

Dried Dairy Ingredients

3rd
Edition

Types of milk, whey and permeate ◇ Dairy ingredients from milk ◇ Dairy ingredients from whey ◇ Summary of dried dairy ingredients

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Introduction

The Dried Dairy Ingredient Handbook is designed to be an easy to use, quick source of information on the wide range of ingredients that can be made from milk and whey. The Handbook is intended only as a guide to dairy ingredients. Product manufacturing methods, composition and specifications will vary between producers. The guide describes what is typical for products.

Some ingredients can be made from either milk or whey but they have been included in the section under the starting material most typically used.

Information on products is given in several different formats reflecting the varied ways information on dry dairy products is conveyed. Graphs of product composition are on a total solids basis thereby allowing a quick comparison of components. Tables of product composition include moisture thereby reflecting what a customer would typically see for a bag of dry product. The table of typical composition and characteristics gives composition information in a format similar to the product composition table but protein is given on a dry basis.

Regulations for US dairy products often are distributed throughout several agencies. It may be necessary to consult several sources to obtain complete information on regulations and standards for a given product.

Standards and specifications also may vary between government agencies and trade groups. It is important to check for regulations governing your particular product as well as for any changes in regulations/standards.

Karen Smith

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Types of Milk, Whey and Permeate

Milk

- Whole
- Skim
- Buttermilk (from butter manufacture)

Whey

Resulting from:

Cheese manufacture

- ♦ Sweet
- ♦ Acid
- ♦ Salty

Casein production

- ♦ Sweet
- ♦ Acid

Greek yogurt production

- ♦ Acid

Permeate

Resulting from:

Milk

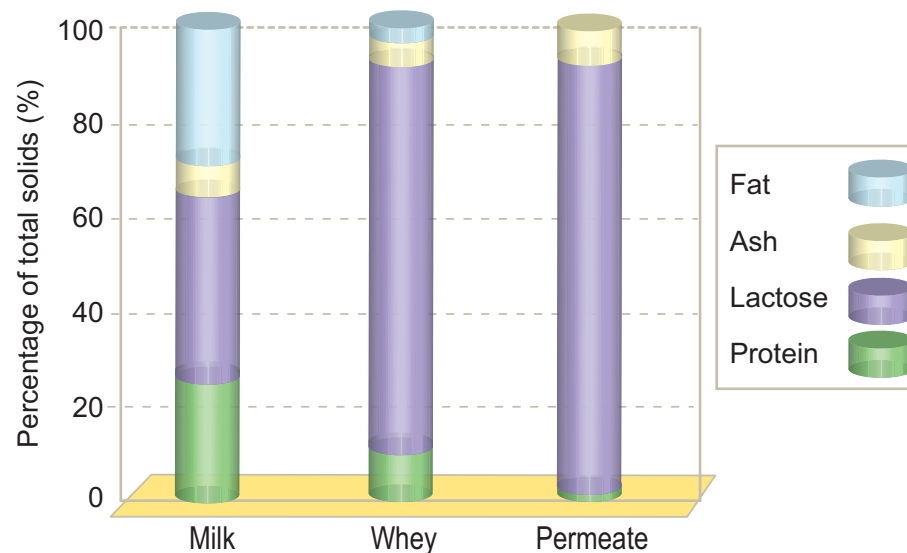
Cheese manufacture

- ♦ Sweet whey
- ♦ Acid whey

Casein manufacture

- ♦ Sweet whey
- ♦ Acid whey

Milk, whey and permeate composition



General composition of milk, whey and permeate

	Milk	Sweet whey	Whey permeate
Component	----- % -----		
Total solids	12.5	6.5	5.5
Protein	3.5	0.8	< 0.1
Lactose	4.8	4.9	4.9
Ash	0.7	0.5	0.5
Fat	3.5	0.3	0.0

Dried Dairy Ingredients

Milk based

Milk powder

- ◆ Nonfat dry milk (NFDM, NDM)
 - Low heat
 - Medium heat
 - High heat
- ◆ Whole milk
- ◆ Buttermilk

Colostrum

- ◆ Skim
- ◆ Whole

Casein

- ◆ Acid
- ◆ Rennet

Caseinate

- ◆ Potassium
- ◆ Calcium
- ◆ Sodium

Co-precipitate

- ◆ Acid
- ◆ Medium calcium
- ◆ High calcium

Milk protein concentrate (MPC)

- ◆ 42 to 85

Milk protein isolate (MPI)

Reduced calcium milk protein concentrate

Permeate (milk)

Micellar casein

Native whey protein

Whey based

Whey

- ◆ Sweet
- ◆ Acid

Demineralized (reduced minerals) whey

- ◆ 25 to 90%

Reduced lactose whey

Lactose hydrolyzed whey

Protein hydrolyzed whey

Lactalbumin

Whey protein concentrate (WPC)

- ◆ 34 to 80

Whey protein isolate (WPI)

Heat stable whey protein concentrate

Whey protein phospholipid concentrate (WPPC)

Alpha-lactalbumin enriched whey protein concentrate

Individual proteins

- ◆ Lactoferrin
- ◆ Lactoperoxidase
- ◆ Glycomacropeptide (GMP)

Permeate (whey)

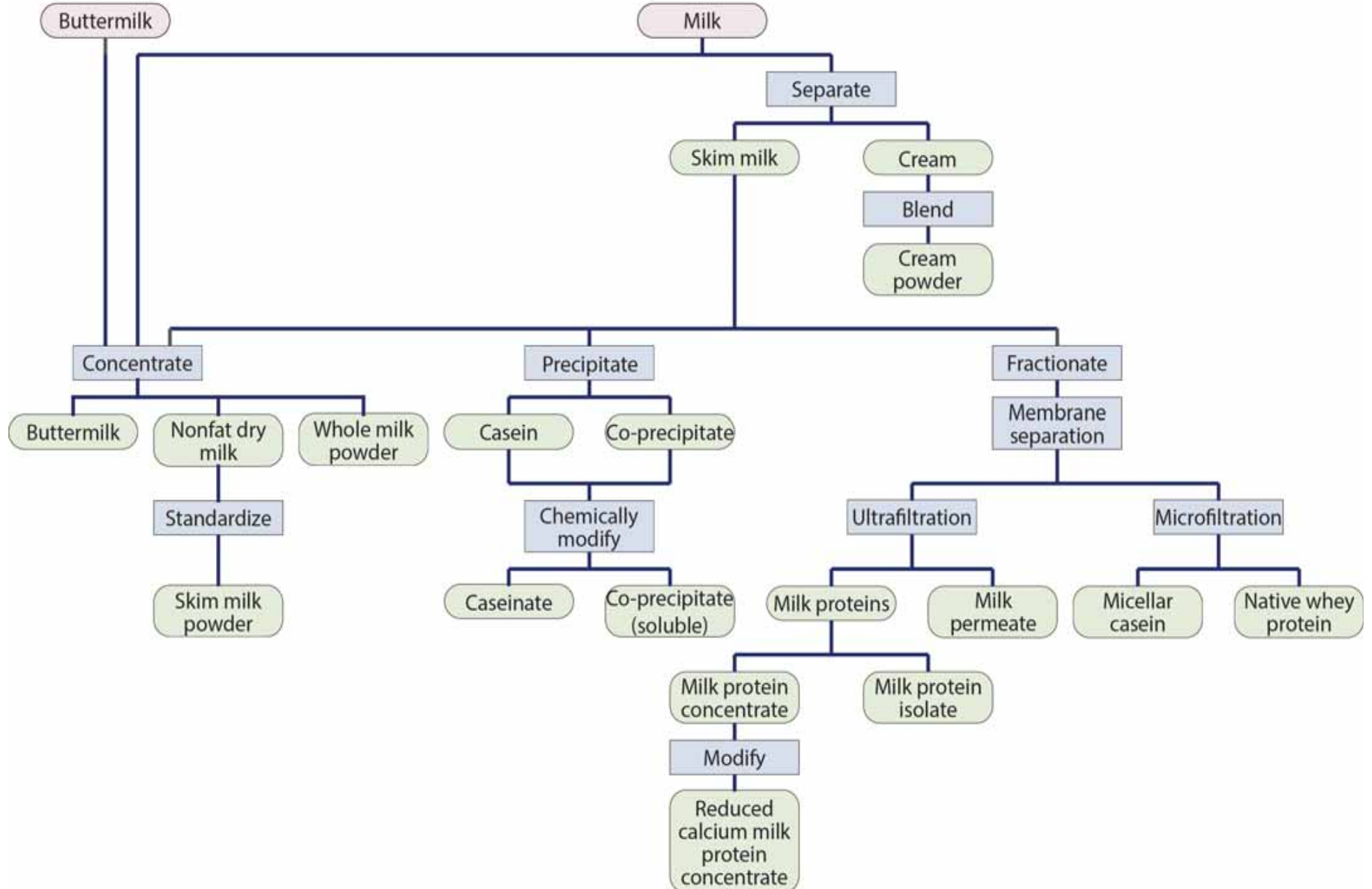
Galacto-oligosaccharides (GOS)

