WHEY PROTEIN CONCENTRATES IN LOW-FAT APPLICATIONS

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Whey products contribute to creaminess, texture, water binding, opacity and adhesion in a variety of food systems. Their high nutritional quality and unique range of functional properties make them valuable in a wide range of low-fat products including soups, sauces, salad dressings and meats.

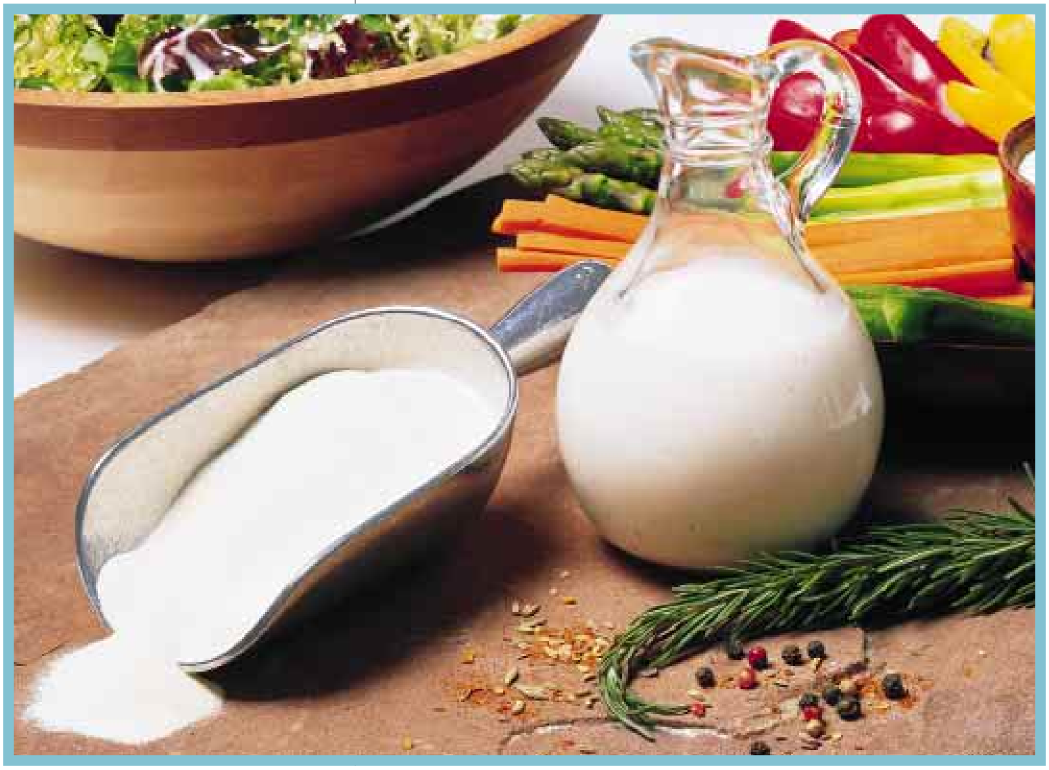
U.S. WHEY PROTEINS AS FAT MIMETICS

Consumer concerns about excess fat consumption of some types of lipids have led to the development by the food industry of a new category of foods to meet this demand. The development of reduced-fat foods with the same desirable attributes as the corresponding full-fat foods has created a distinct challenge to food manufacturers. Fat has functional properties that influence processing and the eating qualities of a food item, and these functions must be accounted for when lowering the fat in a product.

Key properties of food products influenced by fat include appearance, mouthfeel, texture, juiciness, flavor and storage stability. Some lipids may be replaced in foods by reformulating with selected ingredients that provide some fat-like attributes. These fat replacers can be lipid, protein or carbohydrate-based and can be used alone or in unique combinations.

Fat replacers are generally categorized into two groups: fat substitutes and fat mimetics. Fat substitutes are ingredients that have a chemical structure somewhat close to fats and have similar physiochemical properties. They are usually either indigestible or contribute lower calories on a per gram basis.

