U. S. WHEY INGREDIENTS AND WEIGHT MANAGEMENT

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Whey ingredients are an excellent source of high quality protein and thus are highly valued as components in a variety of weight management foods. The scientific community is increasingly recognizing that diets higher in protein may indeed provide a key to weight loss. Recent research is evaluating possible mechanisms through which specific whey protein, minerals and peptides may promote weight loss through increasing satiety, influencing glucose homeostasis, and maintaining lean body mass.

Various whey ingredients can also be rich sources of milk minerals, including calcium. Recent clinical trials and epidemiological studies have shown that optimal dietary intakes of dairy products may protect against excess adiposity, while low calcium intakes increase the risk of obesity. In addition, lactose, the sugar in whey ingredients, has a low glycemic index, which assists in controlling hunger and promoting weight loss. Thus, whey ingredients contain a combination of nutrients that have a positive synergistic effect in weight management diets. Combined with their clean flavor and wide versatility, whey ingredients make ideal components in a variety of foods designed for weight control.

THE WORLDWIDE INCREASE IN OBESITY

Obesity is emerging as a major health issue worldwide. On every continent of the globe, even in countries where malnutrition is widespread, the percent of the population that is either overweight or obese is increasing at an alarming rate. The World Health Organization notes, "More than 1.2 billion people worldwide are classified as overweight and 250 million are classified as obese." The growing problem of obesity and sedentary lifestyles also increases the risk of other major diseases such as high blood pressure, type 2 diabetes, coronary heart disease, stroke, and some types of cancers. Perhaps the largest single issue associated with obesity is the concurrent surge in diabetes. Some experts predict the number of diabetics worldwide will triple by 2014 to about 320 million.

The rise in obesity has created a large market in many countries for dietetic foods including meal replacement beverages, nutrition bars, and healthier snack items. Sports nutrition beverages are also an important part of a wider market targeted to individuals who want to maintain current weight and prevent obesity. Concerns over the rise in childhood obesity are helping to fuel the market for healthier snack items, such as high- protein cookies, cake-like products and chips. Other factors driving the demand for dietetic foods include longer life expectancy, higher costs of related health care, and increased awareness of nutrition issues.

THE ROLE OF PROTEIN IN WEIGHT MANAGEMENT DIETS

Over the past 30 years, many popular diets have recommended increased protein consumption, with various levels of carbohydrate restriction, as a key component of weight management regimens. Initially, health professionals dismissed these diets as fads, and encouraged the population to decrease fat in their diets as the major strategy to fight obesity. However, the rise in obesity despite lower fat intakes, and the copious anecdotal evidence for high-protein diets, has led traditional nutrition and health professionals to reevaluate the role of protein in weight and fat loss diets.

As noted, some type of carbohydrate restriction is key to the higher protein diets. Scientists now know that eating large amounts of dietary carbohydrates such as sweets, pastas, and breads can raise cholesterol, triglyceride, and insulin levels; and that elevated insulin can promote obesity and high blood pressure. Conversely, severely limiting carbohydrate intake will switch the metabolism so that the body uses its fat and protein stores, a state known as ketogenesis. In these restricted carbohydrate diets, a high protein intake is believed to protect the muscles. While there are some issues with their long-term safety, these diets have proven effective in promoting short-term weight loss.

In weight loss regiments, higher levels of dietary proteins have been shown to have an effect on satiety. In short-term studies, increased dietary protein has proven effective in increasing satiety and modulating energy intakes with a resultant loss in both body fat and weight. Six of eight preload studies, which compare hunger and satiety in the hours following a single high-protein meal versus a control meal, reported increased satiety with a high-protein diet. Perhaps more significantly, eight of ten studies reported lower energy intakes following a higher protein preload. One longer-term, 6 month, study showed an 18% lower energy intake with a higher protein diet. Further research to evaluate contributions of whey proteins to satiety is currently underway.

