U.S. WHEY INGREDIENTS IN BAKERY PRODUCTS

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Whey ingredients have been utilized by the baking industry for decades for many of the same reasons that whey ingredients are used today. Early on, sweet whey was the only whey ingredient commercially available. It provided the benefits of added browning, a tender crumb texture and cost savings for many bakery products.

The benefits today have increased tremendously, as additional whey ingredients with improved functionality have been developed and commercialized. Whether you are developing cakes, cookies, bread or pastry, there are a multitude of new opportunities, both functional and nutritional, for the use of whey ingredients in bakery products.

CHOOSING THE OPTIMAL WHEY INGREDIENT

Selecting the whey ingredient that will provide the desired functionality requires an understanding of the composition and unique functional properties of each specific whey ingredient. The majority of whey ingredients contain protein, lactose, ash, fat and moisture.

Whey ingredients have the ability to provide emulsification, foaming or whipping, good solubility, thickening, browning, gelation, nutritional fortification, water binding and a clean flavor. An in-depth review of the functional properties of whey ingredients is available in the *Reference Manual for U.S. Whey and Lactose Products* published by the U.S. Dairy Export Council and available online at www.usdec.org.

Whey proteins are amphiphilic molecules that display an affinity for water at one end and an affinity for oil at the other end. This characteristic makes whey proteins natural emulsifiers. Protein is typically associated with emulsification, foaming, good solubility and water binding so whey ingredients with an increased protein content (34-90% protein) will better perform these functions.

Protein also plays a part in browning when in combination with lactose and heat. The resulting Maillard reaction, which is a chemical reaction between an amino acid and a reducing sugar, usually requires the addition of heat. Like caramelization, it is a form of non-enzymatic browning that imparts flavor to the finished product. The fat in whey ingredients is high in phospholipids so the fat can contribute to emulsification. However, this will depend on the fat content of the ingredient and most whey ingredients have less than 8% fat.

REPLACING EGGS

Cakes are a category of baked products where egg is an important part of their structure, texture and flavor. Protein is the responsible factor in the structure of a cake. Most cakes are high sugar formulations, called high ratio cakes. They have a greater amount of sugar than flour by weight and sugar is known to inhibit gluten development. Less gluten from wheat means a moister crumb that will stay fresh for a longer time period. Sugar increases the temperature needed to set flour gluten and it also increases the temperature needed to gelatinize starch. This delays the setting of the cake crumb. In order for the cake structure to form at the right point in the baking process the presence of a protein that sets at a lower temperature (e.g. eggs) is required. For this reason, only a partial replacement of egg is recommended in layer cakes.

Before substituting eggs with a whey ingredient, there are many factors to consider. For example: Are fresh or dried eggs being replaced? What is the total amount of protein being replaced? What other effects will whey have on the finished product and will these effects be beneficial?

One large egg weighs between 52 and 55 grams (g), and is composed of 75% water. When using a whey ingredient to replace a whole egg, the water must be replaced as well. When looking at the functional properties of the egg, protein is the replaceable ingredient. The replacement should be done on an equal protein basis – 12% of fresh egg is protein and 46% of dry egg is protein. Protein levels in whey products vary from 11% in sweet whey to 90% or more in whey protein isolates (WPI).

Typically, whey protein concentrate (WPC) with 34-80% protein is recommended for egg replacement.

WPC 80 has excellent egg replacing capabilities in dry products such as cookies and biscotti. Each product must be carefully analyzed as the technique used for egg replacement may vary. For substitutions in cookies that have "spreadability," the WPC might be better utilized when added to the fats and sugars in the creaming process where they are whipped until light and fluffy. The liquid replacement (such as water) for the egg liquid is then added at the point where the eggs would normally be added. This diminishes the possibility of over-spreading.