Fat mimetics are ingredients that have distinctly different chemical structures from fat. They are usually carbohydrate and/or protein-based. They have diverse functional properties that mimic some of the characteristic physiochemical attributes and desirable eating qualities of fat: viscosity, mouthfeel and appearance. Fat mimetics are the most widely used ingredients for producing emulsion-based reduced-fat products. Whey protein concentrates (WPCs) are considered as fat mimetics and they have found extensive use in reduced-fat foods, either alone or in combination with other mimetics.



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U.S. WHEY PROTEINS IN LOW-FAT FOODS: AN OVERVIEW

The whey protein concentrates used as fat mimetics are typically WPC34 and WPC80 (whey products containing 34% and 80% protein, respectively). Their use in low-fat foods offers many advantages. Their multifunctional characteristics provide several fat-like attributes. Their major functions are gelling, water binding, emulsification, viscosification and adhesion. Modifying processing conditions during the manufacture of WPCs can also selectively enhance specific functional aspects.

A majority of fat mimetic applications for WPCs involve emulsification within applications such as salad dressings, mayonnaises, cream soups, sauces and processed meats. In addition, WPCs offer cost-efficiency benefits when replacing or extending egg whites, hydrocolloid gums, soy proteins and modified starches.

WPCs retain their functionality in low pH environments, achieving good emulsification in highly acidic systems. Thus, in low-fat salad dressings, the important function of efficient fat dispersion and high water binding can be achieved. WPCs enhance water binding and allow for cost reductions through the addition of extra water, while yielding a product with good viscosity and opacity.

Reduced-fat soups and sauces benefit from the efficient dispersion of fat and the excellent emulsifying properties of whey proteins. Furthermore, the gelling properties of WPCs impart creaminess and a superior texture to low-fat soups and sauces. Another key function provided by WPCs in low-fat applications is increased opaqueness, which otherwise is significantly reduced with decreasing fat content. Whey proteins also function well in sausage and processed meat applications by binding water and pieces of meat to each other. Cost reduction, improved texture, mouthfeel and a superior nutritional profile are provided by WPCs.

U.S. WHEY PROTEIN CONCENTRATES AND FUNCTIONAL ENHANCEMENTS

Some of the special functional aspects of WPCs are emulsification, high solubility, gelling, whipping/foaming, water binding and viscosity. Whey proteins in their native form are globular folded structures. As such they are highly soluble and efficient in whipping and emulsification functions. The pH, ionic environment, concentration, presence of lipids and heat treatments influence their functional properties in food applications. Controlling various parameters during the production of WPCs allows for selective enhancement of specific physical properties. A number of unique functionally-enhanced WPCs are available from U.S. suppliers for specialized applications.

- *High Gelation*: An important function of WPCs is their ability to form heat-induced gels. These gels can hold water and other non-protein components of food systems. Calcium is required for gelling to occur and free calcium concentration is critical in determining gel hardness and water retention properties. Heating time, heating temperature, pH, and NaCl all influence the texture of WPC gels. High-gelling WPCs function particularly well in reduced-fat meats. Studies have shown that high-gelling WPCs, when combined with a gum and starch, yield a low-fat (3%) pork sausage that has similar textural characteristics to a full-fat (20%) control.
- *Cold Gelation*: Studies have demonstrated that whey proteins have to be pre-treated by heating to at least 70°C to achieve cold-gelling ability. Cold-gelling WPCs are now commercially available, and they can find good applications in salad dressings and mayonnaise type products. In meat applications using vacuum tumbling, cold-gelling WPCs can be added until the protein is in the meat, to be followed by the addition of salt to gel the WPC. Tests have shown that this method improves meat quality and yields.
- *Heat Stability*: Heating WPCs leads to the unfolding of globular proteins followed by association to form aggregates. Researchers have shown that α-lactalbumin heated alone did not form aggregates while β-lactoglobulin formed large aggregates with no evidence of intermediates. However, the two proteins interact to form soluble aggregates, as well as larger particles, by means of both disulfide bonds and hydrophobic interactions. This step can lead to the formation of small aggregate precipitates or gel lattice structures. Small aggregates remain soluble, they bind increased amounts of water, increase viscosity and add body or improve the product texture. However, gelation and some flocculating can occur. Lowering the pH of WPCs has been shown to inhibit unfolding of the protein and to increase their stability to thermal denaturation. Controlling the heat denaturation process in low-fat systems to prevent defects is important. Some precautions to follow include keeping the temperature below 75°C while the system is dilute. Denaturation of WPCs decrease from 80% to 40% when solids increase from 9% to 44% (with heating at 80°C for 20 minutes). Finally, adjusting calcium levels with chelators can be effective in some systems.
- *Water Binding*: Efficient water binding is an important function provided by WPCs in reduced and fat-free salad dressings. The retained water improves texture and reduces cost by replacing oil with water. This function is also valuable in reduced-fat chopped meat and seafood products, providing improved texture and mouthfeel.

