ENHANCING NUTRITION BARS, BITES AND GELS WITH U.S. DAIRY PROTEINS

When first introduced to body builders and endurance athletes, high protein bars and gels were considered a nutraceutical food. Since then, clinical nutrition research has demonstrated that foods containing high quality protein contribute positively to muscle growth and recovery which impacts overall health across all life stages. Studies have also revealed the importance of quantity and timing of protein consumption on the body's response. This mounting clinical evidence has put a spotlight on the connections between protein, fitness, and health. As a result, protein-containing bars, bites, and gels have become a part of mainstream consumer diets. This monograph will discuss how U.S. dairy ingredients are well suited to play a vital role in foods for healthier living. For more in-depth descriptions of the nutritional and functional characteristics of U.S. dairy ingredients, visit ThinkUSAdairy.org to view online publications from the U.S. Dairy Export Council.

Everyday Living

Protein is an essential nutrient needed in the daily diet. Whey and milk proteins are high quality, complete sources of protein. Whether striving to be an endurance athlete, avid cyclist, casual golfer, or neighborhood walker, grab and go bars, bites, gels, and pastes can be formulated with high quality dairy protein ingredients for consumption before, during or after exercising. Mild flavor and neutral appearance make whey and milk protein ingredients compatible with a wide variety of flavors, textures, and colors that improve consumer appeal. This versatility across applications was demonstrated by a nearly threefold increase in new whey-containing sports and nutrition product launches between 2014 and 2018.[1]

Upon consumption, the human body digests protein into amino acids for further absorption and use. The three branched chain amino acids (leucine, isoleucine, and valine) are unique because 70% of their metabolism takes place outside of the liver which makes them available for muscle protein synthesis.[2] Muscle protein synthesis is important because as we move and exercise, our existing muscle is broken down. Regeneration of muscle is necessary for maintaining strength and metabolism. Consuming high-quality dairy proteins after exercise can accelerate the repair process and reduce muscle soreness by increasing muscle protein synthesis.[3]

Since maintaining and building lean muscle is important for all people, the good news is that stimulating muscle protein synthesis (lean muscle growth) may be achieved by consuming as little as 10g of whey protein after resistance exercise.[4] For the more serious athletes focused on endurance and performance, consuming a 20-25 gram dose of whey protein during and/or right after exercise can help with recovery, but the amounts required will vary based on body size and length of training period.[5]