U.S. Whey Ingredients Composition and Advantages in Bakey Applications

Whey Ingredient	Protein (%)	Carbohydrate* (%)	Fat (%)	Minerals (Ash) (%)	Advantages
Whey permeate (food grade)	3-8	68-85	1.5 (maximum)	8-20	• Source of calcium and other milk minerals • Color enhancement for a golden brown color • High lactose content for added functionality • Potential salt replacement • Flavor enhancement
Sweet whey	11-14.5	63-75	1-1.5	8.2-8.8	• Color enhancement • Source of calcium and other milk minerals
WPC 34	34-36	48-52	3-4.5	6.5-8	• Protein fortification • Color enhancement • Source of calcium and other milk minerals
WPC 80	80-82	4-8	4-8	3-4	• High protein content for fortification and added functionality
WPI	90-92	0.5-1	0.5-1	2-3	• High protein content for fortification and added functionality • Contributes little to no fat or carbohydrates
Lactose	0.1	99-100 (minimum)	0	0.1-0.3	• Increases browning • Enhances flavor • Helps retard staling • Lowers sweetness • Retains moisture

*Primarily in the form of lactose

Yellow Cake
(50% egg replacement)

Ingredients	Usage Level (%)
Cake flour	29.17
Granulated sugar	24.96
Water	18.79
All purpose shortening	13.12
Fresh whole eggs	7.24
WPC 34	2.83
Skimmed milk powder (SMP)	1.40
Vanilla extract	1.20
Baking powder	0.69
Granulated salt	0.60
Total	**100.00**

Procedure:

1. Mix shortening and sugar for 1 minute on low.
2. Add WPC 34, SMP, water, vanilla and whole egg and mix 2 minutes on low.
3. Add cake flour, baking powder and granulated salt and mix 2 minutes on high.
4. Pour batter into a 20 cm (8") round pan that has been greased and lined with parchment paper.
5. Bake at 177°C (350°F) for 17 minutes.

Nutritional Content per 100 grams

Calories	350 kcal
Total Fat	15 g
Saturated Fat	3.5 g
Trans Fat	3.5 g
Cholesterol	30 mg
Sodium	330 mg
Total Carbohydrate	51 g
Dietary Fiber	1 g
Sugars	28 g
Protein	4 g

Formula courtesy of the Wisconsin Center for Dairy Research

In general, whey substitution for eggs in a formula will vary by egg type. In the case of fluid eggs, a replacement liquid will need to be added together with the whey.

100 g of fresh whole eggs =
15 g of WPC 80 and 75 g of water

100 g of fresh whole eggs =
35 g of WPC 34 and 75 g of water

100 g of dried whole egg =
57 g of WPC 80

Viennese, chocolate chip, snickerdoodle and soft lemon cookies can utilize WPC 34 as both a partial fat and egg replacer. In addition to reduced ingredient costs, the re-formulated cookies will have good browning capabilities, chewiness, rounded edges and better preserving qualities. WPC 80 is a good egg replacer in products such as breads, cakes, cookies (both dry and soft) and muffins. Replacing whole egg with whey ingredients can reduce ingredient costs and create a product with a softer texture when required.

Bakery products have different specifications and in some cases dry, hard and crunchy are positive terms. In the case of biscotti, whey ingredients creates a texture that will dry more rapidly and have enhanced browning and increased nutritional value, all of which are favorable characteristics for biscotti. In both bar cookies and biscotti, the texture created by the use of whey ingredients makes the product more stable causing less crumbling during cutting and packaging for additional cost savings.

ENHANCED BROWNING AND FLAVOR

When using sweet whey or WPC 34, the largest component of both products is lactose, the sugar component in dairy ingredients. Adding either ingredient will increase the Maillard reaction (surface browning), affect the sweetness level and increase the tenderness of the finished product.

Biscotti, rusk, savarine and crackers all have a similar issue – the loss of flavor during the drying process. Whey ingredients can help bind and enhance flavors, and in some instances, flavoring levels may be able to be reduced. Whey ingredient products have also been shown in certain situations to make flavors more resilient through the drying process, yielding a more intense flavor profile in the finished product.