The popularity of these diets has created a market for higher protein, lower carbohydrate foods. This category includes "high-protein, zero-carb" and "high-protein, sugar-free" foods. Another approach is to formulate snacks and meal replacement foods with a more balanced nutritional profile, such as the 40/30/30 formula which derives 40% of calories from carbohydrates, 30% of calories from protein, and 30% of calories from fat. A final category fortifies foods that are traditionally low sources of protein to qualify for claims as a good or excellent source of protein.

Protein Quality

When formulating these weight management foods, food scientists around the world can select from a variety of protein sources. Whey proteins score higher on various measures of protein quality than other protein sources, making them ideal for weight management foods.

While it is widely accepted that whey proteins contain an excellent balance of essential amino acids, new research reveals that they also contain various bioactive compounds that may have positive effects in weight management, body composition, satiety and various biomarkers of health. Various possible mechanisms for the role of whey proteins in weight management have been proposed.

Protein Source	BV	PER	NPU	PDCAAS
Whole egg	100	3.8	94	1.18
Whey protein concentrate	104	3.2	92	1.15
Cow's milk	91	3.1	82	1.21
Beef	80	2.9	73	.92
Casein	77	2.5	76	1.23
Soy protein	61	2.1	61	.91

Biological Value (BV), Protein Efficiency Ratio (PER), Net Protein Utilization (NPU), and Protein Digestibility Corrected Amino Acid Score (PDCAAS)

Whey Peptides and ACE *Inhibitory Action*

One theory looks at the ACE inhibitory action of whey peptides. In one study, replacing casein in mouse diets with skim milk powder produced significantly greater effects on body composition at each level of calcium intake, suggesting that the additional bioactivity in improving body composition resides in the whey fraction. While the exact mechanism has not been determined, it has been hypothesized that the ACE inhibitors in whey are involved. Recent data demonstrate that adipocytes have an autocrine/paracrine renin-angiotensin system, and that adipocyte lipogenesis is regulated in part by angiotensin II. Thus, it is possible that whey-derived ACE-inhibitory activity may contribute to the antiobesity effect of dairy products that contain whey proteins and whey ingredients.

BCAAs *and Maintenance of Lean Muscle Mass*

Other research has evaluated the possible role of branched chain amino acids (BCAAs). Whey proteins contain a higher concentration of the branched chain amino acids (L-isoleucine, L-leucine, and L-valine) than any other protein source. BCAAs are unique in that they are metabolized for energy by muscle rather than by the liver. Because of this, they counteract muscle catabolism during exercise. They are particularly important for athletes in endurance sports such as marathons. Recent research also revealed a potential role for BCAAs in sparing of lean muscle mass in weight management programs, as well as the ability to reduce the role of insulin in managing acute changes in blood glucose, thus influencing glucose homeostasis.

One recent clinical trial compared diets with higher levels of leucine, one of the BCAAs, to diets with higher levels of carbohydrate. In this trial isocaloric energy restricted diets, equal in fat and fiber content, were fed to two groups. In the 16-week trial, the Protein Group lost significantly more total weight (9.8 kg versus 6.7 kg), body fat (8.8 kg versus 5.6 kg) and less lean body mass (0.4 kg versus 1.1 kg) than did the Carbohydrate Group. In addition, subjects in the Carbohydrate Group had insulin values that were more than double fasting levels and >40% above those of the Protein Group.

Glycomacropeptide and Appetite Suppression

One final area of research evaluates a potential role of glycomacropeptide (GMP) in appetite suppression. In the cheese making process, k-casein is cleaved into two sections. GMP is the portion that is removed with the whey. In animal studies, GMP has been shown to stimulate the intestinal hormone cholecystokinin (CCK), which inhibits gastric emptying, inhibits gastric secretions, and induces satiety. Researchers in one study found that feeding GMP resulted in inhibition of gastric secretion during the first and second hour after feeding. Human trials have been limited, but one study demonstrated that a pre-meal beverage containing whey protein enriched with GMP, oleic acid, calcium and specific fibers reduced hunger and subsequent meal intake in overweight females. Further research is warranted in this area.