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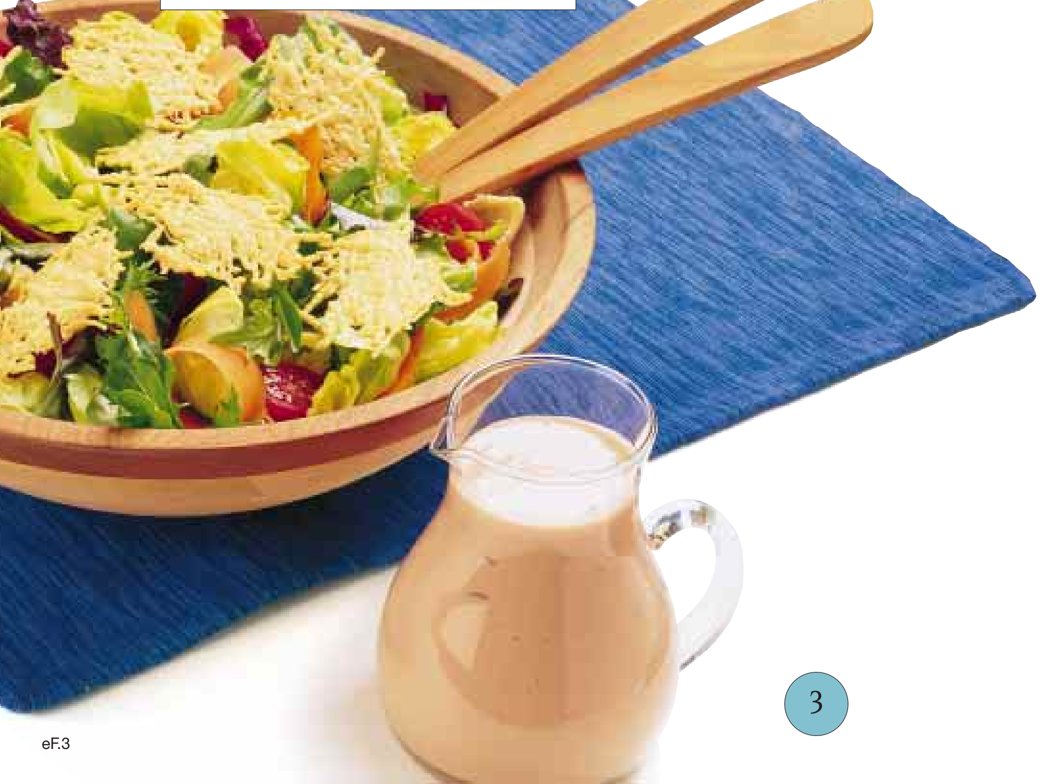
BENEFITS OF U.S. WHEY INGREDIENTS IN REDUCED-FAT SALAD DRESSINGS

- *Efficient dispersion of fat from the high emulsification properties aids in low-fat applications. This yields high opacity to salad dressings and the appearance of regular, high-fat products.*
- *Water binding enhancement by whey proteins is important in reduced-fat and fat-free formulations. to retain the increased water in the formula, and to replace fat and maintain texture and yield.*
- *Stable emulsions are formed in extended shelf-life products, even in acid systems as in salad dressings.*
- *Full and partial egg yolk replacement gives equivalent product qualities and provides cost-saving opportunities.*