Formulating products with lower protein, high lactose whey ingredients, such as sweet whey or dairy product solids (DPS), is recommended when the goal is to develop surface browning and caramelized flavors. DPS (also called whey permeate or deproteinized whey) is a versatile ingredient for the baking industry because of its ability to replace other carbohydrates and eliminate added salt in a product. In addition, it imparts a desirable flavor and added minerals to baked products.

Pie Crust with Whey Permeate

Ingredients	Usage Level (%)
Flour, all-purpose	51.00
Shortening	22.25
Water, cold	15.30
Whey permeate	6.20
Butter	3.00
Sugar	1.50
Salt	0.75
Total	**100.00**

Procedure:

1. Mix together flour, whey permeate, sugar and salt.
2. Cut in shortening and butter until texture is similar to coarse corn meal.
3. Sprinkle water over the dry mixture and stir with a fork until dough comes together.
4. Gather the dough into a ball, cover with clear, plastic food-grade wrap and chill for several hours.
5. Roll out on floured surface and place in a pie pan.
6. Fill with desired filling (or bake blind) at 204°C (400°F) until golden brown.

Nutritional Content per 100 grams

Calories	450 kcal
Total Fat	26 g
Saturated Fat	7 g
Trans Fat	6 g
Cholesterol	10 mg
Sodium	400 mg
Total Carbohydrate	46 g
Dietary Fiber	1 g
Sugars	7 g
Protein	6 g

Formula courtesy of the Wisconsin Center for Dairy Research

DPS is produced when sweet whey is processed via ultrafiltration (UF) into WPC or WPI. The dairy components that pass through the UF membrane – mostly water, lactose and ash – become the "whey permeate" or DPS. DPS is a wholesome, natural product that contributes a number of valuable nutrients to bakery products such as calcium, phosphorous, potassium and sodium. It also acts as a flavor enhancer similar to salt, but without the high sodium which is a positive factor for the nutrition label.

Crackers are another product that benefit from the addition of whey ingredients. Crackers can be sweet or savory and can utilize yeast, baking soda and/or baking powder as a leavening agent. No matter what the method of leavening, crackers have one thing in common – they are shelf stable products with low water activity. Most commercial crackers will have a 6 month shelf life in an unopened package. In most cases, crackers are low in sugar or have no sugar, and utilize bread flours of medium strength at 11.5% to 13% (baker's percent) protein content. WPC 34 is widely used with good results at a 4% to 5% level (baker's percent) by replacing flour of the same weight. The longer the dough's fermentation time, the better the finished cracker's taste profile and shelf life. Crackers made with yeast as a leavening agent benefit from using WPC 34 because of the lactose content. Since lactose is not metabolized by yeast, it has a constant browning effect. The result will be an improved crust color in the finished product without the expected and undesirable sweetness of cane or beet sugar.

NUTRITIONAL BENEFITS OF WHEY IN BAKERY

Reducing Carbohydrates

Consumers world-wide are more proactive than ever in managing their health and well-being and often start with diet. As a result, low carbohydrate diets have increased in popularity in recent years and protein is a major focus of these diets. Whey proteins found a niche in many of the foods created for low carbohydrate diets because of their superior functionality.

Baked products are very high in carbohydrates and very low in protein which can make the formulation of low carbohydrate products with whey proteins quite challenging. When modifying the composition of a product where a component like carbohydrates is such an integral part of the product, it is necessary to take a systems approach.

Whey protein ingredients, such as WPC 80 or WPI, in combination with sugar alcohols, fibers and artificial sweeteners all contribute to reducing the carbohydrate content of baked products. Most bakery products have 2 g of protein per serving or less. In order to maintain the product characteristics, it is realistic to increase the protein to 4-5 g per serving.