Concerns Over High-Protein Diets

There has been some concern over potential long-term health effects of high-protein diets. One concern is that higher protein intakes might create a negative calcium balance resulting in bone resorption. However, long-term data from epidemiologic studies show a positive correlation between dietary protein intake and increased bone mineral content or reduced fracture risk. It is further suggested that the diets high in acid-buffering foods, plus adequate levels of phosphorus, potassium, and calcium are protective for bone health. Dairy ingredients are good sources of all three nutrients.

Another concern is that many of the popular high-protein diets also recommend high fat intakes, which might raise the risk for cardiovascular disease. Whey ingredients are very low in total fat and saturated fats, so weight management foods can be formulated to a variety of desired fat levels, and more heart-healthy fats can be used. More scientific studies are needed to determine the long-term effects of these various diet recommendations, and to determine ideal ratios of fats, carbohydrates and protein for specific population groups.

WHEY PRODUCTS, CALCIUM AND WEIGHT LOSS

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Please note: This is the summary of a longer paper by Dr. Zemel. A full version of this paper is available from the U.S. Dairy Export Council upon request.

A substantial body of accumulating evidence from both experimental animal and human studies provides a theoretical framework and clinical data to support a significant, beneficial role for dietary calcium in weight management. Notably, dairy sources of calcium exert markedly greater (approximately two-fold) effects than supplemental calcium sources, indicating an important role for dairy products in both the prevention and treatment of obesity. Further, available evidence suggests that the additional anti-obesity bioactivity of dairy may reside in whey. Thus, these findings make dairy, non-fat dry milk, whey minerals, and whey isolates logical ingredients in functional products designed to elicit a favorable pattern of energy partitioning and body composition.

Dietary calcium and dairy products are now well recognized to play an important role in the prevention of chronic disease, including hypertension, cardiovascular disease, osteoporosis and colon cancer. Among these, the practical relevance of the blood pressure benefits of dairy products was clearly demonstrated in

the DASH (Dietary Approaches to Stop Hypertension) trial, which demonstrated that increasing consumption of low-fat dairy products exerted profound effects on blood pressure regulation. Although this effect is largely attributable to the calcium contained in dairy products, an evaluation of multiple food-based versus supplement-based trials demonstrates that dairy sources of calcium exert approximately two-fold greater, and more consistent, antihypertensive effects than found with calcium supplements. An accumulating body of recent evidence now suggests that dietary calcium plays a pivotal role in the regulation of energy metabolism and, consequently, reduces body weight and fat. Thus, dairy rich diets not only reduce cardiovascular risk by exerting an antihypertensive effect, but also by reducing the risk of obesity.

Dairy-rich diets produce metabolic effects which result in a significant reduction of body fat. A clinical trial of the antihypertensive effect of calcium in obese African-Americans in which dietary calcium was increased from approximately 400 to approximately 1,000 mg/day by feeding two cups of yogurt/day resulted not only in lower blood pressure, but also a significant 4.9 kg reduction in body fat. Although the data were inexplicable at the time, they have recently been re-evaluated and placed in a logical theoretical framework based upon recent research describing the role of intracellular calcium in the regulation of adipocyte metabolism. This work, described below, shows that dairy-rich diets are likely to play an important role in the prevention of obesity in both children and adults, as well as in the management of adult obesity. Interestingly, as with the antihypertensive effect of calcium described above, dairy sources of calcium are markedly more effective than calcium supplements in the management of obesity, and available evidence suggests that the additional "anti-obesity" bioactivity is found in whey.