Reduced-fat "French" Salad Dressing

Ingredients	% Use Level
• Tomato puree	10.00%
• Water	14.50%
Seasoning dry blend	
• Paprika	0.05%
• Oregano	0.02%
• Ground mustard	0.30%
• Xanthan gum	0.30%
• Propylene glycol alginate	0.10%
• Salt	1.30%
• Sugar	19.93%
• Vinegar	22.50%
WPC solution:	
• Water	7.50%
• WPC80	3.50%
• Vegetable oil	20.00%

Formula courtesy: Calpro Ingredients/DFA, Corona, CA

Procedure

1. Mix at medium speed tomato puree and water.
2. Add dry blended seasonings.
3. Add vinegar.
4. Add WPC80 solution.
5. Slowly add vegetable oil at increased mixing speed.
6. Deaerate using 750 mm vacuum.

Fat-free Thousand Island Dressing

Ingredients	% Use Level
Fraction 1a	
• Water	50.47%
• Sugar	10.00%
• Salt	1.00%
Fraction 1b	
• WPC80	5.00%
• Modified starch	2.00%
• Xanthan gum	0.10%
• Guar gum	0.10%
Fraction 2	
• Vegetable oil	1.00%
Fraction 3	
• Sweet pickle	10.50%
• Tomato paste	10.50%
• Vinegar 12%	5.00%
• Mustard	2.30%
• Onion powder	1.50%
• Flavoring	0.53%

Procedure

1. Add fraction 1a to emulsifying equipment.
2. Mix fraction 1b with part of oil in fraction 2 then add to fraction 1a.
3. Homogenize until the optimum viscosity is produced.
4. Emulsify fraction 2 into fraction 1.
5. Mix fraction 3 into the emulsion.

Advantages

1. Full functionality in cold-processed high acid dressing.
2. Egg yolk replacement is cost-efficient and desirable from a bacteriological standpoint.
3. WPCs have excellent emulsifying properties, yield smooth and creamy texture.
4. WPCs increase product opacity, appearance and consumer appeal.
5. WPCs have a neutral taste.

These formulas are provided as a starting point for product developers and may require adjustments. Check local regulations for the use of product names and ingredient usage. For additional help, please call U.S. suppliers or the U.S. Dairy Export Council.

BENEFITS OF U.S. WHEY PROTEIN CONCENTRATES IN REDUCED-FAT SOUPS AND SAUCES

- *Whey proteins contribute to increased opacity and help reduced-fat soups and sauces retain a good visual appeal, with the creamy appearance of regular products.*
- *Whey proteins provide fat-like functions of lubricity and significantly improve the mouthfeel of low-fat soups and sauces.*
- *Emulsification properties of whey proteins aid in efficient dispersion of fat by forming interfacial membranes around oil globules that prevent creaming, coalescence, and oiling off. Whey proteins contribute to increased shelf-life in terms of product appearance and consumer acceptability.*
- *WPC34 adds a clean dairy flavor and higher protein WPCs have a clean, bland flavor that blends well with other flavors present in the system.*

Low-fat Cream of Celery Soup

Ingredients	% Use Level
Emulsion Fraction	
• WPC80	0.70%
• Buttermilk powder	0.60%
• Cream (30% fat)	1.55%
• Vegetable oil	1.50%
• Water	12.00%
Condiments	
• Celery, diced	18.00%
• Water	22.00%
• Salt	1.30%
• Flavors	0.50%
• Sugar	1.20%
Thickener Fraction	
• Modified starch	3.50%
• Wheat flour	1.40%
• Corn starch	1.80%
• Water for slurry	14.00%
• Steam condensate & final dilution	19.95%

Procedure

EMULSION PREPARATION

1. Hydrate dairy powders in water at 38°C.
2. Add oil and cream to hydrated milk proteins and blend.
3. Heat to 60°C and homogenize at 211kgf/cm sq.

SOUP PREPARATION

1. Blanch celery in formula water for 3–4 minutes at 90–95°C.
2. Add salt, sugar and flavors.
3. Heat with live steam to 60°C.
4. Add emulsion to the kettle.
5. Add the thickener slurry and heat with live steam to expand the starch (88–92°C).
6. Adjust to final weight with hot water, mix thoroughly.
7. Fill into cans while hot.