Lactose

- ◆ Food
- ◆ Pharmaceutical

Dairy minerals

Manufacturing Dairy Ingredients from Milk



Milk Powder

Milk powders are skim milk, whole milk or buttermilk with only water removed. All of the original constituents except water are present in their original ratios.

Note: The terms nonfat dry milk and skim milk powder are often used interchangeably but they are defined by two different sets of regulations and authorities. Nonfat dry milk is defined by FDA/USDA and skim milk powder is defined by Codex Alimentarius. Dry whole milk and whole milk powder also are used interchangeably but again are defined by two different sets of regulations and authorities. FDA/USDA defines and regulates dry whole milk while Codex Alimentarius defines and regulates whole milk powder.

Heat treatment of nonfat dry milk

Nonfat dry milk (NFDM, NDM), also known as skim milk powder (SMP), may receive a heat treatment in addition to pasteurization.

The heat treatment alters the functional properties of NFDM. Whey protein nitrogen index (WPNI) is a measure of the amount of heat treatment the powder has received. Whey proteins are denatured or altered by heat. The test measures the amount of undenatured whey protein present in the powder. Lower levels of undenatured whey protein in the powder indicate exposure to higher temperatures.

WPNI does not indicate the heat stability of the powder.

Low heat powder will have < 25% of the whey protein denatured while > 81% of the whey proteins are denatured in high heat powder.

Type of dryer used

Milk powder functionality is affected by the type of dryer used.

Majority of milk powder is produced by spray drying which is a less severe process than roller drying.

Roller drying milk powder is relatively uncommon because of the amount of protein denaturation that results. Roller dried product will have a flaked appearance, browner color and more cooked flavor compared to sprayed dried powder.

Final form of the powder

Agglomeration is used to increase particle size and is a step in the instantizing process.

Instantizing improves the ability of powder to disperse and dissolve quickly. Lecithin may be added to whole milk or buttermilk powder to improve the ability of higher fat products to go into solution.

Agglomeration and instantizing do not improve powder solubility. Rather they increase the rate of powder dispersing and dissolving. Powder that is insoluble will not be made soluble if agglomerated or instantized.

Agglomerated/instantized powder will have a shorter shelf life as compared to ordinary powder because of the additional heat treatment used during manufacture.

Types

- ♦ Nonfat
- ♦ Whole
- ♦ Buttermilk

Grades

- ♦ Extra grade
- ♦ Standard grade
- ♦ Grade not assignable

Pre-heat treatments (nonfat)

- ♦ Low heat
- ♦ Medium heat
- ♦ High heat

Dryer used

- ♦ Roller
- ♦ Spray

Final form

- ♦ Ordinary (non-agglomerated, non-instant)
- ♦ Agglomerated
- ♦ Instantized

Regulations

- ♦ Nonfat dry milk
21 CFR 131.125

United States Standards for Grades of Nonfat Dry Milk
(Spray Process)
USDA, AMS - Dairy Division, February 2, 2001

United States Standards for Grades of Nonfat Dry Milk
(Roller Process)
USDA, AMS - Dairy Division, May 18, 1984

United States Standards for Grades of Instant Nonfat
Dry Milk
USDA, AMS - Dairy Division, February 2, 2001

- ♦ Skim milk powder
Codex Stan 207-1999

- ♦ Dry whole milk
21 CFR 101.4 (b)(4)

United States Standards for Grades of Dry Whole Milk
USDA, AMS - Dairy Division, April 13, 2001

- ♦ Whole milk powder
Codex Stan 207-1999

- ♦ Buttermilk
21 CFR 101.4 (b)(6)

United States Standards for Grades of Dry Buttermilk and
Dry Buttermilk Product
USDA, AMS - Dairy Division, February 2, 2001

Milk Powder Definitions

(summarized from Code of Federal Regulations)

Nonfat dry milk (NFDM, NDM) is the product obtained by removal of water only from pasteurized skim milk. It contains not more than 5% by weight moisture, and not more than 1.5% by weight milk fat unless otherwise indicated. Product also may be known as skim milk powder (SMP).

Dry whole milk (DWM) is the product resulting from the removal of water from pasteurized milk and contains by weight not less than 26%, but less than 40% milk fat and not more than 5% by weight of moisture. It contains lactose, milk proteins, milk fat and milk minerals in the same proportions as the milk from which it was made.

Dry buttermilk (DBM) is obtained by removing water from liquid buttermilk derived from the churning of butter. It shall contain not less than 4.5% milkfat and not more than 5% moisture. It shall have a protein content of not less than 30%.

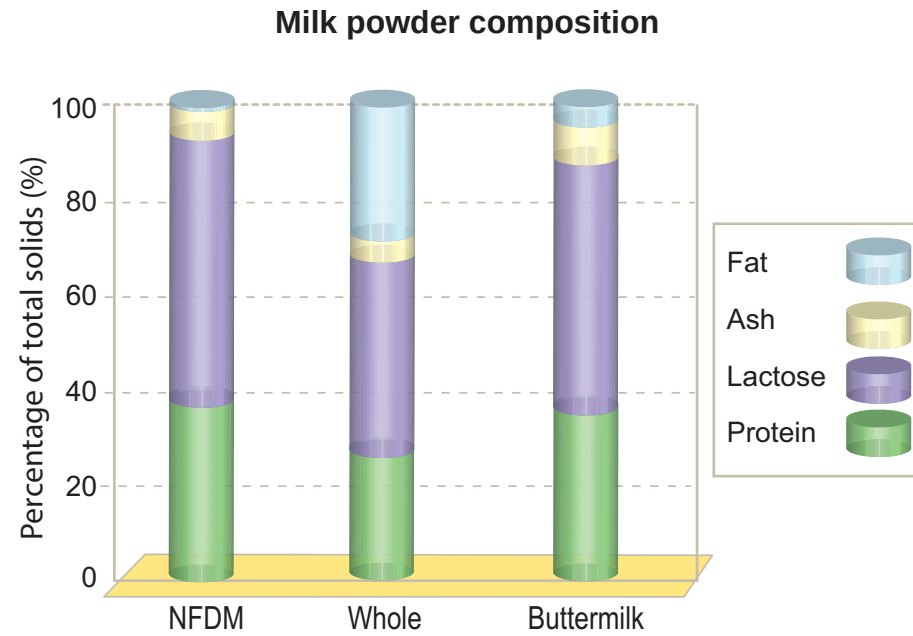
The phospholipid and total lipid content of dried buttermilk is higher than NFDM. It may not contain or be derived from, skim milk powder, dry whey or products other than buttermilk, and contains no added preservative, neutralizing agent or other chemicals.

