

Whey

Protein	% total	% whey
Whey	17	
-lactoglobulin	10	58
-lactalbumin	2	13
Immunoglobulins	2	12
Serum albumin	1	6
Minor Proteins	2	12

-lactoglobulin

Comprises 58% of whey protein

Genetic variants A and B

162 amino acids

Molecular weight = 18,300

2 S-S and 1 SH

-lactoglobulin

Isoelectric region 5.1 - 5.6

Below pH 3.0 and above 8.0 exists as a monomer

Between pH 3.0 and 8.0 exists as a dimer

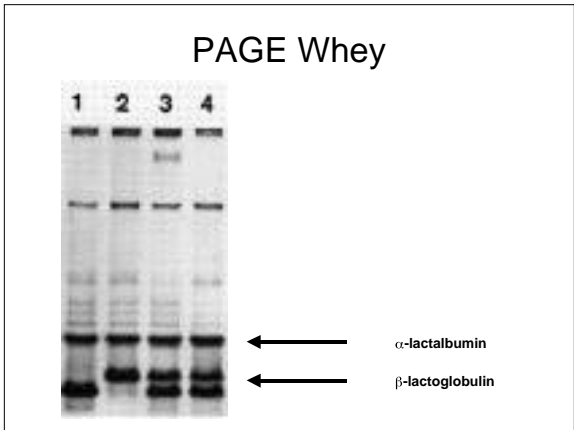
At high protein concentrations and low temperatures exists as an octamer between pH 3.8 and 5.1

-lactoglobulin

Octamer formation involves ionization of COOH groups

Genetic variants A/B (Asp/Gly) 64

Variant A forms much better octomers than does B



-lactoglobulin

Heating causes loss of solubility

Greater denaturation in presence of calcium

Can interact with other proteins with -SH group

-casein- β -lactoglobulin interaction proposed

β -lactoglobulin

-casein - β -lactoglobulin complex seen in model systems

Prevented by reducing conditions

Also seen in UHT milk

Forewarming

Complex not sensitive to rennin (?)



β -lactoglobulin

Molecule has been shown to have a high affinity site for retinol in the β -barrel region

Can also bind 1 mole of fatty acid very tightly

Can bind several moles of fatty acids with lower affinity

Strong fatty acid site located adjacent to barrel

β -lactalbumin

Comprises 13% of whey protein

123 Amino Acids

Molecular weight = 14,146

4 SS bonds

Modifies enzyme activity



β -lactalbumin

Modifies galactosyl transferase to become lactose synthetase

GT places UDP galactose units onto glycoproteins

GT K_m for glucose is 1400 mM

In presence of β -lactalbumin K_m for glucose is 5 mM

-lactalbumin

Molecule resembles lysozyme in size and structure

Both work on 1-4 linkages between glucose and galactose

Probable gene duplication

-lactalbumin

Heat resistant in presence of Ca^{++}

Denatures at 37°C in absence of Ca^{++}

Can form a complex with -lg

Bovine Serum Albumin (BSA)

Comprises about 1% of total protein

Molecular weight = 69,000

Contains 17 SS and 1 SH

Identical to blood protein

In plasma carries FFA

Easily denatured

Immunoglobulins

2% of total protein

Comprised of light and heavy chains:

Light = 20-25,000

Heavy = 50-70,000

Variable amounts of SS

Easily denatured

Immunoglobulins

Bovine milk contains:

IgG1

IgG2

IgA

IgM

Immunity to young

Important in creaming of cold milk

Proteose - Peptones

Do not precipitate after heating milk to 95°C for 20 minutes and adjusting to pH 4.6

Will precipitate with TCA

Four main types

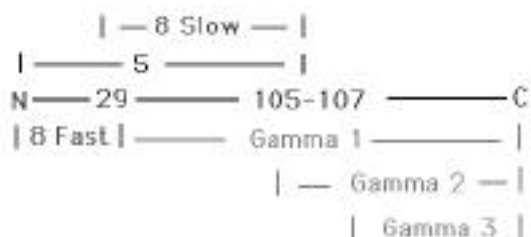
Proteose - Peptone 3 (MFGM)