Dairy Product Solids Usage Levels Recommended for Bakery Products:

Breads, rolls, pizza crust and crackers	2% to 3% of Flour
Cakes, cupcakes and muffins	10% to 14% of Sugar
Cakes, cookie icings and glazes	10% to 20% of Sugar
Pie and tart dough (fat content of 50% or greater)	6% to 8% of Flour
Fruit tart (cooked) and pie fillings	10% to 20% of Sugar

Cranberry Orange Bran Muffin

Ingredients	Usage Level (%)
Water	23.29
Maltitol syrup	22.87
Flour, all-purpose	13.76
Eggs	8.04
Vegetable shortening	6.77
Plum powder	6.60
Cranberry pieces	5.59
Oat fiber, finely ground	4.13
Crude wheat bran	2.91
WPC 80	2.54
Baking powder	1.38
Orange peel	1.17
Inulin	0.53
Salt	0.32
Xanthan gum	0.09
Sucralose	0.01
Total	**100.00**

Procedure:

1. Measure out plum powder and wheat bran into a bowl. Add half of the formula water. Mix and set aside
2. Mix all remaining dry ingredients except oat fibers in a second bowl and set aside.
3. Cream sugar alcohol and shortening in mixer on the highest speed for 4 minutes. Stop and scrape the bowl twice during this time.
4. Add eggs slowly to the maltitol/ shortening mixture, while beating on low. Scrape the bowl twice.
5. Mix in plum/bran mixture on low, just until combined.
6. Fold in half of the flour mixture, stir in remaining water, then add the rest of flour mixture, followed by the oat fibers, mixing just until combined.
7. Add cranberry pieces and orange peel and gently mix.
8. Fill each muffin cup 2/3s full.
9. Bake at 204°C (400°F) for 15 minutes.

Nutritional Content per 100 grams

Calories	230 kcal
Total Fat	9 g
Saturated Fat	3 g
Trans Fat	0 g
Cholesterol	40 mg
Sodium	300 mg
Total Carbohydrate	46 g
Dietary Fiber	8 g
Sugars	4 g
Protein	5 g

Formula courtesy of the Wisconsin Center for Dairy Research

Reducing Fat

Fat reduction has been a nutritional goal in a variety of baked products for the past twenty years. Cookies, cakes and sweet goods are typically high in fat making them a good target for fat reduction. WPCs with 34% protein have been used as fat mimetics and are typically used with added water to replace fat.

Heat modification of whey protein results in the denaturation, or unfolding of the whey protein molecule. The unfolding makes water binding sites along the protein molecule more readily available and the protein will have the ability to bind more water. WPCs function well as fat mimetics in baked products with higher moistures, e.g. cakes, soft cookies, and muffins. The fat mimetic properties of WPC come from its ability to bind water. A WPC will bind the added water in a reduced-fat formulation and the product will have a soft texture similar to the full-fat product. With the use of WPC, a 50% fat reduction is a realistic target. This high level of fat reduction is important as more consumers are carefully reading ingredient and nutrition labels, selecting products based on fat levels and avoiding certain types of fats. WPC usage to replace fats in a formula can result in a cleaner product label and one that is more attractive to consumers.

50% Reduced-Fat Soft Cookie

Ingredients	Usage Level (%)
Bleached flour, all purpose	31.64
Chocolate chips	15.14
High fructose corn syrup (HFCS)	11.87
Brown sugar	9.50
Water	8.11
WPC 34	7.17
Granulated sugar	5.27
All purpose shortening	5.20
Modified starch, instant	2.62
Liquid soybean oil	1.89
Natural butter flavor	0.53
Vanilla extract	0.44
Granulated salt	0.40
Sodium bicarbonate	0.22
Total	**100.00**

Procedure:

1. Mix oil, shortening, sugar, brown sugar, HFCS, WPC 34 and flavors together for 2 minutes on high.
2. Add water and mix on high for 3 minutes.
3. Add flour, sodium bicarbonate, salt and starch and mix 2 minutes on low.
4. Add chocolate chips and mix 1 minute on low.
5. Weigh 20 g of dough per cookie and place on a baking surface.
6. Bake at 177°C (350°F) for 7 minutes.

