U.S. WHEY PROTEINS IN PROCESSED MEATS

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The use of whey ingredients in processed meats is increasing due to the changing attitudes of consumers, processors and regulatory agencies.

Whey proteins are being widely used in meat and poultry products as binding, extending and texture modifying agents.

In addition to their functional characteristics, they contain readily digestible and bioavailable essential amino acids, which provide a high nutritive value.

There are several different types of U.S. whey proteins that can be used in processed meat, poultry and seafood products. Among the most commonly used are: sweet whey, whey protein concentrates (34-80% protein), whey protein isolates (≥ 90% protein) and other specialized tailor-made WPCs and/or WPIs.

Since there is not one type of whey protein that can be used for all meat applications, it is necessary to match the application requirement with the specified functionality of WPC or WPI. Whey proteins can be used either as stand-alone proteins, as partial replacement of meat proteins, or as partial or total replacement of soy protein products or other non-meat binders such as modified starches or hydrocolloid gums.

U.S. whey proteins have been successfully used in comminuted (emulsified) products such as hot dogs and bologna, as well as in coarse ground products such as dinner sausage, breakfast sausage and ground meat patties, for their moisture, fat-binding, emulsifying and emulsion stabilizing properties.

In restructured meat and poultry products such as chicken nuggets, meat patties and restructured ham, whey proteins have been used to improve firmness, enhance slicing characteristics, reduce purge under vacuum packaging and improve binding between meat pieces.

FUNCTIONAL PROPERTIES OF WHEY PROTEINS

Functional properties of whey proteins encompass those physicochemical attributes of a protein that make it useful in food products. For any food ingredient, it must be free from off-flavors and off-colors, compatible with other ingredients and processes, readily available at affordable prices and serve a function in the product.

The most important functional properties of whey proteins in meat applications are: solubility, water-binding and viscosity, emulsification, adhesion, gelation, and organoleptic characteristics. Other properties of whey proteins such as dispersion, edible film formation, antioxidant activity and browning do contribute to the functionality, but are of less importance in a meat product.

Typical Composition of Whey Protein Concentrates and Whey Protein Isolates

Component	WPC 34 %	WPC 80 %	WPI %
Protein	34.0–36.0	80.0–82.0	90.0–92.0
Lactose	48.0–52.0	4.0–8.0	0.5–1.0
Fat	3.0–4.5	4.0–8.0	0.5–1.0
Ash	6.5–8.0	3.0–4.0	2.0–3.0
Moisture	3.0–4.5	3.5–4.5	4.5

Solubility

Whey proteins are highly soluble, especially when compared to sodium caseinate and soy proteins. Sodium caseinate is soluble above pH 5, whereas soy protein concentrate and soy protein isolate are soluble above pH 5.5. Whey proteins show excellent solubility over the entire pH range (pH 2 to 10).

The wide ranges of pH over which whey proteins are soluble make them ideal for use in injected products. In injected meat and poultry products, the whey protein is dissolved in a brine solution containing salt, phosphate, dextrose, nitrite and erythorbate. The ease with which the whey protein can be dissolved over a wide pH range is very critical in the preparation of the brine solution for injection into meat products.

Water-Binding and Viscosity

Products that bind large quantities of water create viscosity. When whey proteins are heated, the bonds that are responsible for their globular structure breakdown. As the protein molecule unfolds, additional water-binding sites are created which increase the viscosity of the solution.

In meat products, the water-binding properties of whey proteins contributes to the texture of the meat product. Water-binding reduces cooking losses and contributes to the juiciness or moistness of the final product. This increased juiciness helps the sensory profile and mouthfeel of the meat product.

Emulsification

Whey proteins are widely used in the food industry to stabilize oil-in-water emulsions. Whey proteins have both hydrophilic and hydrophobic groups, which allow the proteins to adsorb and unfold rapidly at the oil-water interface and form a layer that stabilizes the oil droplets and prevents flocculation and/or coalescence. The hydrophilic sites of the whey protein molecule bind water while the hydrophobic sites encapsulate the fat, resulting in stabilization of the system. Whey proteins function as well as traditional emulsifiers and are lower in cholesterol. The stability of whey protein emulsions can be further enhanced by adding gums or heating the system to create a protein gel. Heating the proteins will reduce fat mobility and minimize coalescence while gelation can provide complete entrapment of the fat emulsion.

The emulsification properties of whey proteins can be very useful in emulsified products such as hot dogs and bologna to improve stability, especially when low quality meat is used, or to replace expensive lean meat.

Adhesion

The adhesion properties of whey proteins help to improve the homogeneous texture of food products. Whey protein concentrates may be used to adhere breadcrumbs or batter to meat, poultry or fish. Effective adhesion between meat pieces is an important quality characteristic in the manufacture of products such as chicken nuggets or restructured ham.