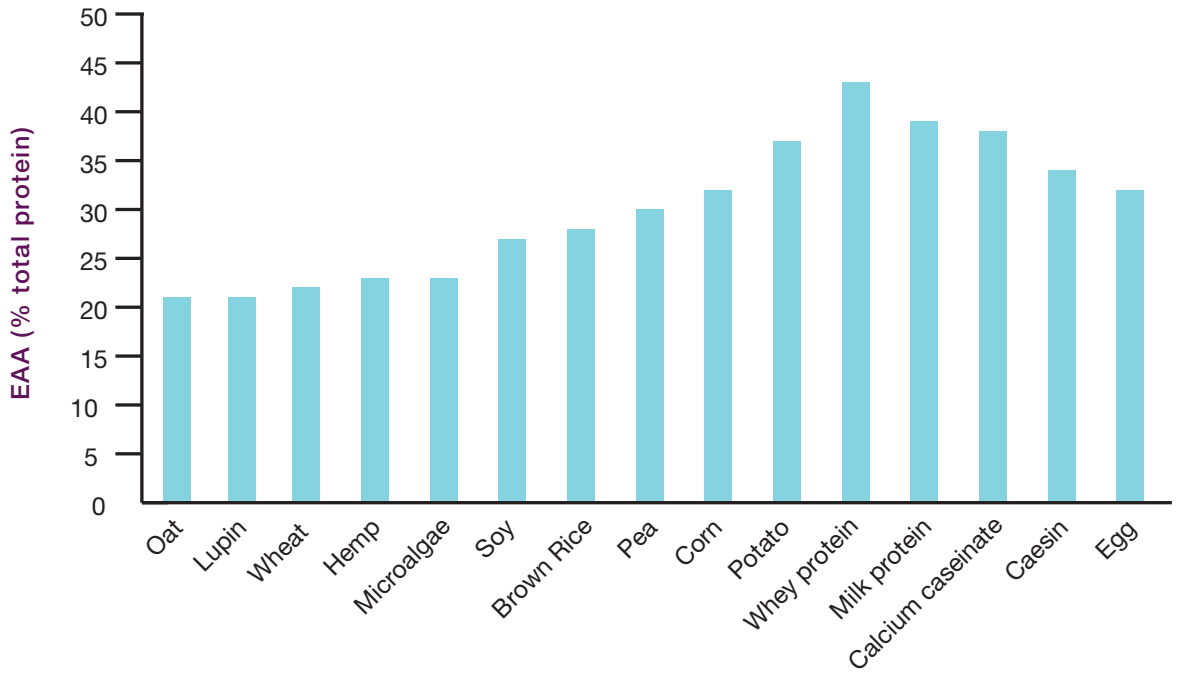
All Proteins are Not Created Equal

While all animal foods and most plant foods contain varying amounts of protein, not all proteins are created equal. Sources of protein vary in their content of essential amino acids. Animal sources tend to be higher in essential amino acids as a percentage of total protein compared to plant-based sources. Dairy proteins have the highest levels.[6] Among the animal sources, dairy and eggs have the additional advantage of fitting into many vegetarian/flexitarian diets.

Healthy Aging

As early as age 40, people may experience the start of progressive loss of lean muscle mass (sarcopenia) and increases in fat mass.[7] Sarcopenia can advance with aging due to declines in protein intake caused by decreased appetite or digestive and metabolic changes which may cause further declines in health, strength, and physical function.[8] Intake of high-quality protein has been shown to preserve muscle in older adults.[9] A longitudinal study measuring changes in muscle mass beginning at age 40 and older showed that higher intake of animal-based protein foods, alone or in combination with physical activity was associated with a higher percentage of skeletal muscle mass.[10] By preserving muscle mass, aging individuals have a greater chance of performing daily tasks. In addition to milk and whey proteins, hydrolysates may also be formulated into products for aging consumers. Hydrolysates are produced by pre-digesting proteins with enzymes to form amino acids and peptides which help make the protein easier to absorb.

FIGURE 1:
AMOUNTS OF ESSENTIAL AMINO ACIDS BY PROTEIN SOURCE



Source: van Vliet, S., Burd, N.A. and van Loon, L.JC. 2015. The skeletal muscle anabolic response to plant- versus animal-based protein consumption. J Nutr doi: 10.3945/jn.114.204305

Daily protein intake from animal-based versus plant-based sources has also been associated with better muscle maintenance in both older and clinically compromised individuals.[6] Some plant-based protein materials (i.e., soybeans, pea, and rice) naturally contain antinutritional factors that require processing for removal. This processing may reduce the digestibility and availability of the protein.[11] As a result, higher consumption of plant-based proteins may be required to achieve the same clinical results, which could negatively impact the appearance, calorie load, sodium levels, cost, and/or flavor of the finished product.

Nutrition Bars, Bites, and More

Nutrition bars, bites, and even balls can be baked or unbaked (cold manufactured). Cold manufacturing utilizes either an extrusion process or binders (sugar syrups) that allow the ingredients to adhere together prior to cutting to the desired bar shape and size. Textures may range from crunchy granola cereal to chewy nougat. Often, bars and bites will be coated in chocolate or other flavors. U.S. dairy proteins are