Nutritional Content per 100 grams

Calories	390 kcal
Total Fat	12 g
Saturated Fat	1.5 g
Trans Fat	1.5 g
Cholesterol	0 mg
Sodium	250 mg
Total Carbohydrate	64 g
Dietary Fiber	2 g
Sugars	32 g
Protein	6 g

Formula courtesy of the Wisconsin Center for Dairy Research

Protein Fortification

Protein fortification has long been popular in the sports and fitness market and the fortification of baked products is included in this section. Similar to the formulation of low carbohydrate baked products, adding protein to a product that is traditionally low in protein can change the product flavor and texture quite dramatically. In some cases, a formulator may only want to increase the protein by 2-3 g per serving but for some products, this is a 50% or more increase in protein. The addition of WPC 80 or WPI to food products such as tortillas, pizza crust, bread and cookies is recommended for protein fortification. Incorporating the use of whey crisps, or extruded whey proteins, can also add various protein levels and textural variety. Added whey protein has many nutritional benefits, including improving body composition, muscle recovery and satiety, the feeling of being full. More detailed information on these topics can be found in the USDEC Monographs titled "*Whey Proteins and Body Composition*" and "U.S. *Whey Proteins in Sports Nutrition*," both of which are available at www.usdec.org.

Sucrose Replacement

In baking, lactose is often used to replace sucrose for a variety of functional benefits. Compared to other sugars, lactose results in low relative sweetness, increased browning, enhanced emulsification, moisture retention, non-hygroscopicity and enhanced flavors. When replacing sucrose (up to 50%), lactose can contribute to improved crumb texture and freshness, increased volume, reduced fat levels, improved gas retention and enhanced flavors which are ideal for icing, frosting or filling.

Cheese Crackers

Ingredients	Usage Level (%)
Flour, all-purpose	28.36
Extra sharp cheddar cheese, grated	21.13
Butter	19.56
WPC 60	9.78
Whey crisps 50, smallest size	7.82
Whey permeate	5.87
Water	5.09
Natural cheddar cheese flavor	2.35
Cayenne pepper	0.04
Total	**100.00**

Procedure:

1. Place all ingredients in a bowl and mix on low until ingredients come together to form a ball.
2. Sheet to 10 mm thickness, cut into small pieces approximately 1.3 x 1.9 cm (0.5 x .75") and place on parchment-lined cookie sheet.
3. Bake 25 minutes at 163°C (325°F).
4. Cool on cookie sheet.

Nutritional Content per 100 grams

Calories	450 kcal
Total Fat	26 g
Saturated Fat	16 g
Trans Fat	0 g
Cholesterol	70 mg
Sodium	440 mg
Total Carbohydrate	31 g
Dietary Fiber	1 g
Sugars	6 g
Protein	18 g

Formula courtesy of the Wisconsin Center for Dairy Research

DEVELOPING ARTISAN BREADS

Artisan breads utilizing a long fermentation process, such as a pre-ferment sponge, poolish, biga or a sourdough starter, can benefit from the use of WPC 34. The use of WPC 34 yields easier handling dough with what is known as "relaxed machineability," softer crumb and a more intense flavor profile. However, one of the biggest benefits of all is an increase in shelf life. Most of the attributes resulting from the use of whey proteins can be replicated with chemicals, but this is a much less desirable option, especially in today's "natural" market environment. The addition of whey proteins (not just whey) in a formula allows for a "clean label," whereas a chemical dough relaxer or emulsifier would not. In addition, protein fortification to reduce carbohydrates and fat cannot be easily replicated. Whey's all natural ingredients help products achieve good nutritional results.