The principal mechanism of adhesion in a meat product is twofold: the binding of meat particles together as well as water-binding (holding) by the meat proteins – caused by heat induced gelation of myofibrillar proteins. The actual meat particle binding occurs during cooking as heat setting of the proteins takes place. Whey proteins aid in this binding by forming strong, irreversible gels that restructure into an extended three-dimensional network, thereby helping adhesion.

Gelation

Whey proteins form thermo-irreversible gels. Gel characteristics depend on the protein concentration, the pH of the solution, calcium ion concentration and sodium ion concentration.

The principal protein in whey protein is β-lactoglobulin, which accounts for 50-65% of the dry weight. β-lactoglobulin is also the protein that forms thermal gels, which are of utmost importance in meat products. Heating whey proteins to temperatures above 70°C (158°F) can cause denaturation and polymerization, resulting in gel formation. Whey proteins form irreversible gels by restructuring into extended three-dimensional networks. The gel has the capability of entrapping fat and water that are released from the meat protein matrix when it shrinks during the heat treatment of the meat product.

A strong gel network helps hold this water and prevents moisture loss. This can improve the cook yield of the meat product. The gelling properties of whey proteins are also responsible for maintaining moistness and improving texture and mouthfeel in meat products. The water-binding and gelation properties of whey proteins can help with purge reduction. Purge is free water that is released during the refrigerated storage of a meat product. This free water can be a potential medium for the growth of spoilage microorganisms reducing the shelf life of the product.

In products that are frozen such as fully-cooked breakfast sausage or beef patties, whey proteins can reduce freeze-thaw purge during reheating in a microwave.

To provide a better understanding of the physical properties and performance of whey proteins, their gel profile at different temperatures was compared to other proteins in a model system. The proteins for comparison were whey protein isolate, whey protein concentrate, soy protein isolate, soy protein concentrate, texturized vegetable protein and sodium caseinate. A 12% protein concentration was used in each system. The proteins were heated from 40°C to 90°C (104°F to 194°F) with 2% salt to simulate conditions similar to those experienced in meat processing. Results show that WPI and WPC have the ability to form the strongest gels at a temperature above 65°C (149°F), when compared to the other proteins. At temperatures above 70°C (158°F), they form irreversible elastic gels whose gel strength increases with increase in temperature.

Flavor

In their pure form, whey proteins are very bland in flavor. However, depending on the application, they can either serve to bring out already present flavors, or add flavor of their own. For example, when whey proteins are heated, volatile sulfides are produced.

Free amino acids are also converted to flavorful compounds by heat and chemical interaction with other compounds. When whey proteins are enzymatically hydrolyzed, they develop flavor enhancing properties. Proteases are enzymes added to whey to hydrolyze the proteins. The hydrolyzed form of whey proteins can refine, brighten, accentuate and naturally enhance key flavor notes in soups, sauces, dips and meat products.

Whey protein based flavor enhancers can also help reduce formulation costs by heightening the perception of expensive flavors and spices. Another added benefit of WPC is that it can improve mouthfeel of foods by creating a richer, fuller flavor. This can be especially important when formulating reduced-fat or low-fat meat products where some of the flavor contributed by fat is lost. The incorporation of WPC can be an economic alternative to other high priced flavor enhancing additives.

Dispersibility

Generally, whey ingredients have good dispersibility. For applications that require whey ingredients to dissolve in water quickly and without an excessive amount of agitation, there are instantized forms of WPC and WPI.

The process of instantizing involves the use of a unique spray-drying method, which produces agglomerates with improved wettability, sinkability and dispersibility. This process of instantizing whey protein is commonly done for dry beverage mixes. When whey proteins are added to a brine solution for injecting meats, instantizing the product can improve dispersibility of the ingredient in the brine. Proteins are known to foam excessively when agitated. This property is not desirable for brines. Excessive foaming can be resolved by using an antifoaming agent.

Edible Film Formation

Edible films are defined as a thin layer of edible material formed on a food as a coating or placed on or between food components. Edible films are used to prevent quality changes in foods by functioning as barriers to moisture, oxygen, oil and aromas.

Whey protein ingredients have the ability to form water-based edible films that are transparent, bland and flexible with excellent oxygen, aroma and oil barrier properties at very low relative humidity. Whey protein isolate at concentrations from 5 to 10% have typically been used for this application. Recent research has demonstrated that a film made from polymerized WPC could help meat retain moisture during heating without affecting its rheological properties such as texture.

In addition, researchers showed that when antimicrobial agents were added to the WPC film systems, they effectively inhibited the growth of pathogenic and spoilage microorganisms including *Listeria monocytogenes*.