FIGURE 2:
U.S. DAIRY INGREDIENT COMPOSITION AND ADVANTAGES IN BARS

	PROTEIN (%)	LACTOSE (%)	FAT (%)	ASH (%)	MOISTURE (%)	ADVANTAGES
WPC 34	34-36	48-55	3-4.5	6.5-8	3-5	Cost Effective, Clean Label
WPPC	50-55	31	5-6	6	3-5	Cost Effective, Emulsifier
WPC 80	80-82	4-10	4-8	3-5	3.5-5	High in Protein, Low Lactose/Fat
WPI	90-92	0.5-1	0.5-1	2-3	4-5	Highest in Protein, Lowest in Lactose/ Fat, Gelling Properties
Hydrolyzed Whey Protein	80-92	Varies	Varies	Varies	Varies	Improves Shelf-Life, Faster Absorption
MPC 42	42	<51	<1.25	<10	<5	Cost Effective, Cohesiveness
MPC 70	70	<20	<2.5	<10	<5	High in Protein, Low in Fat, Heat Stable
MPC 85	85	<8	<2.5	<8	<6	High in Protein, Good Source of Minerals, Emulsifier
MPI	>89.5	<5	<2.5	<8	<6	High in Protein, Low in Fat, Heat Stable
Nonfat Dry Milk[a]	34-37	49-52	0.7-1.5	8.2-8.5	3-4	Clean Label, Excellent Flavor
Permeate	2-7[b]	70-85	0-1.0	8-11	3-4.5	Cost effective source of Minerals, Enhanced Salty Perception
Lactose	0.5-1	99-100	0.1	0.1-0.5	4.5-5.5	Limited Sweetness, Low Glycemic Index
Extruded Crisp	40-80	Varies	Varies	Varies	Varies	Adds Texture, Equilibrates Moisture

[a] Skim Milk Powder with Maximum of 34% Protein | [b] Nonprotein Nitrogen
Source: Industry Sources

key elements in sports and fitness products due to their functionality and nutritional characteristics. The desired nutritional content, texture, and mouthfeel of the finished product and process conditions during manufacturing will determine which dairy ingredients are best suited for the formulation.

Dairy proteins offer numerous functional benefits for food formulators. In general, U.S. dairy ingredients add high solubility, water-binding, gelation, thickening, foaming, emulsification, and flavor to formulations (See Figure 2). These characteristics are ideal for the creation of bars, bites, and gel applications with consumer appealing appearance, flavor, and texture. Understanding the functionality differences between ingredients is important, especially when formulating with higher protein concentrates and isolates.

For example, milk protein concentrate (MPC 80) or whey protein concentrate (WPC 80) have the same level of protein yet contain different combinations of proteins which impart different functional properties. MPC 80 contains 80% casein protein and 20% whey proteins versus WPC 80 which contains only whey proteins. Casein is generally heat stable when the pH of the application is above 6. When the pH decreases below 6, caseins will form acid gels. Casein protein is also good for emulsification and water binding, which is why it is often blended with other proteins to bind the fat and water components in bar formulations. Whey proteins are soluble across a wide pH range yet can denature upon heating at or above 62°C (145°F). Whey proteins in concentrations above 7% can also form gels when heated.

Maillard browning is an important reaction that occurs between a reducing sugar (in this case lactose) and an amino acid (coming from the whey proteins) in the presence of heat during baking or cooking, resulting in the characteristic golden-brown color as well as the sweet caramelized flavor notes associated with baked products and caramel confections. Depending upon the final product, those attributes may be positive or negative. If the presence of lactose is a concern, consider formulating with whey protein isolate (WPI) or milk protein isolate (MPI) products where filtration has removed nearly all of the lactose.

COMPOUND COATINGS

U.S. dairy ingredients can be added to compound coatings which are used to add flavor, texture, stability, and nutrition to many bar formulations.

PROTEIN FORTIFIED CHOCOLATE COMPOUND COATING

INGREDIENTS

	Usage Levels (%)
Sugar	43.90
Vegetable fat 38°C	40.00
Whey protein isolate	7.60
Dutched cocoa 10/12	7.60
Sorbitan tristearate	0.50
Soy lecithin	0.20
Vanilla extract dry	0.10
Flour salt	0.10
Total	**100.00**

PROCEDURE

1. Melt fat without exceeding 38°C (100°F) and mix in lecithin and sorbitan tristearate.
2. Combine dry ingredients in Hobart mixer.
3. Add enough fat to mixture to make a refiners paste.
4. Refine on three roll refiner (three passes) to a particle size below 25 microns.
5. Place fines back into Hobart and use a mantel for heat.
6. Conch coating for 4 hours without exceeding 66°C (150°F).
7. Add remaining fat to coating
8. Add any flavors desired.
9. Place into chocolate melter without exceeding 54°C (130°F).