The long fermentation process often utilized by artisan bakers can produce additional product benefits. During the long fermentation period, the available sugars are consumed by the yeast as fuel, turning the sugar into alcohol and thereby creating large bubbles in the dough, which are then released into the air. The use of WPC 34 in the 1% to 4% (baker's percent) of the flour weight range or lactose in the 3% to 4% (baker's percent) of the flour weight level can promote browning while adding other nutrients. Because lactose is not digested by the yeast, breads will achieve a desirable, highly flavored golden-brown color with this addition. Lactose in breads has flavor binding qualities which are particularly useful in products with delicate flavors. Since lactose is not fermented by the baker's yeast (utilized as yeast-food), it retains its functional characteristics through possibly freezing then baking. If nutrient fortification or other functionalities are desired, WPC 50 and WPC 80 may be used instead of lactose at levels up to 5% (baker's percent). Higher levels are not recommended as they may have a drying effect on the final product.

Jalapeño Cheddar Bread

Ingredients	Usage Level (%)
Chef Dough:	(69.87)
Bread flour	35.91
Water @ 30°C (85° F)	26.68
Whole wheat flour	3.96
WPC 34	2.22
Salt	0.92
Cake yeast	0.18
Bread Dough:	(30.13)
Cheddar cheese, grated	15.25
Canned jalapeño peppers, drained and chopped	7.62
Bread flour	6.86
Cake yeast	0.40
Total	**100.00**

Procedure:

1. Place dry ingredients of the Chef Dough in a mixer bowl.
2. Add water and mix for 7 to 8 minutes, or until a uniform dough is produced. (The resulting dough will be sticky, but not dripping wet.)
3. Set the Chef Dough aside while weighing the other ingredients.
4. Add all remaining ingredients to the Chef Dough (all ingredients referred to under Bread Dough) and mix for 2 to 3 minutes. Do not over-mix at this stage or cheese pieces will smear.
5. Cover and set aside dough for 1 hour.
6. Divide dough into pieces that weigh about 510 g (18 oz) each and shape into loaves.
7. Bake at 193°C (380°F) for 35 minutes, or until golden brown.

Nutritional Content per 100 grams

Calories	280 kcal
Total Fat	8 g
Saturated Fat	4.5 g
Trans Fat	0 g
Cholesterol	20 mg
Sodium	570 mg
Total Carbohydrate	39 g
Dietary Fiber	2 g
Sugars	2 g
Protein	11 g

Formula courtesy of the Wisconsin Center for Dairy Research

WORKING WITH WHOLE GRAINS

Many population groups in the world consume less than the recommended amount of fiber in their diets. Breads are a popular product for increasing the intake of whole grains and fiber.

A whole grain can best be described as a grain that is milled in its entirety after the husk has been removed. It has not been refined in any way. While it seems easy to make the change from refined flours to whole grains, there is nothing simple about the process. A key challenge is the management and control of water. Understanding and controlling how the components of the whole grain will interact with water is critical to achieving the desired functionality while minimizing staling. Whey proteins can help resolve these potential problems. They have a clean, neutral taste and from a functional perspective, their water binding properties help reduce the staling rate and improve the mouth feel of the product. Whey proteins stand out as a great way for bakeries to naturally meet the multitude of challenges that whole grains present. Whey can also address the decreased concentration of gluten in whole grain flours. Whole grain wheat flour has lower gluten content than refined wheat flours which can have a negative effect on loaf volume.

Whole grains have a wide variability in the amount and type of fiber they contain. Whole oat flour typically has approximately 14% TDF (total dietary fiber) and whole wheat flour contains around 12% TDF. Whole brown rice flour only contains about 5% TDF, but even at this low level, the fiber will completely change the effect and performance of a product.

Flours made from rye, flaxseed, oat, barley, millet and some other grains are high in soluble fiber and will become gummy. Gumminess is best described as the lack of machineability – meaning, a dough that is difficult to handle either because it is too slack and sticky, "overly relaxed" or too dry and tight, which the baking industry calls "bucky." Gumminess can limit or eliminate the amount of 100% whole grains used in a product. Gumminess problems associated with the use of high levels of soluble fiber in some types of whole gains can be alleviated with the addition of some form of whey proteins. Soluble fibers are good in bakery products as they bind moisture, yield a more even crumb and inhibit staling which extends the shelf life of the product. Insoluble fibers are less desirable in bakery products as they can be the cause of premature staling if not handled properly.