Proteose - Peptone 5 (1-105)

Proteose Peptone 8 fast (1-29)

Proteose - Peptone 8 slow (29-105)

Origin of Protease Peptides



Minor Proteins

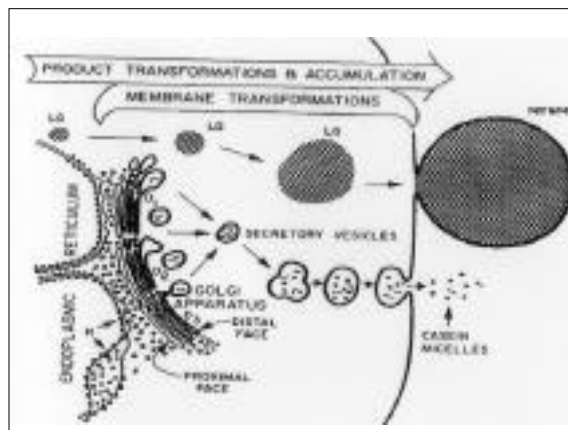
Lactoferrin - 86,000 - binds 2 moles of iron - much higher in human milk. Proteolytic fragments can inhibit microorganisms

Alkaline phosphatase - pH max around 9.0 - indicator of efficiency of pasteurization

Lipase - activated by mixing - can cause hydrolytic rancidity - destroyed by pasteurization

Milk Fat Globule Membrane

- Surround fat droplets upon secretion
- Derived from plasma membrane
- Hydrophobic and surface active
- Contains many enzymes in low concentrations
- Contains large amounts of xanthine oxidase
- May be important in some functionalities



Functions of Proteins in Foods

- | | |
|------------------------|-------------------|
| Foam Formation | Binding |
| Fiber Spinning | Viscosity |
| Emulsification | Gelation |
| Dough Formation | Flavor |
| Extrusion | Solubility |
| | Nutrition? |

Whey Product Utilization

Concentrated whey - source of milk solids and possibly cheese flavor. Generally used at or very near to point of production.

Dried whey - Approximately 15% in animal feed and 85% in human foods in 2001. Inexpensive source of solids. May get minimal functionality from protein. Slight cheese flavor is possible

Whey Product Utilization

WPC 34 - Replacement for NFDM in applications where functionality of casein is not essential for product formulation.

WPC 80 - Applications where specific protein functionality is required. Many of the well developed applications involve gel formation as part of the functionality.

Whey Product Utilization

WPI - Ion exchange - most expensive and functional of whey products. Virtually fat free, fairly heat stable, very low flavor profile, gives clear solutions. Cost makes use in typical food application unlikely.

WPI - MF/UF - Less expensive than ion exchange product. Contains more fat and flavor profile not as good, not as heat stable. Used where possible as a substitute for IE /WPI

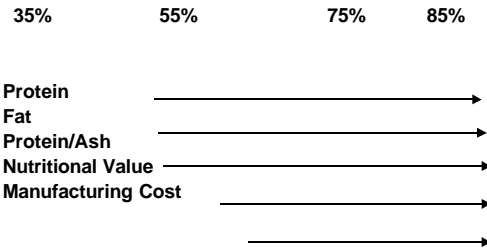
WPC Functionality

34 % protein WPC is not very functional

75 % protein WPC can have good functionality

The costs of WPC that contain greater than 34% protein require that increased functionality justify the additional expenditure

Whey Protein Concentrate Protein Levels and Characteristics



Whey Production

Product	Metric Tons(2001)	Cost(4/02)
Concentrated Whey	65,000	?
Dried Whey	545,000	\$0.21
WPC 34	176,000	\$0.79
WPC 75-83	?	\$2.50
WPI - IE	?	\$5.00
WPI - MF/UF	?	\$4.50
Lactose	255,000	\$0.20

You Can Pay More

Bulk whey 5 pounds for \$33.95. Analysis of label suggests it is 70% protein WPC.