Antioxidant Activity

Some research has been done using whey protein for its antioxidant properties in foods. Whey has been evaluated for its ability to prevent lipid oxidation in pre-cooked meat such as pork and salmon. Commercial application of whey for this purpose has not been evaluated but could be beneficial when used in meat products, which are high in fat.

Browning

The combination of lactose and protein in whey provides the necessary components for the development of heat induced browning (Maillard reaction). Whey proteins can also participate in caramelization reactions.

The browning characteristics of whey proteins are of greater importance in baked goods; however, there is an advantage when whey protein-lactose browning occurs in meat products cooked by microwave, where lower surface temperatures are insufficient for the browning produced in a conventional oven.

NUTRITIONAL PROPERTIES OF WHEY PROTEINS

Protein quality refers to the ability of a particular protein to provide nitrogen in a balanced pattern of essential and non-essential amino acids. Protein Digestibility Corrected Amino Acid Score (PDCAAS) measures protein quality based on the amino acid requirements of humans. Criteria needed for PDCAAS are approximate nitrogen composition, essential amino acid profile and true digestibility. According to this method, the PDCAAS of an ideal protein meeting all the essential amino acid requirements of the human body has a value of 1.00. Whey protein has a PDCAAS score of 1.14; values greater than 1.00 are considered to indicate that the protein contains essential amino acids in excess of the human requirements. This excess can serve to complement the essential amino acid profile of food that may have deficiencies and result in a more nutritious prepared/processed food or meal.

PDCAAS of Animal and Vegetable Proteins

Protein Source	PDCAAS
Whey protein isolate and concentrate	1.14
Casein	1.00
Milk protein isolate	1.00
Soy protein isolate	1.00
Egg white powder	1.00
Ground beef	1.00
Canned lentils	0.52
Peanut meal	0.52
Wheat gluten	0.25

Among all protein sources, whey proteins contain the highest concentration of branched chain amino acids (L-isoleucine, L-leucine and L-valine). Branched chain amino acids must be present in the muscle cell to promote protein synthesis and provide safe nutritional support for athletes and individuals seeking optimum lean mass. Virtually every essential amino acid present in whey exceeds Food and Agriculture Organization/World Health Organization (FAO/WHO) nutritional intake recommendations for both children and adults.

CATEGORIES OF MEAT AND SEAFOOD PRODUCTS – FORMULATIONS

Whole Muscle Products

Whole muscle products consist of primal cuts of pork including whole hams and bacon, whole poultry breasts and legs, whole muscle cuts of beef and other cuts processed in the intact form. A pork ham is cured with a mixture of salt, sugar, nitrite, erythorbate and polyphosphates. Bacon is processed using pork whole bellies.

Typically, whole cuts or portions of red meats and poultry when injected with a brine containing salt, polyphosphates and whey proteins can enhance moistness and tenderness (induced by water uptake and retention) of the meat upon cooking.

Restructured Meat Products

Restructured meat products in today's food market represent a wide range of processed meat. The technology of meat restructuring involves conversion of primal cuts of the carcass and trimmings to resemble whole muscle. These products include ham, poultry or roast beef. In these types of products, water-holding is affected by retention of water inside intact muscle cells, as well as swelling of the meat fibers.

A brine solution containing WPC or WPI is usually injected, massaged or tumbled directly into the muscle. Upon cooking, the resulting product shows improved firmness, enhanced slicing characteristics and reduced purge under vacuum packaging. Whey proteins can also be used to increase juiciness and impart a more desirable flavor after cooking.

In a 50% extended ham, WPC 80 or WPI can be used to improve tumbling yield and cook yield, enhance slicing yield and texture and reduce purge over an 8 week period of refrigerated storage.

50% Extended Ham
Use of Whey Protein Concentrate 80% or Whey Protein Isolate

	Usage Level (%)		
Ingredients	**Control**	**WPC 80**	**WPI**
Lean ham	66.67	66.17	66.17
Water	29.78	29.28	29.28
Salt	2.20	2.20	2.20
Sodium tripolyphosphate	0.30	0.30	0.30
Dextrose	1.00	1.00	1.00
Sodium erythorbate	0.04	0.04	0.04
Sodium nitrite	0.01	0.01	0.01
WPC 80	0.00	1.00	0.00
WPI	0.00	0.00	1.00
Total	**100.00**	**100.00**	**100.00**

Procedure:

1. Trim ham of excess fat.
2. Prepare brine by dissolving phosphate followed by the rest of the dry ingredients.
3. Inject brine to obtain a 50% extension.
4. Macerate and tumble for 4 hours at 8 rpm.
5. Stuff into pre-stuck fibrous casings.
6. Cook in smokehouse to an internal temperature of 71°C (160°F).