Whey is recognized as a rich source of bioactive compounds, which may act either independently or synergistically with the calcium to attenuate lipogenesis, accelerate lipolysis and/or favorably affect nutrient partitioning between adipose tissue and skeletal muscle. For example, whey proteins have recently been reported to contain significant angiotensin converting enzyme (ACE) activity. Although ACE inhibitory activity may appear to be more relevant to an anti-hypertensive effect than to an anti-obesity effect of dairy, recent data demonstrates that adipocytes have an autocrine/paracrine renin-angiotensin system, and that adipocyte lipogenesis is regulated, in part, by angiotensin II. Indeed, inhibition of the renin-angiotensin system mildly attenuates obesity in rodents, and limited clinical observations support this concept in hypertensive patients treated with ACE inhibitors. Thus, it is possible that whey-derived ACE-inhibitory activity may contribute to the anti-obesity effect of dairy. However, it is also possible that other whey bioactive compounds may contribute or, alternatively, that a synergistic effect of multiple factors, along with the aforementioned effects of the calcium, are responsible.

References

McCarron DA, Reusser ME: Finding consensus in the dietary calcium-blood pressure debate. J Am Coll Nutr 18: 398s-405s, 1999.

Appel LJ, Moore TJ, Obarzanek E, Vollmer WM, Svetkey LP, Sacks FM, Bray GA, Vogt TM, Cutler JA, Windhauser MM, Lin P-H, Karanja N, for the DASH Collaborative Research Group: A clinical trial of the effects of dietary patterns on blood pressure. N Engl J Med 336: 1117-1124, 1997.

Svetky LP, Simons-Morton D, Vollmer WM, Appel LJ, Conlin PR, Ryan DH, Ard J, Kennedy BM for the DASH Research Group: Effects of dietary patterns on blood pressure. Subgroup analysis of the Dietary Approaches to Stop Hypertension (DASH) randomized clinical trial. Arch Intern Med 159: 285-293, 1999.

Zemel MB: Calcium modulation of hypertension and obesity: Mechanisms and implications. J Am Coll Nutr (in press, 2001).

Zemel MB, Shi H, Greer B, DiRienzo D, Zemel PC: Regulation of adiposity by dietary calcium. FASEB J 4: 1132-1138, 2000.

Lin Y-C, Lyle RM, McCabe LD, McCabe GP, Weaver CM, Teegarden D: Dairy calcium is related to changes in body composition during a two-year exercise intervention in young women. J Am Coll Nutr 19: 754-760, 2000.

Carruth BR, Skinner JD: The role of dietary calcium and other nutrients in moderating body fat in preschool children. Int J Obesity 25:559-566, 2001.

Tanasescu M, Ferris AM, Himmelgreen DA, Rodriguez N, Perez-Escamilla R: Biobehavioral factors are associated with obesity in Puerto Rican children. J Nutr 130:1734-1742, 2000.

Lovejoy JC, Champagne CM, Smith SR, deJonge L, Xie H: Ethnic differences in dietary intakes, physical activity, and energy expenditure in middle-aged, premenopausal women: The Healthy Transitions Study. Am J Clin Nutr 74:90-95, 2001.

Photo courtesy: Glanbia Nutritionals USA

LACTOSE AND GLYCEMIC INDEX

Dairy foods in general have a low-glycemic index, and lactose has a lower glycemic index than many other sugars. This makes dairy ingredients ideal for use in weight management products. The glycemic index is an indication of the response of a fixed amount of available carbohydrate from a test food to the same amount of available carbohydrate from a standard food. Initially the standard "food" was glucose, but more recently it has been white bread. A more useful term, the glycemic load, has emerged. Glycemic load assess the total glycemic effect of the diet or a particular food, and is calculated by multiplying the glycemic index by the total amount of carbohydrate in a food or meal.

Diets based on low-fat foods that produce a low-glycemic response may enhance weight control because they promote satiety, minimize postprandial insulin secretion, and maintain insulin sensitivity. In contrast, long term studies in animal models have shown that diets based on high-glycemic index starches promote weight gain, visceral adiposity, and higher concentrations of lipogenic enzymes than do isoenergenetic, macronutrient-controlled, low-glycemic index-starch diets. Early studies showed that starchy carbohydrate foods have very different effects on postprandial blood glucose and insulin response.

Glycemic Index

Food	Glycemic Index Glucose =100	Glycemic Index Bread =100
Glucose	100	140
Sucrose	60	95
Lactose	46	65

Adapted from JAMA May 8, 2002 – Vol 287, No 18 (4) (5) and other sources.