NUTRITIONAL CONTENT

	per 100 g
Calories	580 kcal
Total Fat	41.00 g
Saturated Fat	4.00 g
Trans Fat	1.00 g
Cholesterol	0.00 mg
Sodium	75.00 mg
Total Carbohydrates	47.00 g
Dietary Fiber	2.00 g
Sugars	44.00 g
Protein	8.00 g
Calcium	4.00 %
Iron	15.00 %
Vitamin A	0.00 %
Vitamin C	0.00 %

In the United States, chocolate is a "Standard of Identity" product and formula. Ingredient modifications are somewhat limited or prohibited. Verify specific regulations by country. Also, chocolate requires special processing parameters during its enrobing process (tempering).

Chocolate flavored coatings are among the most popular, but vanilla, peanut butter, caramel, and yogurt flavored coatings are also common. Coatings typically contain cocoa, fractionated vegetable oils, sugar, soy lecithin and flavors. Milk-based compound coatings contain approximately 3-7% protein. WPI and WPC 80 may be incorporated to further increase the protein level for improved nutrition without affecting the coating's physical properties. However, due to variability in moisture levels and particle size, proteins should be added prior to refining and viscosity adjustments.

If the coating is for flavor purposes, a formulator can consider ingredients such as sweet whey, permeate, and/or demineralized whey as options. Due to lower mineral content, demineralized whey has the mildest flavor of these ingredients and is commonly used in chocolate and other flavored coatings. The lactose provides desirable crystallization properties and a smooth mouthfeel in the finished product. Sweet whey or whey permeate can also be used cost effectively in coatings to provide dairy flavor with the benefits of lactose crystallization and a smooth mouthfeel.

COLD PRESSED PRODUCTS

Extruded Bars & Bites

Extruded bars and bites represent one of the most common type of products available on the market. They are formulated to be cold-extruded and are often coated with a compound or chocolate coating.

The product typically contains:

- Protein ingredients, oils, flavors, nuts, and/or other inclusions.
- A combination of sugar syrups and sugar alcohols are used to keep the water activity below 0.60 to avoid mold or bacterial issues and to keep the texture of the bar soft throughout its shelf life.
- Other carbohydrates and/or fibers may be added as bulking agents and/or to reduce calories.
- Additional vitamins and minerals may also be added.

YOGURT-DIPPED PEACH SNACK BAR

INGREDIENTS

	Usage Levels (%)
Low fat granola	42.13
Dried peaches	19.60
Yogurt coating	14.00
Whey crisp 50%	3.80
Whey protein isolate	3.40
Evaporated cane sugar	3.00
Nutriose FM06	2.90
Dry roasted whole almonds	2.50
Water	2.50
Honey	2.10
Cinnamon, ground	1.90
Peach flavor	1.70
Salt	0.45
Bourbon vanilla extract	0.02
Total	**100.00**

PROCEDURE

1. Combine granola, peaches, almonds, whey crisp, cinnamon, and whey protein isolate.
2. Combine remaining ingredients except vanilla, peach flavor and yogurt coating.
3. Heat syrup to 88°C (190°F) and add vanilla and peach flavor to the syrup.
4. Combine cooked syrup and dry ingredient mix until coated uniformly.
5. Compress into a sheet and cool.
6. Cut to desired size 3.1 cm x 3.1 cm x .9 cm (1.25" x 1.25" x .75").
7. Half coat squares in yogurt coating and allow to cool.

NUTRITIONAL CONTENT

	per 100 g
Calories	380 kcal
Total Fat	10.00 g
Saturated Fat	6.00 g
Trans Fat	0.00 g
Cholesterol	0.00 mg
Sodium	320.00 mg
Total Carbohydrates	67.00 g
Dietary Fiber	8.00 g
Sugars	33.00 g
Protein	11.00 g
Calcium	8.00 %
Iron	15.00 %
Vitamin A	20.00 %
Vitamin C	6.00 %

Glycerin, a common ingredient in high-protein bars and bites, helps reduce water activity, keeps the dough pliable and helps to maintain softness during shelf life.