Benefits of using whey proteins:

Whey protein concentrate 80% and whey protein isolate improve cook yield, sliceability and imparts a firmer texture in a 50% extended, restructured ham while reducing purge over an 8 week period.

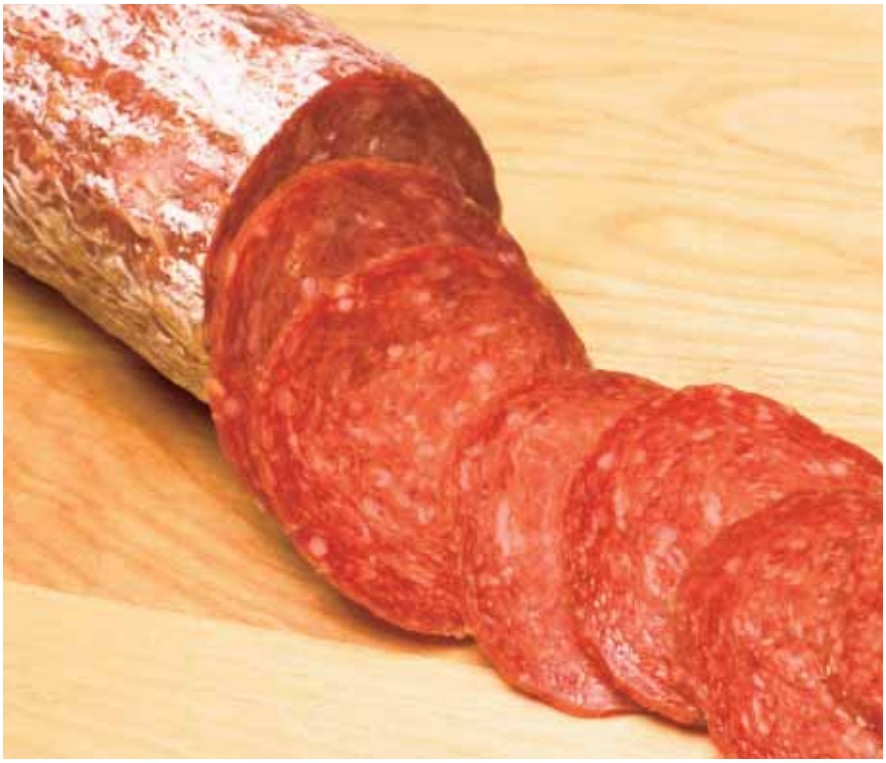
Coarse Ground Meat Products

Coarse ground meat products have visible fat and a particulate yet gelled texture. These consist of coarse ground sausages including a variety of fresh uncooked sausages such as breakfast sausage, bratwurst, Italian style sausage and Polish sausage. In these types of products, water-holding can be attributed mainly to the formation of a thermo-irreversible gel that entraps water and to the attraction of water to the proteins in the product.

The gelation properties of WPC or WPI are responsible for entrapping fat and water that are released from the meat protein matrix when it shrinks during the heat treatment of the meat product. A strong gel network holds this water and prevents moisture loss. Like water-binding, fat-binding is facilitated by building of a strong protein gel by natural entrapment of fat within the protein matrix or encasement of fat within fat cell membranes, which have not been substantially disrupted by the chopping process.

In a smoked sausage formulation, 1% (w/w) WPC 80 or WPI (hydrated 1:3) can be used to increase cook yields and reduce formulation costs by replacing 4% of the 95% lean pork. Cook yield increases of 3.4% and 4.1% respectively over the control can be obtained when WPC or WPI is used in the formulation resulting in significant cost savings to the processor.

Most dry and semi-dry sausages such as summer sausage, salami or pepperoni are also made from coarse ground meat. These products are usually salted and cured and sugar, such as dextrose, must be present. Dextrose serves as a substrate for the starter culture producing lactic acid. Lactose can be used as a substrate instead of dextrose in these types of products, however, the pH drop produced by lactose breakdown is not as high as dextrose and the resulting product is less "acid tasting."