Studies have shown that low-glycemic index diets improve glycemic control in diabetic subjects. Studies have also shown that lowering the glycemic index and load of the first meal will result in decreased food consumption in a subsequent meal, thus positively impacting weight management efforts. In one study, a 50% increase in a meal's glycemic index (e.g. from 50 to 75) resulted in a 50% decrease in satiety. Conversely, a high-glycemic index diet is associated with increased central obesity and insulin resistance.

Several short-term or small-scale studies in humans have addressed the issue of glycemic index and obesity. These trials included tests on obese men, children and pregnant women. All found lower adiposity in low-glycemic index diets versus high-glycemic index diets. One study showed reduced body mass index (BMI) in children prescribed an ad libitum low-glycemic index diet over four months, compared with those prescribed an energy-restricted low-fat diet. Similar results were found in other studies.

In addition to their importance in controlling obesity, low-glycemic index diets have also been associated with reduced serum lipids in hyperlipidemic subjects, higher HDL-cholesterol concentrations, and in reduced risk of developing diabetes and cardiovascular disease.

While much of the popular literature on low-glycemic index diets encourages consumption of fruits, vegetables and unprocessed grains, it must be remembered that dairy foods and dairy ingredients are also an important part of a low-glycemic index diet, as shown in this chart.

FORMULATING WEIGHT CONTROL PRODUCTS

Whey protein isolates and whey protein concentrates are valuable functional food ingredients, not only for their ability to aggregate and provide structure to foods, but also because they are highly soluble over a wide pH range. This property makes them suitable for use in such applications as sports beverages and liquid meal replacements.

Ready to Drink Beverages

In the sports beverage category, whey proteins are frequently used in a variety of ready-to-drink high acid, low pH beverages geared towards faster uptake of amino acids. These include low carbohydrate and zero carbohydrate products. Whey proteins are also used extensively in meal replacement beverages, which can be a valuable tool in weight loss regimens.

Data suggests that structured meal plans, which provide good nutrition and portion control for at least one or two meals a day, helped patients monitor caloric intake and resulted in short-term weight loss. Typically these products are sterilized in a retort and stored for extended time periods. This particular category of beverages offers certain formulation challenges. These products can be subject to phase separation, heat denaturation of proteins, and age gelation.

Various combinations of dairy ingredients are typically used in these beverages including skim milk powder, whey proteins and casein. Increasing the concentration of whey proteins to 60% of the total protein increases the stability of the emulsion. In products with higher levels of whey protein, incorporation of emulsifiers significantly increases the emulsion stability and helps counter the effects of heat aggregation on whey proteins. Using skim milk powder as the source of casein, rather than a combination of caseinates and sucrose, also allows the food formulator to take advantage of both the lower glycemic index of lactose and the clean flavor profile of milk powder.

In retorted meal replacement beverages, a 1:1 combination of lecithin and monoglycerides provides the best emulsion stability. High-pressure homogenization at 50 or 90 MPa produces more stable emulsions than homogenization at 20 MPa. It is possible to produce smaller and more stable fat globules in emulsions when milk fat is used compared to sunflower oil, coconut oil, or combinations of milk fat with sunflower oil or coconut oil. The most stable emulsions can be prepared using a combination of k-carrageenan and sodium tripolyphosphate in a formulation that contains 3% milk fat, 11% milk solids-not-fat and 8% sucrose at 90 MPa.

Carrageenan is frequently used to stabilize sports drinks and meal replacement beverages using whey protein. When a beverage is processed with UHT or retort processing, it is important to use a more tolerant blend for the higher temperatures. In addition, a lower usage level is implemented due to the enhanced protein reactivity and the lower carrageenan aggregation. Milk-based formulations require a slightly lower usage level than water-based formulations. Calcium and potassium also affect the carrageenan results.