Protein Functionality in Food

Property	Mode of action	Food system
Solubility	Protein solvation	Beverages
Water absorption and binding	Hydrogen bonding water entrapment of water	Meat sausages, cakes, breads
Viscosity	Thickening; water binding	Soups, gravies salad dressing
Gelation	Protein matrix formation & setting	Meats, curds, baked goods, cheese

Protein Functionality in Food

Property	Mode of action	Food system
Cohesion-	Protein acts as adhesive material	Meat sausages, baked goods, pasta products
Elasticity	Hydrophobic bonding disulfide links	Meats, bakery
Emulsification	Formation /stabilization of emulsions	Sausages, salad dressing, coffee whitener, soup, cakes, infant formula

Protein Functionality in Food

Property	Mode of action	Food system
Fat absorption	Binding of free fat doughnuts	Sausages,
Foaming	Forms stable film to entrap gas	Chiffon desserts, cakes, whipped toppings.

Sauces and Soups

Inexpensive source of solids
Browning
Viscosity
Flavor
Ease of formulation



Where's the Cheese?



Cheese sauce mix
 (Whey, Whey Protein Concentrate, Milkfat, Milk Protein Concentrate, Salt, Sodium Tripolyphosphate, Citric Acid, Sodium Phosphate, Lactic Acid, Calcium Phosphate, Yellow 5, Yellow 6, Enzymes, Cheese Culture)

Dairy Foods

Inexpensive source of solids
Reduced fat - adds richness
Enhances other dairy flavors



Baked Goods

Water binding of dough

Browning

Reduced fat

Aeration



Protein-Fortified Cookies

Developed by Carolyn Podgurski
California Dairy Ingredients Applications Lab

Ingredient Usage Level (%)

WPC 80	18.30
Cake Flour	18.25
Brown Sugar	21.35
Butter	13.35
NDM	1.30
Chocolate Chips	17.35
Eggs	2.55
Misc	0.80
Water	6.75
Total	100.00



Salad Dressings

Inexpensive source of solids

Solubility

Emulsification

Viscosity



Confections

Browning Structure Aeration

Example: Dulce de leche

Ingredient	(%)
Milk, whole	37.08
Sugar (sucrose)	26.68
Corn Syrup, 42 D.E.	19.27
WPC-34	11.12
Cream	5.56



Meats

Reduced fat lubricity

Improved texture - low fat

Less shrinkage



Beverages

Solubility

Emulsification

Clarity



Gelation

Large market for high protein WPC

Very large market potential

Fat replacers

Emulsion stability

Foaming

Nutritional Products - Bars

Usually want low carbohydrate with high protein.

Calories 250

Total fat 6g

Protein 32g

Serving size 78g

Total carbohydrate 18g

Whey Protein Isolate



Nutritional Products - Drinks



Supplement Facts

Serving Size 1 bottle (32 FL. Oz./946 mL)

Amount Per Serving % DV

Calories 260

Total Fat 0g 0%

Total Carbohydrate 25g 9%

Sugars 0g †

Protein 32g 64%

Calcium 50mg 9%

Sodium (as citrate) 60mg 3%

Potassium 45mg 9%

* Percent DV based on a 2,000 calorie diet.

† Daily Value (DV) not established.

Problems with Low Fat

Texture is difficult to mimic

Flavor is a real problem

Proteins bind flavor

Low fat may not be good enough

Water Binding

Reduced fat products are too dry.

Hydrated proteins or carbohydrates may improve texture and mouthfeel

Increased water binding of protein is helpful.

WPC

Useful in applications where bound water may contribute to perception

Cakes

Brownies

Meat products

Low Fat Patty

Sausages at 3% fat were difficult to work with.

Sausages at 5 to 8% fat were acceptable, but did not brown properly. Cooking with an oil spray helped.

Sausages that were 9.5% fat with added glucose to aid browning were preferred to the full fat controls

Nutritional Information

	Regular	Low-Fat
Calories	310	130
Calories - Fat	270	70
Total Fat	30 g	8 g
Saturated Fat	11 g	4 g
Cholesterol	50 mg	45 mg
Sodium	500 mg	500 mg
Protein	9 g	14 g

Summary

Whey utilization continues to grow

More products are available

New markets have opened

Helped to replace “whole” ingredients

Nutrition has become a functionality