Smoked Sausage
Use of Whey Protein Concentrate 80% or Whey Protein Isolate

	Usage Level (%)		
Ingredients	**Control**	**WPC 80**	**WPI**
Beef (90% lean)	5.00	5.00	5.00
Pork (72% lean)	19.00	19.00	19.00
Pork (95% lean)	20.00	16.00	16.00
Pork (50% lean)	28.00	28.00	28.00
Water	18.75	21.75	21.75
Salt	1.90	1.90	1.90
WPC 80	0.00	1.00	0.00
WPI	0.00	0.00	1.00
Sodium tripolyphosphate	0.40	0.40	0.40
Curing salt (6.25% nitrite)	0.17	0.17	0.17
Spice	4.00	4.00	4.00
Sodium lactate	2.75	2.75	2.75
Sodium erythorbate	0.03	0.03	0.03
Total	**100.00**	**100.00**	**100.00**

Procedure:

1. Pre-break meat block through a 2.5 cm (1") plate.
2. Batch and mix meat with water and other ingredients for no more than three minutes.
3. Regrind mixture through a 0.5 cm (3/16") plate.
4. Stuff into a collagen casing.
5. Cook in a smokehouse to an internal temperature of 71°C (160°F).

Benefits of using whey proteins:

When replacing 4% of the meat block with WPC 80 or WPI and water in a smoked sausage formulation, cook yields are increased and a cost saving is achieved while maintaining finished product quality.

Comminuted Meat Products

Comminuted meat products such as wieners, hot dogs, bologna and luncheon meat are produced by fine comminution. These groups of sausages are prepared by finely chopping or emulsifying meat and other non-meat ingredients in a bowl chopper creating sufficient shear to comminute meat and fat into fine particles resulting in an emulsion. Prior to formation of a gel in a meat product, finely chopped fat may tend to migrate and coalesce into larger and larger fat droplets. The emulsifying ability of meat proteins as well as WPC or WPI coat the fat droplets to prevent coalescence. This finely chopped system will be completely stabilized during cooking, where three-dimensional gel structures are formed and fat particles are embedded in the gel matrix.

In a full-fat hot dog formulation, WPC or WPI can be used to maximize the allowable non-meat protein, thereby maximizing the amount of water that can be added to the formulation. Meat processors who maximize their USDA allowable 1% non-meat protein have a competitive advantage over any processor who is not optimally utilizing this U.S. regulation. WPC or WPI can be used to reduce cost and yet provide a meaty, flavorful hot dog. The allowable non-meat protein content and/or the minimum protein content varies between countries. Please check country specific regulations when formulating comminuted meat products to assure compliance with all local requirements.

Hot Dogs
Non-Meat Protein Maximization with Whey Protein Concentrate 80% or Whey Protein Isolate

	Usage Level (%)		
Ingredients	**Control**	**WPC 80**	**WPI**
Pork (42% lean)	25.64	25.64	25.64
Beef (50% lean)	14.00	10.00	10.00
Mechanically deboned chicken	37.50	37.50	37.50
Water	15.00	18.00	18.00
Salt	2.00	2.00	2.00
Sodium lactate/Sodium diacetate	2.00	2.00	2.00
Corn syrup solids	2.00	2.00	2.00
Sodium tripolyphosphate	0.40	0.40	0.40
Spice	1.41	1.41	1.41
Sodium erythorbate	0.04	0.04	0.04
Sodium nitrite	0.01	0.01	0.01
WPC 80	0.00	1.00	0.00
WPI	0.00	0.00	1.00
Total	**100.00**	**100.00**	**100.00**

Procedure:

1. Chop mechanically deboned chicken in small bowl chopper until a temperature of 6-8°C (43-46°F) is reached.
2. Add dry ingredients while chopping on low-speed.
3. Add pork 42's, beef 50's and remaining water and chop on high-speed until the temperature reaches 13-15°C (55-59°F).
4. Stuff product into peelable cellulose casings.
5. Cook and smoke to an internal temperature of 72°C (162°F) and store at less than 4°C (39°F).

Benefits of using whey proteins:

Meat processors who maximize the allowable non-meat protein content have a competitive advantage over any processor who is not optimally utilizing this regulation. Whey protein concentrate 80% or whey protein isolate can be used to reduce cost and yet provide a meaty, flavorful hot dog.

Low-Fat Meat Products

Low-fat meat products such as lite hot dogs and bologna, and low-fat hamburgers have had an increasing demand due to the consumer's desire to limit fat intake. Because fat is a "functional" component in meat products for providing flavor and contributing to the texture, tenderness and mouthfeel of processed meats, a reduction in fat will result in a less palatable product.

For low-fat sausage production, a simple removal of fat or using extra lean meat in the product formulation would not only drastically increase product cost, but also make the cooked product rubbery, dry and tough. WPC and WPI contribute to mouthfeel, texture, water-binding and adhesion in low-fat meat products.

The ability of whey proteins to retain water and fat in a meat system is essential for the moistness and mouthfeel in low-fat meat products. The heat induced gel formation of WPC or WPI and the development of a three-dimensional gel network helps in binding the excess water typically present in low-fat meat products.

Whey proteins are compatible with other meat ingredients and fat mimetics such as starches allowing increased flexibility in the formulation of reduced-fat meat products.

