grams

Calories	60 kcal
Total Fat	1 g
Saturated Fat	0.5 g
Trans Fat	0 g
Cholesterol	5 mg
Sodium	25 mg
Total Carbohydrate	10 g
Dietary Fiber	0 g
Sugars	8 g
Protein	3 g

Formula courtesy of Hugunin & Associates, USA

PARTIAL REPLACEMENT OF SKIMMED MILK PROTEIN IN STIRRED YOGURT WITH WPC 80 INCREASED PRODUCTION CAPACITY AND IMPROVED PRODUCTION EFFICIENCIES

Dr. Steven Young,
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WPC 80 replaced 20 and 30% of the protein provided by skimmed milk powder and fresh milk in stirred yogurts produced during production trials. Based on the local ingredient costs during these tests in Southeast Asia, replacement of 20% of the protein would reduce dairy ingredient costs in the manufacturer's 11% MSNF, 3.25% milk fat formula approximately 8%. Differences in the resulting yogurts were recognized, including an increase in viscosity when WPC 80 was added. Flavors were also different; however, the management believed the flavor of the yogurt with WPC 80 replacing approximately 20% of the protein would be equally acceptable to their customers. An unanticipated benefit was the observed 15-20% reductions in the incubation time required to reach pH 4.5 in the batches with WPC 80. Management recognized that a reduction of this magnitude, on a consistent basis, could increase production capacity of the plant and significantly reduce production costs. Others have reported that reduced buffer capacity and/or unidentified stimulatory compounds reduce the fermentation time of yogurt formulated with WPC. However, further testing and analysis is justified based on the potential economic significance recognized by the plant management during these studies.

Protein Fortified Low-Fat Strawberry Drinkable Yogurt

Yogurt Base

Ingredients	Usage Level (%)
Fresh skimmed milk (0.2% fat, 9% MSNF)	96.80
WPC 80 (high gelling)	3.00
Culture (commercial frozen concentrate)	0.20
Total	**100.00**

Drinkable Yogurt

Ingredients	Usage Level (%)
Water	45.95
Yogurt base (from above)	36.00
Frozen strawberry puree	10.00
WPC 80 (high gelling)	7.20
Strawberry flavor	0.45
Pectin (high methoxyl)	0.27
Sucralose solution	0.05
Citric acid	0.05
Potassium sorbate	0.03
Total	**100.00**

Procedure:

Yogurt Base

1. Hydrate dry ingredients for yogurt base in fresh milk.
2. Heat to 90°C and hold for 10 minutes. Cool to 40°C.
3. Inoculate with yogurt starter culture.
4. Incubate at 42°C until pH reaches 4.4.
5. Agitate yogurt at high speed. Then cool to 20-25°C.

Drinkable Yogurt

1. Dissolve pectin and protein into water.
2. Combine pectin-protein solution, flavor and strawberry puree and remaining ingredients.
3. Agitate drinkable yogurt-mix slowly for at least 15 minutes.
4. Pasteurize at 90-95°C for 10-15 seconds.
5. Fill and store at 0-4°C.

Nutritional Content per 100 grams

Calories	50 kcal
Total Fat	0.5 g
Saturated Fat	0 g
Trans Fat	0 g
Cholesterol	0 mg
Sodium	20 mg
Total Carbohydrate	4 g
Dietary Fiber	0 g
Sugars	3 g
Protein	8 g

Formula courtesy of Hugunin & Associates, USA

ENSURING THE QUALITY OF YOGURT PRODUCTS

Manufacturers with well-designed sanitation and quality assurance programs produce yogurt products with a 30-day shelf life, providing product is properly refrigerated (0-4°C) 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.

Photo courtesy of Glanbia Nutritionals USA

Some Common Defects in Yogurt and Potential Remedies (derived from Tamime and Robinson, 2007)

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
	• 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 handing 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 to 42°C
	• 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
	• Too low an inoculation rate	• Alter inoculation rate or culture type
	• Excessive shearing of yogurt during cooling	• Adjust process conditions

Source: derived from Tamime and Robinson, 2007

Q&A

Q: *Which whey ingredients produce the firmest yogurt gels?*

A: Since it is primarily the β-lactoglobulin component of whey ingredients that is involved in modifying yogurt texture, the higher-protein WPC (i.e. WPC 80) or WPI will provide greater textural benefits than lower-protein products (i.e. SWP and WPC 34) when used at the same level. Modified WPC products enriched with β-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 whey protein is added to yogurt mix?*

A: Excessive whey protein addition or substitution of SMP 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 WPC 80 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 whey 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 WPC can help overcome inconsistencies. Choosing a high-gel strength WPC 80 rather than a standard WPC 80 facilitates production of a firmer, higher water-binding cup-set yogurt and a smoother, creamy-textured stirred yogurt.

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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