Glycemic Index and Glycemic Load of Representative Foods and Ingredients

Food	Glycemic Index Glucose=100	Glycemic Index Bread=100	Grams CHO serving	Glycemic Load (Serving Size)
Instant rice	91	130	27	25 (110 g)
Baked potato	85	121	24	20 (110 g)
White bread	70	100	30	21 (2 slices)
Apple	36	51	22	8 (170 g)
Milk, skim	32	45	13	4 (225 ml)
Whey protein concentrate 80%	*		5	2 (100 g)
Whey protein isolate	*		<1	<1 (100 g)
Broccoli	(too low to measure)			(too low to measure)

Adapted from JAMA May 8, 2002 – Vol 287, No 18 (4) (5) and other sources.

*GI not measured, GL calculated based on glycemic index of lactose.

Meal Replacement Beverage[1]

Ingredients	Usage Level (%)
Skim milk	28.81
Cream, 40% milkfat	7.57
Skim milk powder, low heat	2.30
Whey protein concentrate 34%	5.73
Sucrose	8.00
Sodium Tri-polyphosphate	0.10
Kappa-2 – Carrageenan[2]	0.06
Lecithin	0.03
Mono and diglycerides	0.03
Water	47.37
Vitamins & minerals	As desired
Total	100.00

Formula courtesy of Texas A&M University.

[1] This formula uses a 40/60 ratio of Casein/Whey Protein

[2] Ingredient Solutions, Inc. – CM993X

Procedure:

1. Disperse the vitamins, minerals, sugar and emulsifiers with water.
2. Add skim milk, cream, WPC 34 and skim milk powder.
3. Heat to 70°C.
4. Homogenize at 8,000 psi before retorting.
5. Retort using appropriate time and temperature values (121°C for 6 minutes in stork retort).

High-Protein Ready-to-Drink Beverage

Ingredients	Usage Level (%)
Whey protein isolate	7.800
Flavors, natural or artificial	0.500
85% phosphoric acid	1.150-1.000
Citric acid	0-0.250
High intensity sweetener systems	.020
FD&C colors	.001
Purified water	to 100.000
Total	100.000

Formula courtesy of Glanbia Nutritionals USA.

Procedure:

1. Add water to a batch mixing tank at 15°-25°C.
2. Add whey protein isolate with good agitation, avoiding entrapment of air.
3. Add citric acid.
4. Add flavor and color.
5. Adjust to pH 3.2 using phosphoric acid with continuous mixing.
6. Each processor must determine the appropriate heating conditions to ensure a safe product. Heating to 80°-85°C for 15-30 seconds may serve as a starting point for low pH beverages.
7. Hot fill containers and cool immediately.

Photo courtesy: Proliant, Inc.

Dry Nutritional Supplements

Powdered beverage mixes are another important item in the weight management category. For ease of dispersion, instant whey and dry milk ingredients are used in these formulations. Popular categories include meal replacements, sports beverages, and isotonic drinks. Products for consumers may be packaged in individual serving sizes or bulk canisters, i.e. 0.5 to 1.0 kg. Hydrolyzed whey proteins are sometimes used because they are more rapidly absorbed to maximize protein synthesis after exercise.

Dry Nutritional Beverages[1]

	Sports Beverage Mix	Meal Replacer Mix**	Nutrition Drink Mix
Ingredients		**Usage Level (%)**	
Whey protein concentrate 80%, instant	31.5	22.2	79.4
Whey protein isolate, hydrolyzed			5.6
Skim milk powder, instant		22.5	
Corn syrup solids/Sucrose	11.0	10.3	
Crystalline fructose	49.5	15.0	12.2
Creamer		11.7	
Canola oil		6.2	
Cocoa		2.8	
Guar/Xanthan gum		1.7	
Instant coffee		4.2	
Citric acid	4.0		
Salt			1.1
Milk minerals	3.0	1.3	
Vitamin mineral premix		0.9	
Artificial sweetener			0.1
Flavor/Color (as desired)	1.0	1.2	1.6
Total	100.0	100.0	100.0
Water added by end user	500.0[2]	600.0[3]	550.0[2]

[1] Adapted from formulas developed by Wisconsin Center for Dairy Research, CalPoly Dairy Product Technology Center, and Proliant, Inc.