In a 97% fat-free turkey breakfast sausage, the use of WPC 80 at a 0.5% level in the formulation resulted in a cook yield increase of 1.4% and a lower diameter shrink loss compared to the control.

97% Fat-Free Turkey Breakfast Sausage
Use of Whey Protein Concentrate 80%

	Usage Level (%)	
Ingredients	**Control**	**Test**
Line run turkey thigh meat	86.90	86.40
Spice blend with salt	2.25	2.25
Water	10.35	10.35
Modified corn starch	0.50	0.50
WPC 80	0.00	0.50
Total	**100.00**	**100.00**

Procedure:

1. Grind turkey thigh meat through a 0.6 cm (1/4") plate.
2. Mix meat, water and spices for no more than 1 minute.
3. Stuff into 5.1 cm (2") collagen casing.
4. Freeze product, then temper out partially.
5. Slice chubs into 35 g (1.25 oz) patties.
6. Cook patties in a convection oven under steam to an internal temperature of 71°C (160°F).
7. Package and store in freezer.

Benefits of using whey proteins:

Significant increases in yield and reductions in diameter shrink loss are achieved when utilizing whey protein concentrate 80% in a 97% fat-free turkey breakfast sausage formulation.

Surimi

Surimi is a Japanese term for minced and washed fish tissue. Commercial production of surimi is performed by mechanically separating minced fish muscle from bones and skin, followed by washing with water or a diluted salt solution. This washing removes most of the water-soluble components and fat. Surimi is texturized by extrusion processes with heating to produce imitation lobster tails, crab legs and shrimp.

Most surimi-based products are formed and cooked in metal molds or by elaborate forming machines that produce a product that most closely resembles crab or shrimp meat. This is accomplished by extruding a thin sheet of fish paste onto a moving surface which is heated to gel the paste.

The gel sheet is then cooled, slit lengthwise into narrow "fibers" and rolled. Fish meat paste used to make such products must have high gel-forming ability since the thin gel sheet is exposed to considerable torque during the fiberization process.

The use of whey proteins in seafood is mainly due to their gel-forming and water-binding abilities. Whey protein concentrate and whey protein isolate can be used effectively to improve the textural properties of surimi-based seafood such as fish balls, fish and shellfish and other similar products.

The optimal gelling temperature of fish muscle proteins is around 40°C (104°F), whereas whey proteins require higher gelling temperatures, typically 70-80°C (158-176°F). The addition of whey protein to fish protein is able to boost the gel rigidity by absorbing water and strengthening the fish protein network.

When a mixture of whey proteins and water is used to replace up to 5% of any fish/meat in a product formulation, nearly identical gelling properties are obtained (assuming that the product is cooked to sufficiently high temperatures to allow the whey protein to gel and that the solution of whey protein and water is similar in proportion to the meat protein and water content of the natural muscle).

This ability to substitute lower cost whey proteins for a portion of the more expensive muscle proteins, while keeping the product unchanged in quality, can offer significant profits for processors.

Some fish muscle protein, for example from Pacific whiting, has proteolytic activity from the presence of proteases. Most of these proteases are active during cooking of the gel (especially when the product is in the temperature of 50-70°C) and cleave the protein chain, which makes the sections smaller and less able to build a proper protein gel upon heating.

Whey proteins have been characterized as effective protease inhibitors, controlling autolysis of Pacific whiting surimi such that whey protein addition will decrease the protease activity during cooking.

Surimi Seafood Product
Use of Whey Protein Concentrate 80%

	Usage Level (%)	
Ingredients	**Control**	**Test**
Surimi	47.50	42.50
Modified starch	8.00	8.00
Sugar	2.00	2.00
Salt	1.40	1.40
Crab flavoring	0.75	0.75
Crab extract	0.35	0.35
Monosodium glutamate	1.00	1.00
WPC 80	0.00	1.25
Ice water	39.00	42.75
Total	**100.00**	**100.00**

Procedure:

1. Thaw to soften the surimi or fish meat, not above 1°C (34°F).
2. Chop meat in bowl cutter at lower speed, alternately adding salt and half the amount of ice water until a thick paste is obtained.
3. Add the remaining ingredients and chop at high-speed to a fine paste, not to exceed 10-12°C (50-54°F).
4. Extrude the paste in a thin sheet (2mm or 0.08") onto a hot stainless steel belt or drum; raise temperature of paste to 90°C (194°F) to set gel.
5. Cool, remove from belt/drum and pass through coloring, slitting and rope rolling machines.
6. Cut into sticks, vacuum package and pasteurize at 85-90°C (185-194°F) for 50 minutes.
7. Rapidly chill and store at 5°C (41°F) or below.