Dry buttermilk product (DBP) shall contain not less than 4.5% milkfat and not more than 5% moisture. Dry buttermilk product contains less than 30% protein and the label should specify the minimum protein content.

Additional ADPI Definitions

Instant nonfat dry milk (INDM) is nonfat dry milk which has been produced in a manner to substantially improve its dispersing and reconstitution characteristics. INDM for human consumption complies with all provisions of the U.S. Federal Food, Drug, and Cosmetic Act.

Reduced Fat Milk Powder is the product resulting from the partial removal of fat and water from pasteurized milk. The fat and/or protein content of the milk may have been adjusted, only to comply with the compositional requirements below, by the addition and/or withdrawal of milk constituents in such a way as not to alter the whey protein to casein ratio of the milk being adjusted.



General composition of milk powders			
Component	Skim	Whole	Buttermilk
	----- % -----		
Total protein	36.0	26.0	34.0
Lactose	51.0	37.0	48.5
Ash	8.2	6.0	8.5
Fat	0.8	27.0	5.0
Moisture	4.0	4.0	4.0

Classification of nonfat dry milk*

Category	Typical processing treatment			WPNI (mg/g undenatured whey protein)
	Temperature (°C)	Temperature (°F)	Time (minutes)	
Low-heat	70	158	2	> 6.0
Medium-heat	70 - 78	158 - 172	20	1.51 - 5.99
High-heat	88	190	30	< 1.50

* USDA Dairy Standards for grades of nonfat dry milk (spray process)

Specifications for US Grades of nonfat dry milk (spray)*

Component	Extra	Standard	Instant extra
	----- not greater than -----		
Milkfat	1.25%	1.5%	1.25%
Moisture	4.0%	5.0%	4.5%
Titratable acidity	0.15%	0.17%	0.15%
Solubility index	1.2 ml**	2.0 ml***	1.0 ml
Scorched particles	15.0 mg	22.5 mg	15 mg
Bacteria	10,000/g	75,000/g	10,000/g
Coliforms	10/g	10/g	10/g

* USDA Dairy Standards for grades of nonfat dry milk (spray process)

** Except high heat not greater than 2.0

*** Except high heat not greater than 2.5

Specifications for US Grades of nonfat dry milk (roller)*

Component	Extra	Standard
	----- not greater than -----	
Milkfat	1.25%	1.5%
Moisture	4.0%	5.0%
Titratable acidity	0.15%	0.17%
Solubility index	15.0 ml	15.0 ml
Scorched particles	22.5 mg	32.5 mg
Bacteria	50,000/g	100,000/g
Coliforms	10/g	10/g

* USDA Dairy Standards for grades of nonfat dry milk (roller process)

Specifications for US Grades of dry whole milk (spray)*

Component	Extra	Standard
Milkfat	≥ 26% but < 40%	≥ 26% but < 40%
	----- not greater than -----	
Moisture**	4.5%	5.0%
Titratable acidity	0.15%	0.17%
Solubility index	1.0 ml	1.5 ml
Scorched particles	15.0 mg	22.5 mg
Bacteria	10,000/g	50,000/g
Coliforms	10/g	10/g

* USDA Dairy Standards for grades of dry whole milk

** As determined by weight of moisture on a milk solids-not-fat basis

Specifications for US Grades of dry whole milk (roller)*

Component	Extra	Standard
Milkfat	≥ 26% but < 40%	≥ 26% but < 40%
	----- not greater than -----	
Moisture**	4.5%	5.0%
Titratable acidity	0.15%	0.17%
Solubility index	15.0 ml	15.0 ml
Scorched particles	22.5 mg	32.5 mg
Bacteria	10,000/g	50,000/g
Coliforms	10/g	10/g

* USDA Dairy Standards for grades of dry whole milk

** As determined by weight of moisture on a milk solids-not-fat basis

Specifications for US Grades of dry buttermilk (spray)*

Component	Extra		Standard	
	not less than	not greater than	not less than	not greater than
Milkfat	4.5%	-	4.5%	-
Protein	30.0%	-	30.0%	-
Moisture	-	4.0%	-	5.0%
Titrateable acidity	0.10%	0.18%	0.10%	0.20%
Solubility index	-	1.25 ml	-	2.0 ml
Scorched particles	-	15.0 mg	-	22.5 mg
Bacteria	-	20,000/g	-	75,000/g
Coliforms	-	10/g	-	10/g

* USDA Dairy Standards for grades of dry buttermilk and dry buttermilk product

Specifications for US Grades of dry buttermilk product (spray)*

Component	Extra		Standard	
	not less than	not greater than	not less than	not greater than
Milkfat	4.5%	-	4.5%	-
Protein	-	30.0%	-	30.0%
Moisture	-	4.0%	-	5.0%
Titrateable acidity	0.10%	0.18%	0.10%	0.20%
Solubility index	-	1.25 ml	-	2.0 ml
Scorched particles	-	15.0 mg	-	22.5 mg
Bacteria	-	20,000/g	-	75,000/g
Coliforms	-	10/g	-	10/g

* USDA Dairy Standards for grades of dry buttermilk and dry buttermilk product

Specifications for US Grades of dry buttermilk (roller)*

Component	Extra		Standard	
	not less than	not greater than	not less than	not greater than
Milkfat	4.5%	-	4.5%	-
Protein	30.0%	-	30.0%	-
Moisture	-	4.0%	-	5.0%
Titrateable acidity	0.10%	0.18%	0.10%	0.20%
Solubility index	-	15.0 ml	-	15.0 ml
Scorched particles	-	22.5 mg	-	32.5 mg
Bacteria	-	20,000/g	-	75,000/g
Coliforms	-	10/g	-	10/g

* USDA Dairy Standards for grades of dry buttermilk and dry buttermilk product

Specifications for US Grades of dry buttermilk product (roller)*

Component	Extra		Standard	
	not less than	not greater than	not less than	not greater than
Milkfat	4.5%	-	4.5%	-
Protein	-	30.0%	-	30.0%
Moisture	-	4.0%	-	5.0%
Titrateable acidity	0.10%	0.18%	0.10%	0.20%
Solubility index	-	15.0 ml	-	15.0 ml
Scorched particles	-	22.5 mg	-	32.5 mg
Bacteria	-	20,000/g	-	75,000/g
Coliforms	-	10/g	-	10/g

* USDA Dairy Standards for grades of dry buttermilk and dry buttermilk product

Skimmed Milk Powder (SMP)

Skimmed milk powder is defined by Codex Alimentarius. The Codex Alimentarius Commission was created in 1963 by the Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO) to develop food standards, guidelines and related texts such as codes of practice under the Joint FAO/WHO Food Standards Programme. The main purposes of this Programme are protecting health of the consumers and ensuring fair trade practices in the food trade, and promoting coordination of all food standards work undertaken by international governmental and non-governmental organizations.

Codex definitions and specifications for SMP differ from US standards for NFDM. Whole milk powder and partly skimmed milk powder also are defined by Codex.

An important difference between Codex and US standards is the adjustment of protein levels. Codex allows the protein content of milk powder to be adjusted through the addition of milk retentate, milk permeate or lactose. The protein content of SMP typically is lower than the protein content of NFDM.