Enhancement of Functionality with Whey Protein Concentrates in Low-fat Products

Enhancement	Soups & Sauces	Salad Dressings	Meats
Heat stability	•	•	
High gelation			•
Viscosity	•	•	•
Solubility	•	•	•
Salt tolerance			•
Water binding	•	•	•
Emulsification	•	•	•
Cold gelation		•	•

Premium Reduced-fat Cream of Mushroom Soup

Ingredients	% Use Level
Emulsion Fraction	
• WPC80	0.60%
• Skim milk powder	1.40%
• Vegetable oil	1.75%
• Cream (30% fat)	1.85%
• Disodium phosphate	0.50%
• Water	14.00%
Condiments:	
• Mushrooms, diced	14.00%
• Salt	1.80%
• Dairy flavors	0.40%
• Flavor enhancers	1.05%
• Water	19.00%
Thickener Fraction	
• Wheat flour	1.00%
• Modified starch	3.30%
• Corn starch	1.60%
• Water to slurry	15.00%
• Steam condensate & final dilution water	22.75%

Procedure

EMULSION PREPARATION

1. Hydrate dairy powders in water at 38°C.
2. Add oil and cream to hydrated milk proteins and blend.
3. Heat to 60°C and homogenize at 211kgf/cm sq.

SOUP PREPARATION

1. Blanch mushrooms in formula water for 3–4 minutes at 90–95°C.
2. Add salt, flavors and flavor enhancers.
3. Heat with live steam to 40°C.
4. Add emulsion to the kettle.
5. Add the thickener slurry and heat to expand the starch (88–92°C).
6. Adjust to final weight with hot water, mix thoroughly.
7. Fill into cans while hot.

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REDUCED-FAT MEAT APPLICATIONS

A novel approach to producing a low-fat sausage is shown below. It produces a preformed whey protein/carrageenan gel to replace formula fat. This is an example of a dual ingredient fat mimetic system used to achieve optimal product quality. In this example the use of WPC34 is a cost-efficient solution. Exact formulation savings will depend upon the local cost of ingredients and should be reviewed by each manufacturer.

Low-fat Ground Beef Patties

Ingredients	%
Low-fat beef (90% lean)	85.20%
Water	10.00%
WPC80	4.00%
Salt	0.50%
Tripolyphosphate	0.30%

Preparation

1. Hydrate the whey protein concentrate and phosphate in water with mechanical mixer for 15 minutes.
2. Refrigerate this slurry overnight at 4°C.
3. Add slurry and salt to meat.
4. Mix thoroughly and grind through 9.5 mm plate, then through 4.5 mm plate.

Low-fat Pork Sausage

Ingredient	Low-fat %	Control %
Pork (98% lean)	40.00%	40.00%
Back fat	0.00%	20.00%
Water	23.50%	27.50%
Bread crumbs	10.00%	10.00%
Seasonings	1.50%	1.50%
Phosphates	1.00%	1.00%
Pre-formed gel*	20.00%	0.00%
Starch	3.00%	0.00%
***Preformed gel**		
• High-gel WPC34	8.00%	
• Carrageenan	1.50%	
• Water	90.50%	

Procedure

1. Thoroughly mix and place in an impermeable bag.
2. Heat in a steam oven at 80°C for 2 hours.
3. Cool to 4°C and hold 16 hours.
4. Cut into 3 cm cubes.