Benefits of using whey proteins:

- Meat replacement: 5 parts of fish meat or surimi can be replaced by adding 1.25 parts of WPC to 3.75 parts of water.
- Formulation cost savings.
- Increased cook yield.
- Maintained texture.
- Improved juiciness.
- Reduced package purge.

SAUCES AND GRAVIES FORMULATIONS

Sauces and gravies can utilize WPC and WPI to improve creaminess, texture and mouth coating making it thicker, richer and more full-bodied. WPC and WPI also contribute to increased opacity and viscosity in the sauce or gravy resulting in a more desirable appearance. The sauce or gravy appears more homogeneous because the particles are in a stronger suspension. This is due to the ability of whey proteins to form thermally induced gels. With increase in temperature, whey proteins bind water to provide the increased viscosity in a sauce or gravy. In a white country sausage gravy formulation, WPC 80 can be used to provide a creamy mouthfeel with a richer, fuller flavor.

Regulatory Considerations

There are no international standards (e.g. Codex Alimentarius) for processed meats.

In the U.S., whey protein ingredients are limited by protein content. Non-meat ingredients (including whey protein ingredients) are limited to 3.5% (finished product basis) in sausage products if the non-meat ingredient contains less than 90% protein (dry weight basis). If greater than 90% protein (such as WPI), non-meat proteins are limited to 2.0% (finished product basis).

Also, in the U.S., whey ingredients (all) can be used up to 8% (finished product basis) in standardized meat-containing items such as chili and meat sauces. In non-standard products containing meat (for example, "imitation" meats, nutrient modified meats, soups, stews, etc.) there are no specific limitations for the use of whey or lactose ingredients. In these latter applications, limitations are based on amounts "sufficient for purpose."

Please check local product legislations. Consideration of applicable national standards of identity and nutrient content claims are also needed for products such as "low-fat" or "reduced-fat" processed meats. Whey protein products offer significant functional and nutritional performance in such products.

Alfredo Sauce
Use of Whey Protein Concentrate 80%

	Usage Level (%)	
Ingredients	**Control**	**Test**
Powdered shortening	2.50	2.50
Starch, cold water swelling granular	1.56	1.56
Starch, low temperature gelling modified waxy maize	1.32	1.32
Maltodextrin	2.17	1.67
Salt	1.00	1.00
Romano cheese powder	1.08	1.08
Parmesan cheese powder	1.08	1.08
Buttermilk powder	0.80	0.80
WPC 80	0.00	0.50
Butter powder	0.40	0.40
Garlic powder	0.06	0.06
Black pepper, ground	0.02	0.02
Nutmeg, ground	0.01	0.01
Milk	88.00	88.00
Total	**100.00**	**100.00**

Procedure:

1. Blend dry ingredients together.
2. Slowly add milk to dry ingredients, stir until free of lumps.
3. Heat on stove or microwave until thickened, stirring occasionally.

Benefits of using whey proteins:

Whey protein concentrate 80% improves the mouthfeel of the sauce by making it thicker, richer, and more mouth coating.

FUNCTIONS OF WPC AND WPI IN REDUCING FORMULATION COSTS

Whey powder and the several types of WPCs and WPIs each have specific functions that allow them to find cost effective usage in improving meat, poultry and seafood products:

- Whey powder replaces more expensive carrier-based ingredients in spice and flavor blends;
- WPC 34 is a cost effective alternative to skim milk powder on a 1:1 replacement basis, and can also bind water and serve as a fat mimetic for low-fat products;
- WPC 80 is a functional meat replacer, and when hydrated can also act as a fat mimetic in low-fat products; and
- WPI is an especially effective gelling agent, and is particularly suited for use as a component of marinades for injection into whole meats to improve water-binding and juiciness.

Meat Replacement

Overall, WPC 80 finds the widest usage in meat, poultry and seafood processed products. This is due to its relative low cost to high functionality ratio; it is much less costly than WPI, but is a much better gelling agent than WPCs of lower protein content.

In replacing meat, the goal is to hydrate the WPC such that it will have approximately the same protein content as the meat it is replacing.

Meats from different species, and muscle locations within those species, can vary widely in composition, varying in protein content by 14 to 20%. When 1 part WPC 80 is hydrated with 4 parts water, the paste matches meat of 16% protein content. Likewise, if hydrated with only 3 parts water, the paste can replace meat having 20% protein content.

Meat of higher protein content is generally more expensive than that having lower protein content, so the savings in either applications are commensurate.

The level of meat that can be effectively replaced without noticeable change to the product will of course vary with the product application. At a minimum, 5% of meat can be replaced and much higher replacement levels are common.