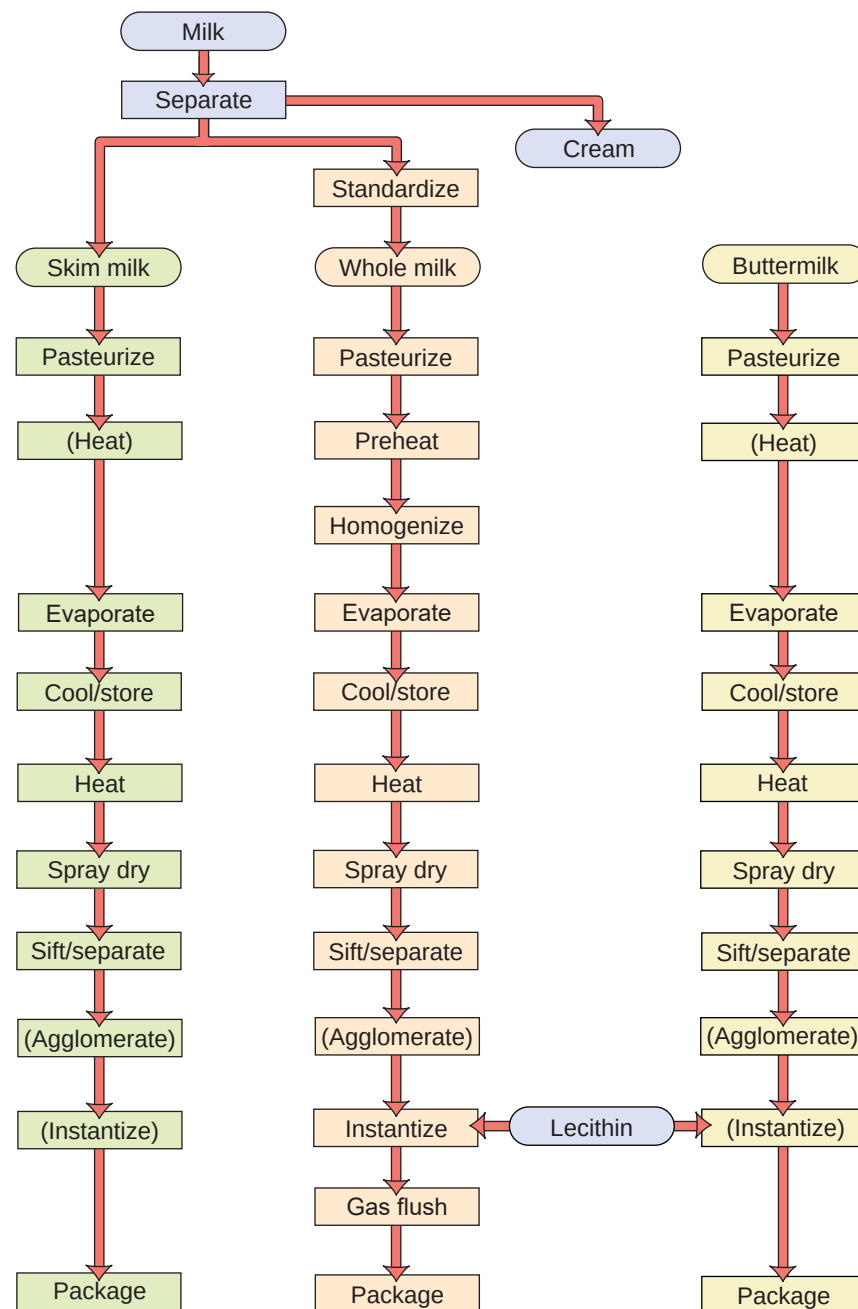
Codex specifications for milk powders*

Component	Skimmed	Partly skimmed	Whole
Milkfat	< 1.5%	≥ 1.5% but < 26%	≥ 26% but < 42%
Protein**	> 34%	> 34%	> 34%
----- maximum -----			
Moisture	5%	5%	5%
Titrateable acidity	0.18%	0.18%	0.18%
Solubility index	1.0 ml	1.0 ml	1.0 ml
Scorched particles	15.0 mg	15.0 mg	15.0 mg

* Codex Stan 207-1999

** Milk protein as determined on a milk solids-not-fat basis

Manufacture of Milk Powder



Typical composition and characteristics

Nonfat dry milk

♦ Typical composition	♦ Characteristics
Protein (db) 37.3%	Color: white to light cream
Moisture 3.5%	Flavor: clean, dairy
Lactose 51%	Titrateable acidity <0.14%
Fat 1%	Solubility index
Ash 8.5%	Instant 1.0 ml
♦ Storage	Low heat spray 1.2 ml
<27 C, <65% rh	High heat spray 2.0 ml
12 – 18 months	Roller dried 15.0 ml
6 – 12 months (instant)	Scorch particle content
	Spray dried <15 mg
	Roller dried <22.5 mg

Whole milk

♦ Typical composition	♦ Characteristics
Protein (db) 26.8%	Color: white to light cream
Moisture 3%	Flavor: clean, dairy
Lactose 38%	Titrateable acidity <0.15%
Fat 27%	Solubility index
Ash 6%	Spray dried 1.25 ml
♦ Storage	Roller dried 15.0 ml
<27 C, <65% rh	Scorch particle content
6 – 9 months	Spray dried <15 mg
Shelf life very dependent on storage conditions	Roller dried <22.5 mg

Buttermilk

♦ Typical composition	♦ Characteristics
Protein (db) 34.4%	Color: uniform cream to dark
Moisture 4%	Flavor: clean, dairy
Lactose 48%	Titrateable acidity 0.10 – 0.18%
Fat 6.5%	Solubility index
Ash 8.5%	Spray dried 1.25 ml
♦ Storage	Roller dried 15.0 ml
<27 C, <65% rh	Scorch particle content
6 – 9 months	Spray dried <15 mg
Shelf life very dependent on storage conditions	Roller dried <22.5 mg

Cream

Dry cream products have fat contents greater than whole milk powders. Drying high fat products can be difficult and may require the addition of other ingredients to keep the fat globules in a stable emulsion. The fat typically must be emulsified or encapsulated, often with milk proteins, before cream can be dried successfully. If the fat is not encapsulated properly the resulting powder will stick to dryer surfaces and powder handling equipment.

The information provided here is a general outline given the process for drying cream can vary significantly depending on the end use of the powder.

Cream powder results from the removal of water from pasteurized cream. The fat and/or protein content of the cream may be adjusted but only if needed to comply with the compositional requirements of the CFR. Milk constituents may be added or removed as long as the whey protein to casein ratio of the cream is not altered.

Dry Cream Definition

(summarized from Code of Federal Regulations)

Dry cream is the product obtained by removal of water only from pasteurized milk or cream or a mixture thereof, which may have been homogenized. Alternatively, dry cream may be made by blending dry milk with dry cream provided that the resulting product is equivalent in composition to dry cream made by the water removal method. Dry cream contains not less than 40% but less than 75% by weight milkfat on an as is basis and not more than 5% by weight moisture on a milk solids not fat basis.

Optional ingredients include emulsifiers, stabilizers, anticaking agents, antioxidants, nutritive carbohydrate sweeteners and flavoring agents (with and without coloring)

Dry Cream Definition

(summarized from Codex)

Cream powder can be obtained by the partial removal of water from cream. The fat and/or protein content of the cream may have been adjusted, only to comply with the compositional requirements. Addition and/or withdrawal of milk constituents must be done in such a way as not to alter the whey protein casein ratio of the milk

Codex permits the use of the following products for standardization of dry cream:

- Milk retentate
- Milk permeate
- Lactose

ADPI Dry Cream Definition

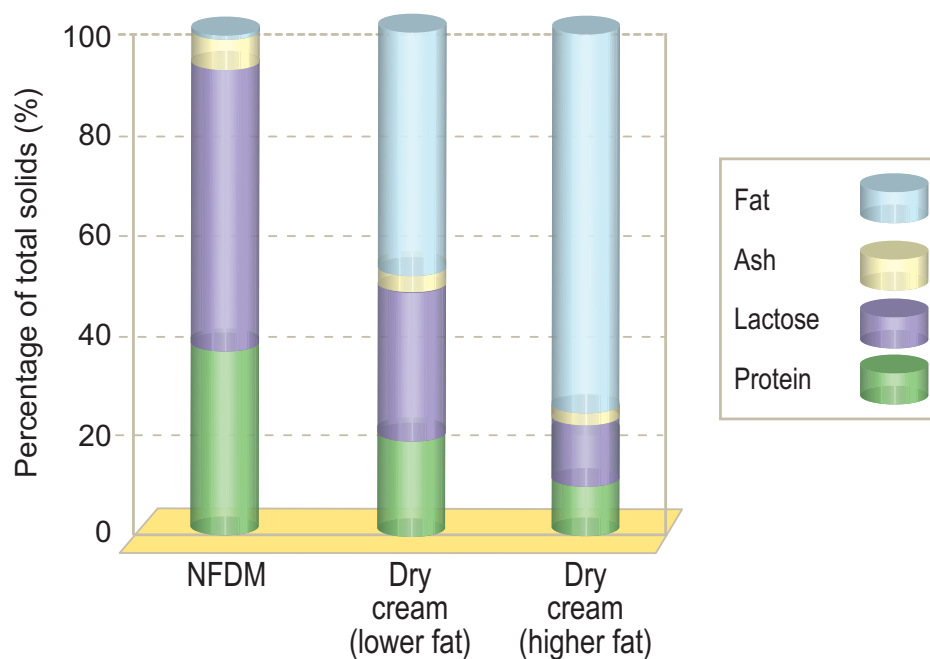
Cream powder is the product resulting from the partial removal of water from pasteurized cream. The fat and/or protein content of the cream may have been adjusted, only to comply with the compositional requirements below, by the addition and/or withdrawal of milk constituents in such a way as not to alter the whey protein to casein ratio of the cream being adjusted.

Regulations

- ♦ 21 CFR 131.149
- ♦ Codex Stan 207-1999

ADPI Industry Standard

General composition of dry cream



CFR specifications for dry cream*

Component	Dry cream	
	not less than	not greater than
Milkfat	40%	75%
Moisture	-	5.0%

* 21 CFR 131.149

Codex specifications for dry cream*

Component	Dry cream	
	not less than	not greater than
Milkfat	42%	-
Protein**	34%	-
Moisture	-	5.0%

* Codex Stan 207-1999

** Protein in milk-solids-not-fat basis

General composition of dry cream

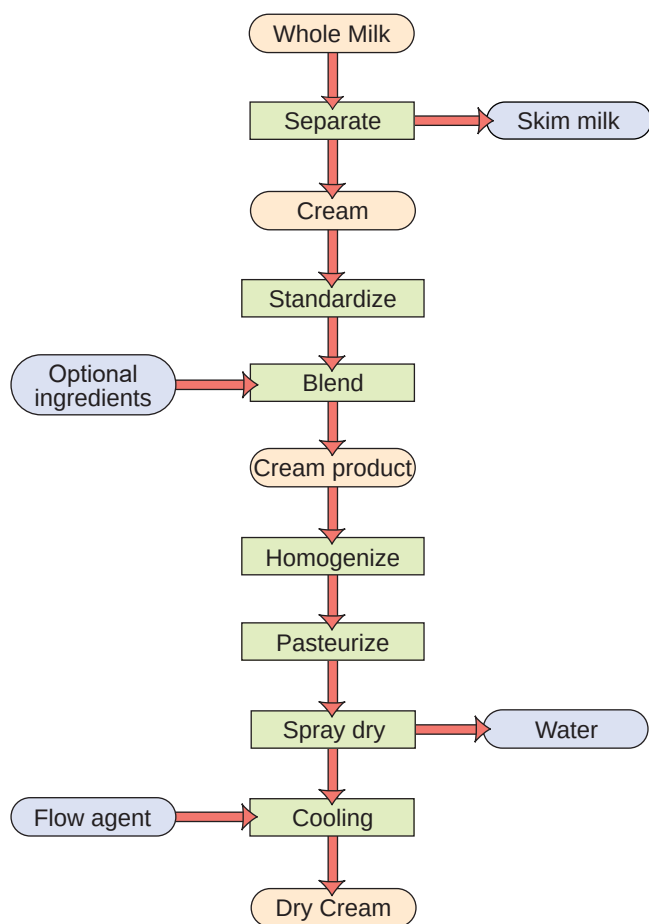
Component	Dry cream
	----- % -----
Protein	na
Lactose	40 - 75
Ash	na
Fat	na
Moisture	5

ADPI industry standard for dry cream

Component	Dry cream	
	not less than	not greater than
Milkfat	42%	-
Protein*	34%	-
Moisture	-	5.0%

* Protein on milk-solids-not-fat basis

Manufacture of Dry Cream



Typical composition and characteristics

Dry cream*

- ♦ Typical composition

Protein (db)	na%
Moisture	3%
Lactose	na%
Fat	72%
Ash	na%
- ♦ Characteristics
 - Color: light cream
 - Flavor: sweet cream
 - TA <0.18%
- ♦ Storage
 - <27 C, <70% rh
 - 12 months

*Exact composition depends on manufacturer

CFR Product Labeling

Dry cream (Contains ____ % milkfat)

The percent fat is given as the whole number closest to the actual fat content of the product.

Codex Product Labeling

Cream powder

Colostrum

Colostrum is the milk that comes from cows within 48 hours of giving birth. Colostrum is a concentrated source of biologically active compounds that are needed to promote the health and growth of the calf.

The composition of colostrum is highly variable. The individual cow, breed, nutrition and length of dry period are a few of the factors that influence composition. In general, colostrum contains less lactose and more protein, peptides, non-protein nitrogen, minerals, vitamins and bioactive compounds than regular milk.

Some of the components of colostrum that often are of interest from the standpoint of health and wellness include:

- Cytokines - small proteins that are involved in the generation of special types of white blood cells and directing the white blood cells to injury sites.
- Thymosin - a hormone that works with the thymus gland to maintain the immune system.
- Proline-rich peptide - acts upon the thymus gland to regulate response to injury.
- Immunoglobulins (IgG, IgM, IgA) - are a group of proteins known as antibodies that protect against bacteria and viruses.
- Transfer factors - small proteins that work in concert with white blood cells to control unwanted bacteria.
- Lactoferrin - an iron binding protein that can inhibit the growth of certain bacteria such as *E. coli*.
- Transferrin - another iron binding protein that works with lactoferrin to inhibit growth of certain bacteria.
- Lysozyme - an enzyme that can kill certain disease causing bacteria.
- Lactoperoxidase - an enzyme similar to lysozyme.
- Oligosaccharides - complex carbohydrates that limit the attachment of microorganisms to the intestine.
- Insulin-like growth factors (IGFs) - hormones involved in the growth and reproduction of cells.
- Mineral binding proteins - examples are lactoferrin and transferrin which can bind minerals such as iron making the iron more readily absorbed by the body.

Skim colostrum powder (ADPI definition) - is obtained by the partial removal of fat and water from colostrum that comes from cows within 48 hours after giving birth. It contains fat (<6%), proteins, carbohydrates, vitamins and minerals. Skim Colostrum Powder for human consumption complies with all provisions of the U.S. Federal Food, Drug and Cosmetic Act.

Whole colostrum powder (ADPI definition) - is obtained by the drying of colostrum that comes from cows within 48 hours after giving birth. It contains fat (>17.5%), proteins, carbohydrates, vitamins and minerals. Whole Colostrum Powder for human consumption complies with all provisions of the U.S. Federal Food, Drug and Cosmetic Act.