[2] Add to cold water and stir.

[3] Can be mixed with either warm or cold water.

**This formula provides a 40/30/30 profile of Carbohydrate/Fat/Protein.

Meal Replacement Bars

Popular meal replacement bars are formulated with whey protein concentrate 80%, whey protein isolate, hydrolyzed whey protein isolate, or a combination of these ingredients. A newer ingredient is a whey protein crisp, similar to a crisped rice, which serves to offer textural variety and boost the overall nutritional profile of the bar.

To keep the bars soft over time, humectants such as glycerin, honey, or fruit pastes are generally added to the formula. Certain U.S. hydrolyzed whey proteins also show a softening effect in meal replacement bars. Bars are often enrobed with a chocolate or yogurt compound coating, which contributes to both flavor and shelf-life of the product.

Meal Replacement Bars[1]

	Enrobed Chewy Bar	Fruit & Crisp Bar	Peanut Butter Bar
Ingredients		**Usage Level (%)**	
Whey protein concentrate 80%	24.0		
Whey protein isolate		4.8	11.12
Whey protein isolate, hydrolyzed			9.79
Rice crisp		14.1	
Rice syrup	17.0	22.0	
Enrobing chocolate	16.1		14.79
Rolled and/or quick oats	8.3	21.2	
Honey	8.0		18.29
High fructose corn syrup			16.17
Assorted dried fruits		22.4	
Peanut butter			8.33
Skim milk powder	7.8		
Raisin paste	7.8		
Peanuts or other nuts	4.3		7.24
Peanut flour	4.2		7.33
Soy oil or butter	2.3	3.4	
Maltodextrin			3.52
Water		10.6	
Glycerin		1.0	
Milk calcium	0.2		
Soy fiber			0.61
Flavors, vitamin/mineral blend	As Desired	0.5	2.81
Total	100.00	100.00	100.00

[1]Adapated from formulas provided by CalPoly Dairy Product Research, and Davisco Foods International.

Procedure:

1. Combine all wet ingredients in mixer for 3 minutes on medium.
2. Dry blend remaining ingredients except fruits and nuts.
3. Add dry ingredients to wet and blend well, and then add fruits and nuts.
4. Fruit & Crisp Bar is baked. The Chewy Bar and Peanut Butter Bar are extruded, and then enrobed.

High-Protein Chocolate Chip Cookie[1]

Ingredients	Usage Level (%)
Whey protein concentrate 80%	18.30
Pastry flour	18.25
Brown sugar	14.35
Sugar replacer	7.00
Butter	13.35
Skim milk powder	1.35
Chocolate chips	17.00
Eggs	2.55
Vanilla extract	0.30
Salt	0.25
Sodium bicarbonate	0.25
Water	6.75
Vanilla extract	0.30
Total	100.00

[1]Adapted from formula provided by CalPoly Dairy Product Technology Center.

Procedure:

1. Mix butter, brown sugar, sugar replacer and skim milk powder at medium speed for two minutes.
2. Add eggs, vanilla and water; mix for another minute.
3. Blend in flour, WPC 80, salt and sodium bicarbonate.
4. Fold in chocolate chips.
5. Drop 30-gram dough portions onto cookie sheet.
6. Bake at 177°C for 10 to 12 minutes.

Photo courtesy: Century Foods International

Frozen Juice Bars

In the past couple of years, a variety of whey based energy foods have entered the market including high-protein frozen juice bars. These high-protein frozen juice bars are becoming a popular snack, meal replacement, or alternative to dessert. Frozen juice bars are offered in a variety of flavors and contain whey proteins for lasting energy and increased satiety. The frozen bar is formulated with instant whey protein isolate and can be formulated to be more nutrient dense, yet low calorie and low carbohydrate. Whey protein isolates provide the raw materials needed to synthesize proteins for increasing lean muscle mass and to protect muscle against catabolic breakdown during exercise.