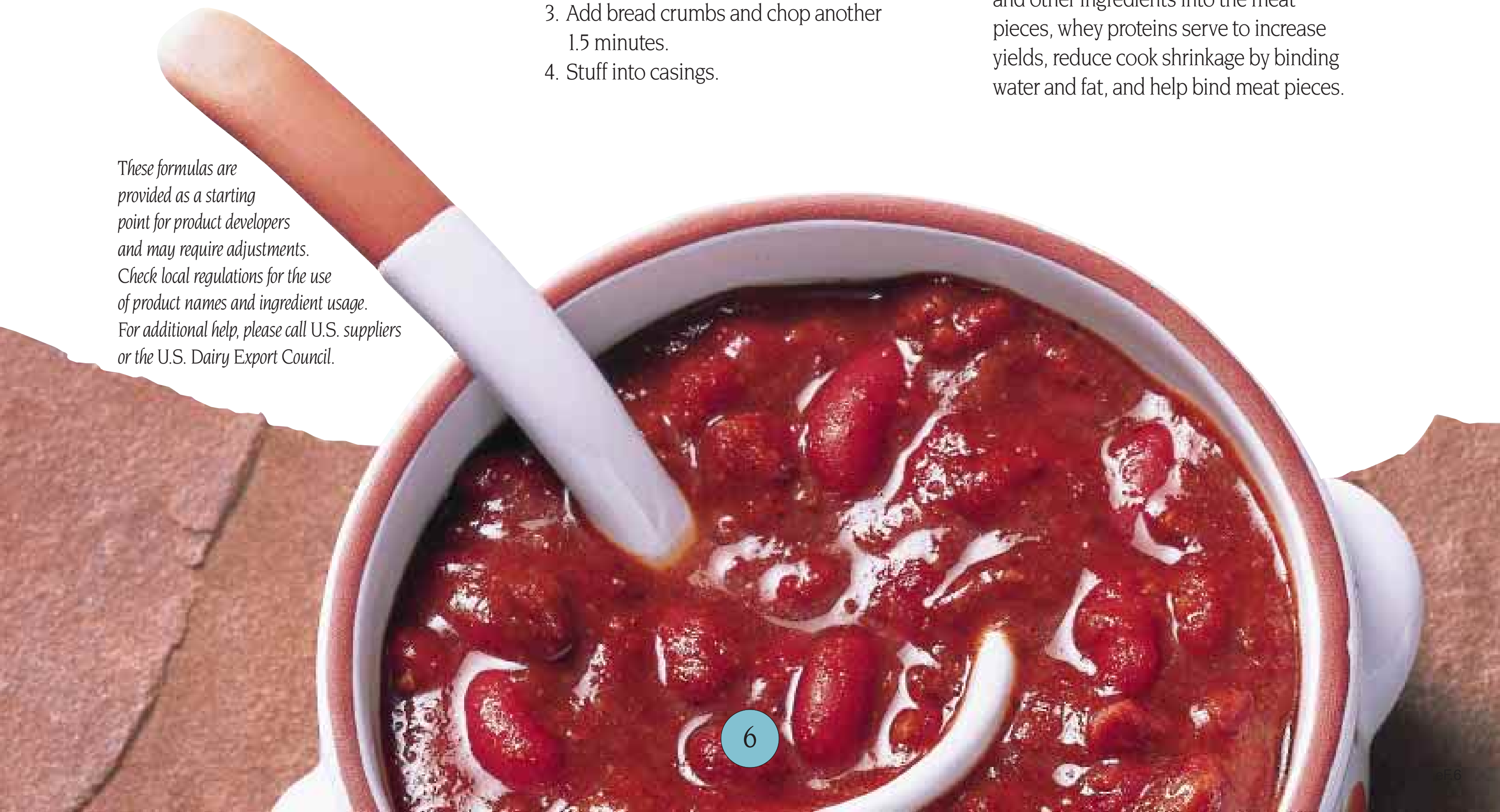
Preparation of Sausage

1. Place meat (minced through a 12 mm plate), water, seasonings and starch in a bowl chopper, and chop 1.5 minutes.
2. Add diced preformed gel (back fat for control) and chop for an additional 1.5 minutes.
3. Add bread crumbs and chop another 1.5 minutes.
4. Stuff into casings.