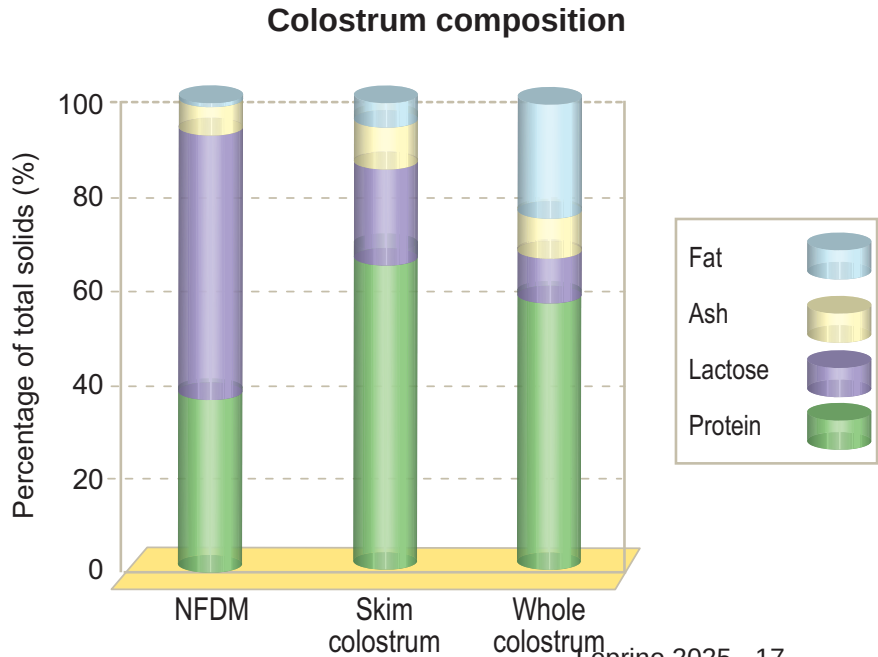
Types

- ♦ Skim colostrum (fat has been removed)
- ♦ Whole colostrum (fat has not been removed)

Regulations

- ♦ US Federal Food, Drug and Cosmetic Act

ADPI Industry Standard



Leprino 2025 - 17

Arla vs. Leprino

IPR2025-01199

General composition of colostrum

Component	Colostrum	
	Skim	Whole
	----- % -----	
Protein	62	50
Lactose	22	18
Ash	8	6
Fat	4	22
Moisture	4	4

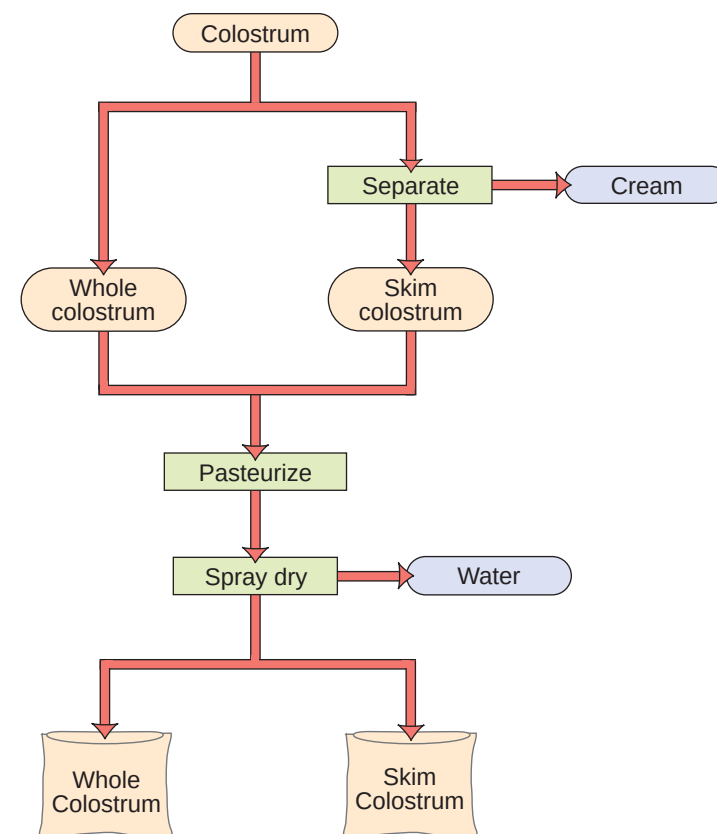
ADPI industry standard for skim colostrum

Component	Typical	Minimum	Maximum
	----- % -----		
Protein	62	50	-
Lactose	22	-	35.0
Ash	8	-	-
Fat	4	-	6.0
Moisture	4	-	6.0

ADPI industry standard for whole colostrum

Component	Typical	Minimum	Maximum
	----- % -----		
Protein	50	40	-
Lactose	18	-	35.0
Ash	6	-	-
Fat	22	17.5	-
Moisture	4	-	6.0

Manufacture of Whole and Skim Colostrum



Typical composition and characteristic
Not available

Casein

Casein is the major protein present in milk. Approximately 80% of the protein in milk is casein while whey proteins account for the remaining 20%.

Commercial casein is prepared from pasteurized skim milk. Acid or rennet is used to coagulate the casein. A washing step is included to remove impurities such as lactose and minerals and thereby increase shelf life of the product. The functional properties of the resulting casein will depend on the coagulation method used.

Casein isolated by coagulation is in a not native or non-micellar form and is not soluble. Additional treatments are required to convert the casein into caseinates which are soluble.

Types

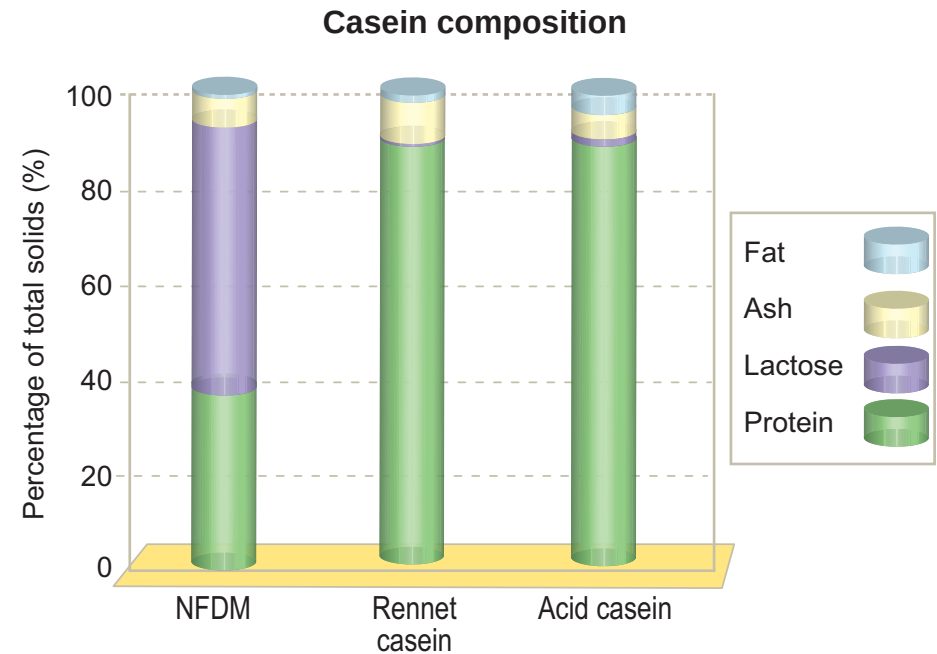
- ♦ Mineral acids
 - Hydrochloric
 - Sulfuric
 - Orthophosphoric
- ♦ Organic acids
 - Lactic
 - Produced by starter culture
 - Addition of lactic acid
 - Acetic
 - Citric
- ♦ Rennet

Dryer

- ♦ Roller
- ♦ Spray

Regulations

- ♦ Acid casein
 - United States Standards for Grades of Edible Dry Casein (Acid)
 - USDA, AMS - Dairy Division, July 20, 1968
 - Codex Stan A-18-1995 Rev 1-2001
- ♦ Rennet casein
 - Codex Stan A-18-1995 Rev 1-2001



General composition of casein

Component	Rennet	Acid
	----- % -----	
Protein	80.5	86.5
Lactose	0.5	0.5
Ash	8	2
Fat	1	1
Moisture	10	10
pH	7	5