The ingredients are mixed together to form a dough. Usually, mixing tanks will be jacketed to control temperature and to keep the dough at a consistency that minimizes stickiness and retains softness for ease of extrusion. The dough is then placed in the hopper of the extruder for forming. As the dough is extruded out in a rope, it is usually rolled and cut to size. Afterwards, the product may go through a drying and coating process before it is individually packaged. This type of product can have a shelf life of up to one year. Good formulation and packaging are critical to maintaining optimal taste and texture during shelf life.

High Protein Bars & Bites

This category of sports and fitness nutrition contains the highest protein content. Commercial products with up to 50% protein are available. The challenge lies in delivering a high level of protein while maintaining good flavor and texture. U.S. dairy ingredients like WPI, WPC 80, WPH, or MPC 80 are commonly used alone or in combination with other non-dairy proteins.

A blend of proteins can help maximize protein level and minimize bar hardening, which often occurs in high-protein bars. Hydrolyzed whey proteins do not tend to draw moisture away from the other ingredients in the formulation. Therefore, adding whey protein hydrolysate (2-20%) can help maintain a softer texture to extend shelf life.[12] Similar improvements in softness and cohesiveness are observed when extruded milk protein concentrates are used in high protein formulations.[13] Consequently, U.S. ingredient manufacturers have designed many different hydrolyzed and extruded whey and milk protein ingredients specifically for bar applications. Please consult with individual suppliers to determine which ingredient(s) will work best in your formulation.

Balanced Nutrition Bars (40-30-30)

A balanced nutrition bar is formulated to provide 40% of its calories from carbohydrates, 30% of its calories from fat and 30% of its calories from protein. These bars first became popular in the 1990s with the introduction of the Zone Diet, developed by Dr. Barry Sears. WPI, WPC 80, MPC 80 and WPH are all commonly used. Other customized sources of dairy proteins, such as high-fat WPCs, could also be used in

this type of formulation as they would contribute typically 60-80% protein and provide up to 15-20% fat, primarily phospholipids from milk. An example is whey protein phospholipid concentrate (WPPC). The added fat provided through the use of ingredients like WPPC will reduce the need to add other fats and oils in the bar to meet the requirement for 30% of the calories to come from fat. Since 30% of the calories from protein translates into about 15 grams of protein in a 50-gram bar, the protein level is considered more moderate than that of the high-protein bars.

Reduced and Low Carbohydrate Bars & Bites

To minimize use of added sugars, formulators may use high levels of fiber and sugar alcohols, in combination with non-nutritive sweeteners, to achieve the desired level of sweetness. Examples of commonly used sugar alcohols are maltitol, sorbitol, xylitol, lactitol and erythritol. Fibers and sugar alcohols will contribute fewer calories to a formulation than a typical carbohydrate. Fibers usually contain less than 0.5 kcal/g and sugar alcohols contain between 0.2-3 kcal/gram. It should be noted that sugar alcohols can cause gastrointestinal distress in some people.

Sugar alcohols have the added benefit of helping to keep the water activity low. However, even with reduced water activity, product stability and textural changes with this type of bar formula will reduce shelf life and consumer acceptability. Adding 0.3% sodium polyphosphate to the basic formula of a low-carbohydrate bar may increase shelf life by maintaining the softness over a four-month period.

BALANCED NUTRITION BAR (40-30-30)

INGREDIENTS

	Usage Levels (%)
Liquid fructose	32.03
Protein blend	30.00
Peanut flavor	9.46
Peanut butter	7.56
Sugar	7.56
Honey	6.56
Vegetable oil	5.56
Vanilla extract	1.27
Total	**100.00**

PROCEDURE

1. Mix liquid fructose, honey, oil, and vanilla extract at low speed for 3 minutes.
2. Add remaining ingredients except peanut butter and mix for 5 minutes
3. Blend in peanut butter.
4. Press the protein mass on a tray before cutting or extruding the dough.
5. Enrobe protein bar with compound chocolate (20% coating by weight).
6. Package and seal.