BENEFITS OF U.S. WHEY INGREDIENTS IN LOW-FAT MEAT PRODUCTS

- Whey proteins possess both hydrophilic and hydrophobic regions, which account for their good emulsification properties. This capability permits interaction with meat pieces, fat and other ingredients, retaining water and fat which are essential for moistness and mouthfeel in low-fat products.
- Heat-induced gelation develops three-dimensional networks, providing binding of meat juices and added formula water. Retention of fat is especially important in reduced-fat products to prevent dryness and maintain some lubricity. Significant economical advantages are realized with higher water retention.
- Whey proteins are compatible with other meat ingredients and fat mimetics, allowing increased flexibility in formulating reduced-fat meat products. Synergistic effects are observed with other fat replacers and yield cost-effective formulation solutions.
- In meat processes which utilize injection or vacuum tumbling to introduce proteins and other ingredients into the meat pieces, whey proteins serve to increase yields, reduce cook shrinkage by binding water and fat, and help bind meat pieces.

These formulas are provided as a starting point for product developers and may require adjustments. Check local regulations for the use of product names and ingredient usage. For additional help, please call U.S. suppliers or the U.S. Dairy Export Council.



Q&A

Q: Do WPCs *have any flavor impact in low-fat products*?

A: WPCs generally have very little flavor of their own, but WPC34 may have slight dairy notes with some light sweetness. Whey proteins do bind some flavors and this can be apparent in low-fat systems since the fat that normally carries flavors is reduced. Depending on the application it can be necessary to increase added flavors to compensate for this type of interaction.

Q: *Does using* WPCs *in low-fat products increase costs*?

A: Generally, low-fat products do cost more and sell for a higher price. The WPC cost, along with other mimetics and flavors can increase the price of the product, compared to a simple, lower quality product. However, these highly functional ingredients are effective at low levels and replace or displace other more expensive ingredients such as modified starches, hydrocolloids and emulsifiers. Furthermore increased yields are often realized by water and fat retention, yielding increased product quality and cost adjustments. Ingredient cost savings of 10–20% can be achieved using WPCs, depending upon the cost of other ingredients and processing variables.

Q: *Are processing changes required when using* WPCs *in low-fat applications*?

A: Each application has its unique requirements that also dictate which WPC should be selected for a specific application. For heat-processed soups and sauces where the WPC is an emulsifier and texturizer, some caution is required when blending the product, taking care with the heating conditions to avoid forming large insoluble precipitates. Selecting a more heat stable WPC will reduce this caution, careful control of the heat treatment is also recommended.

In salad dressing applications, a cold gelling WPC may have little heat stability, and in meat applications attention to salt sensitivity and viscosity may be important. U.S. WPC manufacturers and suppliers will have specific application guidelines for their ingredients.

Q: Is *there a guideline to determine which type of* WPC *is needed for an application*?

A: If cost-effectiveness is a primary concern, the lowest protein level that will provide the functionality is generally best. Each application is unique, but as the level of protein increases in the WPC, less may be required to perform the desired function and yield the best end-result. In some applications, one way to increase price/value of WPC is to add a heat treatment to a standard WPC34 or WPC50 thereby increasing its functionality. In emulsion-based low-fat applications this can be accomplished by heating the pre-emulsion blend to 60–80°C for 5 minutes, followed by homogenization. Significant viscosity and texture increases are obtained.

Q: Do WPCs *provide nutritional benefits*?

A: Whey protein concentrates help increase the protein content of low-fat foods. Furthermore, these high-quality proteins will help boost the Protein Efficiency Ratio of soups and sauces. They are highly desirable in diet foods, formulations for athletes, senior citizens and children. The calcium content of whey protein concentrates, that can be as high as 800 mg/100 g or more (equivalent to high-calcium cheeses), should be taken into account when calculating the nutrient content of formulations. WPCs are valuable ingredients in calcium-enriched foods for children, pregnant women or older consumers.

When designing "low-carb" reduced-fat products, WPC80 and whey protein isolates should be selected as they contain very low amounts of lactose.

Q: How *can a manufacturer find a supplier of* U.S. *whey protein concentrates*?

A: The U.S. Dairy Export Council, a non-profit association that represents the entire U.S. dairy industry, can help you develop relationships with suppliers through a "one-stop" trade lead system. Please contact any of USDEC's nine international offices or its headquarters in the United States. Further information on the Council, products and suppliers is available at www.usdec.org.

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