Codex specifications for casein products*

Component	Rennet		Acid	
	not less than	not greater than	not less than	not greater than
Milkfat	-	2.0%	-	2.0%
Protein (db)	84.0%	-	90.0%	-
Casein in protein	95.0%	-	95.0%	-
Moisture	-	12.0%	-	12.0%
Lactose**	-	1.0%	-	1.0%
Ash	7.5%	-	-	2.5%
Titrateable acidity	-	-	-	0.27%
Scorched particles	-	15 mg	-	22.5 mg

* Codex Stan A-18 1995 Rev 1-2001

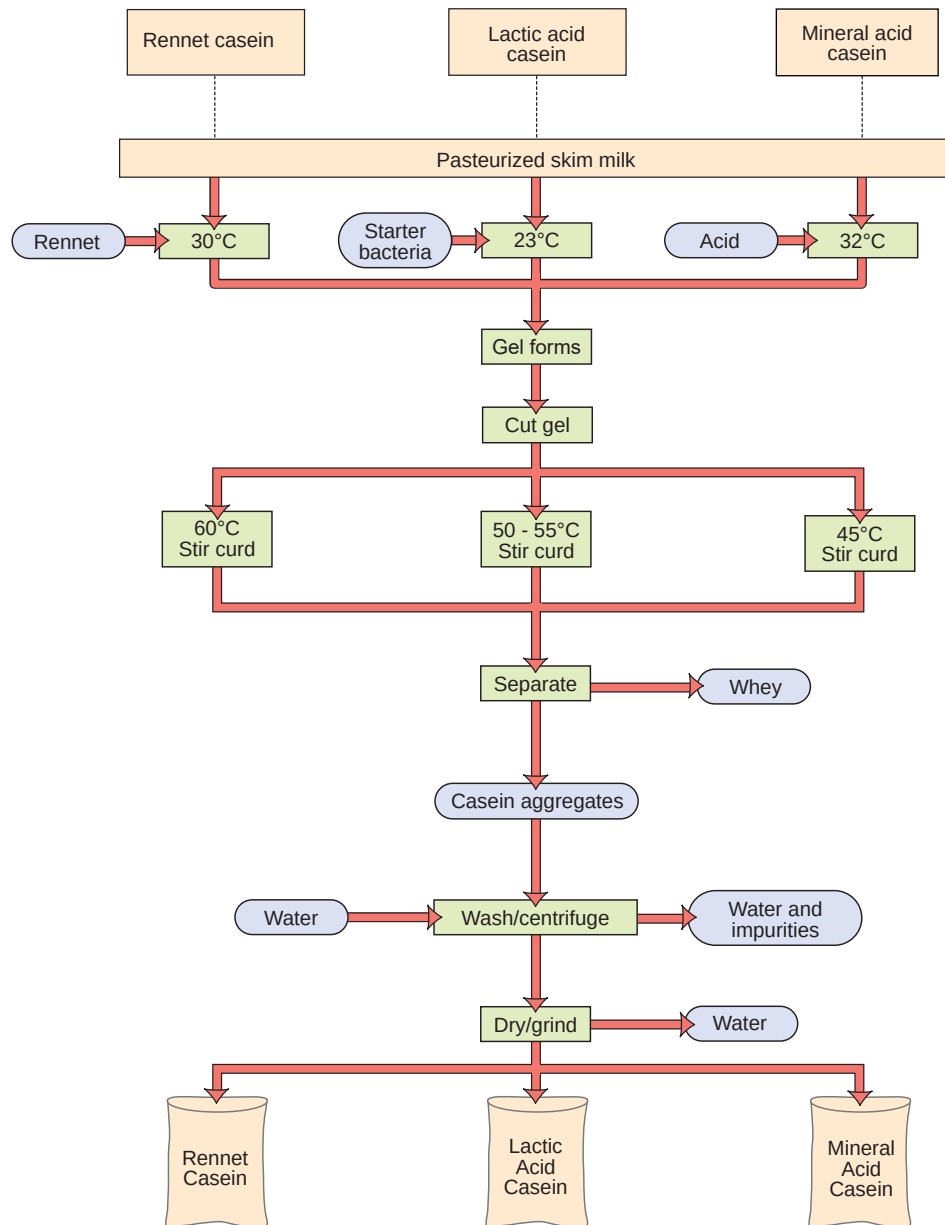
** Expressed in anhydrous form

Specifications for US Grades of acid casein*

Component	Extra	Standard
	----- not less than -----	
Protein (db)	95%	90%
	----- not greater than -----	
Milkfat	1.5%	2.0%
Moisture	10%	12%
Titrateable acidity	0.20%	0.27%
Scorched particles	15 mg	22.5 mg
Bacteria	30,000/g	100,000/g
Coliforms	none/0.1g	2/0.1g

* USDA Dairy Standards for grades of casein (acid)

Manufacture of Casein



Typical composition and characteristics

Rennet casein

♦ Typical composition

Protein (db)	90%
Moisture	10%
Lactose	0.5%
Fat	1%
Ash	8%

♦ Characteristics

Color: white to cream
Flavor: bland
pH 7

♦ Storage

<26 C, <65% rh
12 months

Acid casein

♦ Typical composition

Protein (db)	90%
Moisture	10%
Lactose	0.5%
Fat	2%
Ash	2.5%

♦ Characteristics

Color: white to cream
Flavor: bland
pH 4.6

♦ Storage

<26 C, <65% rh
18 months

Caseinate

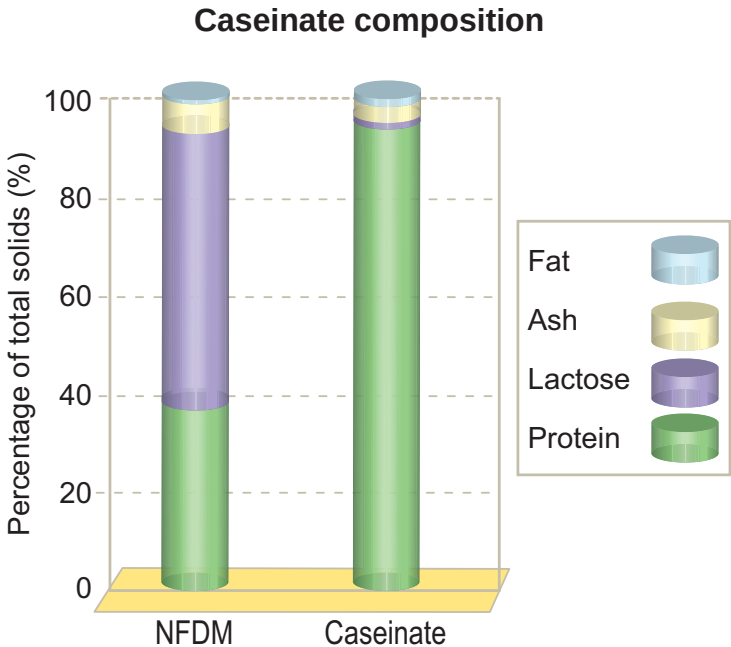
Acid or rennet casein are insoluble in water but they may be treated with alkali to make a caseinate which is soluble. The exact alkali used will determine the functional properties of the resulting caseinate.