NUTRITIONAL CONTENT

	per 100 g
Calories	360 kcal
Total Fat	11.00 g
Saturated Fat	1.50 g
Trans Fat	0.00 g
Cholesterol	0.00 mg
Sodium	250.00 mg
Total Carbohydrates	43.00 g
Dietary Fiber	1.00 g
Sugars	40.00 g
Protein	33.00 g
Calcium	2.00 %
Iron	10.00 %
Vitamin A	0.00 %
Vitamin C	0.00 %

CINNAMON GRANOLA BITES

INGREDIENTS

	Usage Levels (%)
Maltitol	18.75
Water	10.00
Whey protein crisp 70	10.00
Almonds, ground	9.00
Whole wheat flour	7.98
Whey protein concentrate 80	6.00
Oat fiber 300-48	6.00
Butter unsalted	6.00
Plum powder	5.00
Brown rice crisp cereal	4.00
Rolled oats, old fashioned	4.00
Rolled oats, quick	4.00
Raisins, chopped	4.00
Vegetable oil	3.50
Glycerin	0.60
Cinnamon	0.60
Salt	0.35
Sodium bicarbonate	0.20
Sucralose	0.02
Total	**100.00**

PROCEDURE

1. Combine the dry ingredients, whey crisps and rice cereal in a large mixing bowl.
2. Mix on low speed for 2 minutes.
3. Add butter and vegetable oil into dry ingredients and mix until evenly distributed.
4. Combine maltitol and glycerin and add into dry ingredient mix.
5. Mix on low for 1 minute.
6. Add water and mix on low for 1.5 minutes until the mixture comes together.
7. Sheet the bars to .8 cm (.31") thick and cut into 1.9 cm x 1.99 cm (.75"x/75")
8. Place on parchment lined pans.
9. Bake at 204°C (400°F) for 5 minutes.
10. Combine cooked syrup and dry ingredient mix until coated uniformly.
11. Compress into a sheet and cool.
12. Cut to desired size 3.1 cm x 3.1 cm x .9 cm (1.25" x 1.25" x .75").
13. Half coat squares in yogurt coating and allow to cool.

NUTRITIONAL CONTENT

	per 100 g
Calories	350 kcal
Total Fat	15.00 g
Saturated Fat	4.50 g
Trans Fat	0.00 g
Cholesterol	40.00 mg
Sodium	210.00 mg
Total Carbohydrates	52.00 g
Dietary Fiber	10.00 g

	per 100 g
Sugars	4.00 g
Sugar Alcohol	21.00 g
Protein	17.00 g
Calcium	15.00 %
Iron	10.00 %
Vitamin A	6.00 %
Vitamin C	0.00 %

GRAIN-BASED DULCE DE LECHE OATMEAL BAR

INGREDIENTS

	Usage Levels (%)
Corn syrup 42 DE	26.10
Whey crisp 60%	16.70
Rolled oats, old fashioned	12.50
Rolled oats, quick	12.50
Caramel bits, fat-based	8.50
Apple-based fat replacer	7.70
Whey protein isolate	5.70
Water	4.50
Butter, unsalted	4.00
Glycerin	0.90
Flavor dulce de leche	0.80
Sodium bicarbonate	0.10
Total	**100.00**

PROCEDURE

1. Combine oats, fat replacer, sodium bicarbonate and whey protein isolate in a large mixing bowl.
2. Mix on low speed for 1 minute.
3. Add corn syrup, butter, dulce de leche flavor, glycerin, and water.
4. Mix on low speed for 1 minute.
5. Add whey crisp and caramel bits and mix briefly until combined.
6. Sheet the bars to 10 mm (.4") thick and cut into 7.5 cm x 3.75 cm (3"x 1.5") pieces.
7. Place on parchment lined pans.
8. Bake at 204°C (400°F) for 7 minutes.