As an example of savings that can be realized, if dry WPC 80 is $2.00/lb. and lean meat (70% water, 20% protein and 10% fat typically) is $0.75-$1.00/lb., then when the WPC is hydrated by 3 parts water, its cost is only $0.50/lb. as a direct replacement for lean meat in the formulation, a saving of $0.25-$0.50 for each lb. of lean meat replaced in the formulation. The readers should insert current pricing of WPC 80 and whatever meat they wish to replace in the above calculation to determine their own cost savings, keeping in mind that if a meat with lower protein content is replaced, then more water can be used to hydrate each part of WPC.

This discussion of course only considers the savings attributable to replacement of raw meat with hydrated WPC. If the added WPC contributes to less drip, purge or cook loss in the product, or improved sliceability, that greater product yield must also be considered in calculating the overall cost benefit.

Fat Replacement

In coarse ground sausages and some other dark meat product formulations, fat is normally present as white particles or flecks within the darker meat background. In such applications, a WPC gel can be ground or flaked to give the same visual effect and similar mouthfeel characteristics, as the fat would normally impart to the product.

Whey protein concentrate 80% can form a solid white gel when hydrated with up to 7 parts water per 1 part of WPC and heated to 90°C (194°F). Thus meat fats can be effectively replaced quite cheaply by this technique.

In finely cut products (hot dogs, bologna, etc.) where fat typically is invisible (except for overall lightening of the meat product color), fat serves instead to modify the tough or rubbery nature of the meat gel and also imparts juiciness. For such products, the addition of hydrated WPC can also effectively replace the fat component at a very low cost.

Selecting Whey Ingredients

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

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

Nutrition labeling claims

If specific health, structure/function or nutrient content claims are made, processed meat must be engineered to comply. Whey products offer significant sources of high quality protein and dairy minerals such as calcium and phosphorous. Additionally, WPCs and WPIs offer indirect impact on formulas where fat and/or sugar reduction are made by replacing removed fat or sugar functionality.

Processing conditions

The use of whey ingredients does not significantly change the processing or the conditions under which processed meats are prepared. Care does need to be taken in handling and adding whey and lactose to insure full and complete hydration and functionality.

Economics

Whey products add protein and bind water in processed meats formulas, playing a significant role in reducing ingredient costs and improving finished product yields.

Q&A

Q: *What are the typical recommended use rates of sweet whey, WPCs and WPIs in processed meats?*

A: There are no "typical" use rates for whey ingredients. Actual use rates are very dependent on all the key considerations affecting processed meat compositions, the individual functionality of the specific whey ingredient to be used and local regulations.

In the United States, standards limit the use of whey products in sausages as follows:

Sweet whey	3.5% maximum
WPC 34-80	3.5% maximum
WPI	2.0% maximum

However, in general, the following initial recommendations (% of finished product basis) can be considered guidelines in U.S. made products:

Sweet whey	1-3%
WPC 34-80	1-2%
WPI	1-2%

For formulated products such as chili and sauces, the use of up to 8% whey ingredients is possible. There is no limit on the use of whey ingredients in non-specific meat products without standards of identity or compositional standards. These products might be "imitation" meats, nutrient modified meats, and meats containing products such as soups or stews.

Q: *"Whey flavor" is considered a flavor defect; does using whey add "whey flavor"?*

A: "Whey flavor," also called "cardboard," "oxidized" or "cheesy" flavors, can come from whey ingredients, particularly sweet wheys. However, the carryover of such unfavorable flavor profile can be avoided by purchasing good quality sweet whey. Moreover, WPCs and WPIs have virtually no flavor of their own. Typically, whey products have a pleasant dairy flavor (or bland flavor) highly compatible with processed meats and spice/seasoning blends.

Q: *How can WPC 80 or WPI, which carry cost premiums to skim milk solids be cost effective?*

A: Several factors impact the cost effectiveness of WPC 80 and WPI. These highly functional ingredients have excellent water-binding and gel-forming abilities when compared to lower protein level WPCs and sweet whey; hence, less is needed to obtain the desired functionality. Furthermore, WPC 80 and WPI can be used to replace expensive ingredients such as hydrocolloid stabilizers, modified starches, soy proteins and some emulsifiers. WPC 80 and WPI when hydrated can be used as meat replacers in regular meat products and fat mimetics in low-fat meat products. WPI is particularly suited for use as a component of marinades for injection in whole muscle meats to improve water-binding and juiciness.

Q: *What are other benefits of using whey ingredients in meat products?*

A: Whey proteins have a high nutritive value: they contain readily digestible and bioavailable essential amino acids. Virtually every amino acid present in whey exceeds Food and Agriculture Organization/World Health Organization nutritional intake recommendation for both children and adults. Furthermore, whey proteins are all natural and are GMO free ingredients.

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