Orange Flavored High-Protein Freezer Pops

Ingredients	Usage Level (%)
Sucrose	75.65
Whey protein isolate, instant	20.00
Citric acid	2.00
Flavor–orange	1.25
Sodium citrate	0.50
Flavor–tangerine	0.30
Artificial color yellow	0.20
Sodium benzoate	0.05
Potassium sorbate	0.05
Total	100.00

Formula courtesy of Land O'Lakes, Inc.

Please check with your local supplier for detailed ingredient specifications.

Procedure:

1. Blend all dry ingredients.
2. Mix the blended dry ingredients with water in a ratio or 25/75 (solids/water) and stir well until all dry ingredients are dissolved.
3. While mixing, add phosphoric acid to adjust the pH to 3.00-3.50.
4. Pasteurize the mix at 87.7°C for 10 seconds.
5. Fill pouches immediately after pasteurization.
6. Freeze the pouches and maintain the product frozen until consumption.

REFERENCES

Brand-Miller, J. et al. 2002. "Glycemic index and obesity." Am. J. Clin. Nutr., 76s: 281S-285S.

Brody, EP. 2000. "Biological activities of bovine glycomacropeptide." British Journal of Nutrition, 84 Supp 1: S39-S46.

Davies KJ, et al. 2000 "Calcium intake and body weight." J. Clin. Endocrinol Metab., 85:4635-4638.

Eisenstein, J., et al. 2002. "High-protein weight-loss diets: Are they safe and do they work? A review of the experimental and epidemiologic data." Nutrition Reviews, 60(7): 189-200.

Foster-Powell, K., et al. 2002. "International table of glycemic index and glycemic load values:" 2002. Am. J. Clin. Nutr., 76:5-56.

Freedman, M., et al. 2001. "Popular diets: A scientific review." Obesity Research 9:1S-40S.

Heaney, R., et al. 2002 "Calcium and weight: Clinical studies." J. of American College of Nutrition, 21:152S-155S.

Heaney, R. "Normalizing calcium intake: Projected population effects for body weight." J. Nutr. 133:268S-270S, 2003.

Jenkins, D., et al. 2002. "Glycemic index: Overview of implications in health and disease." Am. J. Clin. Nutr., 76:266S-73S.

LaPlaize, B. 2001. "Hyperprotein diet: Are they useful or dangerous?" Vital News, Fall: 1-6.

LaPlaize, B. 1998. "Proteins and Satiety." Vital News, May: 1-3.

Layman, D., 2003. "The role of leucine in weight loss diets and glucose homeostasis." J. Nutr., 133: 261S-267S.

Ludwig, D. 2002. "The glycemic index, physiological mechanisms relating to obesity, diabetes and cardiovascular disease." JAMA, 287(18) 2414-2423.

Madley, R, "Big and getting bigger." Nutraceuticals World, Oct. 2002: p48-64.

Miller, S., et al. "New frontiers in weight management." J. American College of Nutrition, 2002: 21:2 131-S-133S.

Patton, D., 6/12/2002. "Developed nations embrace dietetic foods." Retrieved 12/6/2002 from http:www.nutraingredients.com/news/printnews.asp?id=6026.

Portman, R. 2002 "Effect of a nutritional composition on satiety when added to fat free yogurt or a liquid meal replacement." Retrieved 10/4/2002 from http: www.satietol.com/satietrol_abstracts.htm.

Richter, R. "Effects of formulation and processing on the emulsion stability and sedimentation of retort sterilized dairy-based nutritional products." Report to DMI 2/10/2002.

Spieth L, et al. "A low glycemic index in the treatment of pediatric obesity." Arch. Pediatr. Adolesc. Med., 2000: 154:947-51.

Walzem RL, et al. "Whey components: Millennia of evolution create functionalities for mammalian nutrition: What we know and what we may be overlooking." 2002 Critical Reviews in Food Science and Nutrition. CRC Press LLC, 42(4) 353-375.

Zemel, M. 2003. Mechanisms of dairy modulation of adiposity. J. Nutr., 133:252S-256S.

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