NUTRITIONAL CONTENT

	per 100 g
Calories	360 kcal
Total Fat	7.00 g
Saturated Fat	3.00 g
Trans Fat	0.00 g
Cholesterol	10.00 mg
Sodium	50.00 mg
Total Carbohydrates	57.00 g
Dietary Fiber	3.00 g
Sugars	18.00 g
Protein	19.00 g
Calcium	8.00 %
Iron	6.00 %
Vitamin A	2.00 %
Vitamin C	0.00 %

Soft or Hard Granola Chewy Binder Cereal Bars & Bites

Commercial products that fit into this category are characterized by their textural appeal. They are formulated using grains like oats and rice crisps, along with nuts and/or other inclusions, and are held together by sugar syrups such as brown rice, honey, or corn syrups that function as binders. Like the other cold-extruded products, granola formulations also need to have a water activity below 0.60.

A typical granola bar or bite has about 6-7% protein, but additional protein may be formulated in to expand the bar's use as a meal replacement or snack. To maintain the crunchy texture with the added protein, extruded whey or milk protein crisps can be substituted for the rice crisp products. Extruded whey crisps can contain as much as 80% protein.

The protein contribution of dairy protein crisps in bars can be shown by comparing the protein level in a bar made with 100% rice crisps against a bar made with 100% whey crisps (with 80% protein); the 3% protein level of the bar increases to 23% protein by using whey crisps. Other high-protein whey ingredients such as WPI and WPC 80 could also be added to further increase the protein level to 30%. Additionally, milk powders and dairy calcium may be incorporated to help consumers meet their daily mineral requirements.

BAKED BARS & BITES

These products require baking to form their final texture. The baked process serves a similar purpose as the cold-extruded process for the mixing and forming of the product. Many of the same ingredients are used such as sugar syrups, sugar alcohols, glycerin, oils, protein ingredients, flavors, emulsifiers, and a variety of grains, nuts, crisps and other inclusions. Like cold-processed bars, baked products can be enrobed or coated with flavored chocolate or compound coating after they cool.

The main difference between the cold-processed and baked products is the moisture content of the dough. In the baked bars and bites the dough can have more water because much of it will evaporate during baking. Nevertheless, when adding protein to the dough, it is important to minimize the water to avoid stickiness as this might make machining difficult. Minimizing mixing time is also recommended to prevent "over-working" the proteins. The texture of baked products is shorter and drier than the cold-extruded products, which are dense and chewy.

Baked products are formulated much like an intermediate moisture food where the overall finished moisture can be 4-8%, but the water activity will still need to be below 0.60 to prevent yeast and mold growth. Generally, because of the protein's water-binding characteristics, it is more challenging to produce baked products with high protein levels. Milk and whey protein isolates and concentrates are good sources of protein to use for baked bars. Whey crisps can also be added to raise the protein content and modify the texture of the finished product.

Grain-Based Bars & Bites

Typical grain-based products like cereal bars, breakfast bars or other snack bites have low levels of protein. However, they have the other benefits of grains such as fiber content and a "whole grain appeal". They are often high in sugar, but the fact that they are made with grains such as oats, rice and wheat provide a healthy halo. A typical cereal bar is a co-extruded product having a grain-based outer dough with a fruit filling. It often contains 2.5% protein, 8% fat, 73% carbohydrate and 2.5% fiber. The addition of WPI, WPC 80 or MPC 80 to the outer dough could potentially raise the protein level of the finished bar to 8-10% and reduce the carbohydrates by an equivalent amount.

Breakfast bars are another form of high carbohydrate, grain-based bar that could benefit from added protein. A typical breakfast bar contains 6% protein, 10% fat, 74% carbohydrate and about 6% fiber. The addition of whey crisps, WPI, WPC 80, MPC 80 or other specialized whey protein ingredients is an easy and tasty way to increase the nutrient density of breakfast or meal replacement products.

Nutrition Gels, Pastes, and Jellies

While bars and bites dominate the market, alternative forms such as gels, pastes or jellies continue to grow in popularity to meet the needs of the "on-the-go" consumer. These delivery systems provide a fast-acting, easy to consume and concentrated source of nutrients.

Depending upon the market and product composition, gel products may be consumed in lieu of drinks, energy bars, meal replacements or supplements. Because of their convenient format (small, easy to carry and consume), these products are popular with sports and outdoor enthusiasts such as cyclists, runners, and hikers.