To control the gumminess, products are sometimes formulated with flours from several different sources. Another excellent method for controlling gumminess is with the use of WPC. Whey proteins have good water binding capabilities, making them an excellent ingredient for whole grain bakery applications. This binding capability helps control water management and also helps prevent staling.

Whole wheat flours, by nature, contain lower gluten levels than refined bread flours, which poses a challenge to bakers converting to whole grain products. The addition of whey ingredients helps compensate for the lower gluten level as they contain proteins that mimic the structure and gas-entrapping properties of gluten.

Other added benefits from the use of WPC in whole grain product formulations are an enhanced moistness, flavor and mouth feel. The water binding capability of WPCs improves the texture and the crumb structure, usually without the need for a dough conditioner. Chemical "dough conditioner" is a general term which refers to a "bread improver," yeast food or dough improver; which is an ingredient added to the dough for specific quality improvement purposes. Whey ingredients qualify as a natural "dough conditioner" that would not pose a problem for use by artisan bakers. Whey as an ingredient can also help achieve the golden-brown crust of a well baked product, which is a result of the Maillard reaction.

Whey ingredients have multiple functions and are well designed for use in baked products. No matter what the formulation goal is, there are one or more whey ingredients available to help you achieve the preferred flavor, texture and nutritional attributes in your baked products. Once you become familiar with the different whey ingredients, their composition and corresponding functionality, you will be able to make the right choice for your business.

Q&A

Q: *Is it necessary to pre-hydrate whey ingredients before using in a bakery application?*

A: It is not necessary to pre-hydrate whey ingredients for bakery applications. A whey ingredient can be added together with the other dry ingredients in a formula. In applications such as cookies or cakes the whey ingredient is often added during the creaming stage.

Q: *Will whey protein ingredients absorb a lot of the water in a bakery formulation?*

A: Whey proteins do not typically absorb a lot of water so the rheology or viscosity of the dough will not be substantially altered. Some manufacturers produce functionally modified whey protein ingredients, such as partially denatured whey proteins, which are designed to bind greater amounts of water. This added water binding ability would be beneficial in reduced-fat applications.

Q: *What is the difference in using sweet whey versus deproteinized whey in a bakery application?*

A: Sweet whey and deproteinized whey have a very similar composition with the main difference being the protein content. Deproteinized whey, also referred to as dairy product solids (DPS) or whey permeate, will typically list a protein content of 3-8% and therefore is not as functional as it would be in sweet whey. Sweet whey has a higher protein content of 12-13% and will function more like whey protein, providing the added ability to emulsify and aerate dough. Both ingredients have a high level of lactose which will contribute to browning. Deproteinized whey will often have a higher ash content which naturally contributes saltiness to a product and may allow for a reduction of salt in the formulation. If browning is your main interest and added saltiness is acceptable, then using deproteinized whey is a good and often more economical choice.

Q: *Should whey protein concentrate* 80 (WPC 80) *or whey protein isolate* (WPI) *be used for protein fortification in a baked product?*

A: Either ingredient can be successfully used to add protein to a baked product. WPC 80 has 80% protein and approximately 6% fat and 4% lactose while WPI has 90% or more protein and usually less than 1% fat and less than 2% lactose. WPC 80 is typically less expensive than WPI however, you will need to add more to achieve the same target protein content.

Q: *Should an instantized or non-instantized whey protein ingredient be used?*

A: For the majority of bakery formulations, it is recommended to use a non-instantized whey protein ingredient. One exception might be a protein enhanced bakery mix that a consumer would add ingredients (water, oil or eggs) to at home and mix by hand. In this case, an instantized whey protein ingredient will mix up more readily and without causing lumping.

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