Gel products provide more energy (calories) per ounce than many sports drinks and are easier to consume while on the move. Generally, they are an aqueous blend of simple

PROTEIN GEL SNACK

INGREDIENTS

	Usage Levels (%)
Water	62.72
Whey protein isolate, clear	14.10
Granulated sugar, white	12.53
Calamansi juice 100%	9.40
Gelatin, bloom strength 225	1.25
Total	**100.00**

PROCEDURE

1. Divide water into 30 ml and 70 ml portions.
2. Hydrate whey protein isolate with 70 ml water.
3. Blend well and set aside for 1 hour.
4. Heat 30 ml water to a simmer, pour over gelatin and stir until dissolved.
5. Add sugar to gelatin mixture and stir until dissolved.
6. Stir in Calamansi juice.
7. Blend whey protein isolate mixture into the gelatin mixture.
8. Pour into container and refrigerate until firm.

NUTRITIONAL CONTENT

	per 100 g
Calories	100 kcal
Total Fat	0.00 g
Saturated Fat	0.00 g
Trans Fat	0.00 g
Cholesterol	5.00 mg
Sodium	10.00 mg
Total Carbohydrates	14.00 g
Dietary Fiber	0.00 g
Sugars	13.00 g
Protein	13.00 g
Calcium	2.00 %
Iron	0.00 %
Vitamin A	2.00 %
Vitamin C	4.00 %

and complex carbohydrates, protein, vitamins, and minerals. Their density allows them to deliver the same nutrient load as a small snack or meal replacement bar. Adding high quality dairy proteins to nourish the muscles in combination with carbohydrates to replenish muscle energy stores, helps improve athlete's endurance and aids in recovery prior to an athletes next workout.[14]

Gels are a fun and convenient format to easily add protein to the diet for any age group from kids to older adults. Consuming at the office for a midafternoon snack, while traveling, or while working out are all easy options. Because of their ability to deliver nutrients in a concentrated way, gel products may also be beneficial for elderly consumers who lack the proper amount of high-quality protein in their diets due to diminished appetite and/or swallowing concerns (dysphagia).

GEL PROPERTIES

Under specific conditions, whey proteins form non-reversible gels. Gel characteristics depend upon the protein concentration, the pH of the solution, and calcium and sodium ion concentrations. For example, gels formed in solutions with 3-5% protein and at a temperature of 55-70°C (131-158°F) tend to be more translucent and softer. More opaque gels are formed when higher protein concentrations (10%) are heated to higher temperatures [90-100°C (194-212°F)]. In acidic conditions, gels tend to be opaque, wet, and weak. In neutral and higher pH solutions, gels tend to be more translucent and elastic. The nature of the gel can also be modified by changing the type of sugar used in the formulation. WPI-containing gels with added lactose had no color development, whereas the gels with added ribose were orange/brown. Lactose stabilizes the WPI to prevent denaturation, which increases the time and temperature required for gelation, thus decreasing the fracture modulus of the gel compared to the gels with added ribose and/or no sugar added.[15]

When forming gels, hydration of the protein is key. A mixer may be used to fully dissolve the ingredients in water. However, whey proteins are very susceptible to denaturation from shear, so overmixing will create a lot of foaming and effect the strength of the final gel. Use slow agitation and let the protein hydrate a minimum of 30 minutes, but preferably 60 minutes prior to applying heat.

Gel properties can be manipulated to suit an individual manufacturer's needs by modifying the processing conditions and formulations. For example, protein isolates may be pre-acidified to reduce the need for additional acidulants in the final formulation. The unique gelling properties of whey proteins make them ideal for manufacturers of sport/snack gels who wish to incorporate as much protein as possible per serving to maximize the nutritional impact of their products.

No matter what form (bites, bars, gels or pastes) the finished product takes, U.S. dairy ingredients are versatile enough to deliver superior flavor, texture, appearance, and nutritional benefits that individuals can enjoy at any age. Be sure to visit ThinkUSAdairy.org for additional resources and help identifying U.S. dairy ingredient suppliers.

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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, combined with a long, rich heritage of environmental stewardship and skilled craftsmanship, support the United States' emergence as a leading global supplier of quality, sustainably produced 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.

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