Types

- ◆ Alkali used
 - Sodium hydroxide or carbonate
 - Potassium hydroxide
 - Calcium hydroxide
 - Ammonium hydroxide
- ◆ Dryer used
 - Roller dryer
 - Spray dryer
 - Extruded

Regulations

- ◆ Codex Stan A-18-1995 Rev 1-2001



General composition of caseinate

Component	Caseinate type		
	Potassium	Calcium	Sodium
	----- % -----		
Protein	88	88	88
Lactose	0.3	0.3	0.3
Ash	4.7	4.7	4.7
Fat	1.5	1.5	1.5
Calcium	0.2	1	0.2
Moisture	5.5	5.5	5.5
pH	6.5-7.0	6.5-7.0	6.5-7.0
Solubility	99	95	99

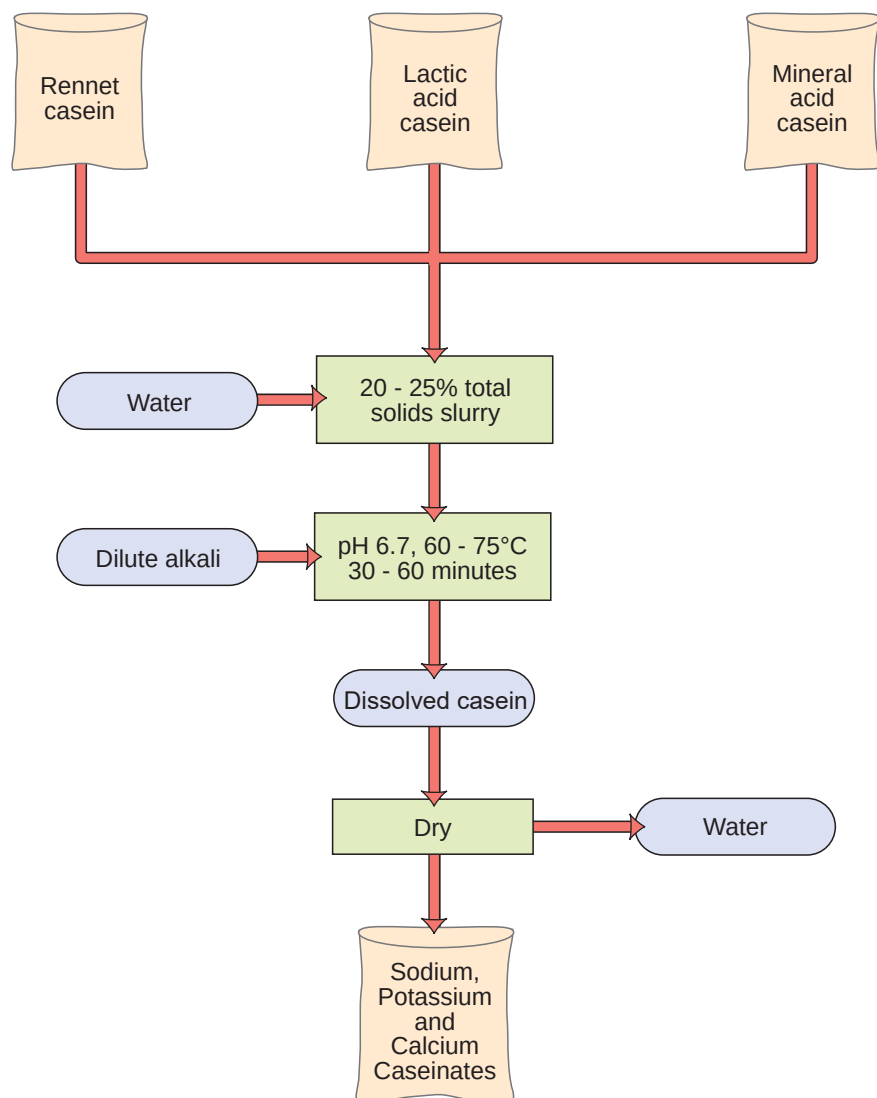
Codex specifications for caseinate*

Component	Caseinate	
	not less than	not greater than
Milkfat	-	2.0%
Protein (db)	88.0%	-
Casein in protein	95.0%	-
Moisture	-	8.0%
Lactose**	-	1.0%
Scorched particles	-	22.5 mg 81.5 mg
Spray	-	
Roller	-	
pH	-	8.0

* Codex Stan A-18-1995 Rev 1-2001

** Expressed in anhydrous form

Manufacture of Caseinate



Typical composition and characteristics

Potassium caseinate

- ♦ Typical composition

Protein (db)	92%
Moisture	6%
Lactose	<1%
Fat	2%
Ash	5%
Potassium	1.5%
Calcium	0.2%
- ♦ Characteristics
 - Color: white to cream
 - Flavor: bland
 - pH 6 - 7
- ♦ Storage
 - <25 C, <65% rh
 - 12 - 24 months

Calcium caseinate

- ♦ Typical composition

Protein (db)	91%
Moisture	6%
Lactose	<1%
Fat	1.5%
Ash	5%
Calcium	1.2%
- ♦ Characteristics
 - Color: white to cream
 - Flavor: bland
 - pH 6.6 - 7
- ♦ Storage
 - <25 C, <65% rh
 - 12 - 24 months

Sodium caseinate

- ♦ Typical composition

Protein (db)	92%
Moisture	6%
Lactose	<1%
Fat	1.5%
Ash	5%
Sodium	1.2%
Calcium	0.2%
- ♦ Characteristics
 - Color: white to cream
 - Flavor: bland
 - pH 6.6 - 7
- ♦ Storage
 - <26 C, <65% rh
 - 12 months

Ammonium caseinate

- ♦ Typical composition

Protein (db)	91%
Moisture	6%
Lactose	1%
Fat	1.5%
Ash	5%
- ♦ Characteristics
 - Color: white to cream
 - Flavor: bland
 - pH 5.7 - 6.7
- ♦ Storage
 - <25 C, <65% rh

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Arla vs. Leprino

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Co-precipitate

Co-precipitates consist of casein and whey protein complexes. Heat is used to cause the whey proteins and casein to interact. Acid or calcium salts then are used to precipitate the protein complexes.

Co-precipitates are classified according to their calcium content. The pH of the milk when the proteins coagulate determines the calcium content of the co-precipitate.

Co-precipitates are insoluble unless modified by alkali in a process similar to the conversion of casein into caseinates. Low and medium calcium co-precipitates can be converted into very soluble products. High calcium co-precipitates may not be converted into a completely soluble product. Functional properties of the soluble co-precipitate will depend on the calcium content.

Co-precipitates typically are not produced in the United States. Products similar to soluble co-precipitates produced outside of the United States include total milk protein (TMP™), soluble lacto-protein and milk proteinate.

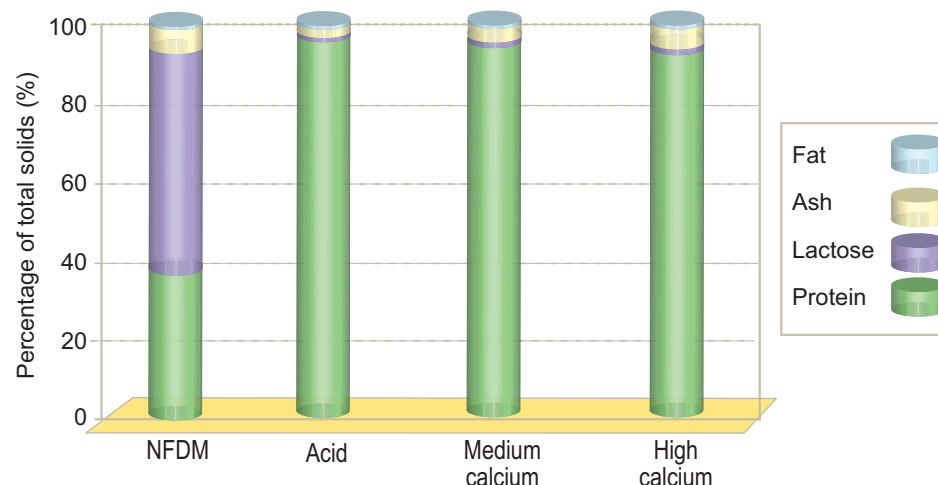
Types

- ♦ Acid
- ♦ Medium calcium
- ♦ High calcium

Regulations

- ♦ None, product not defined

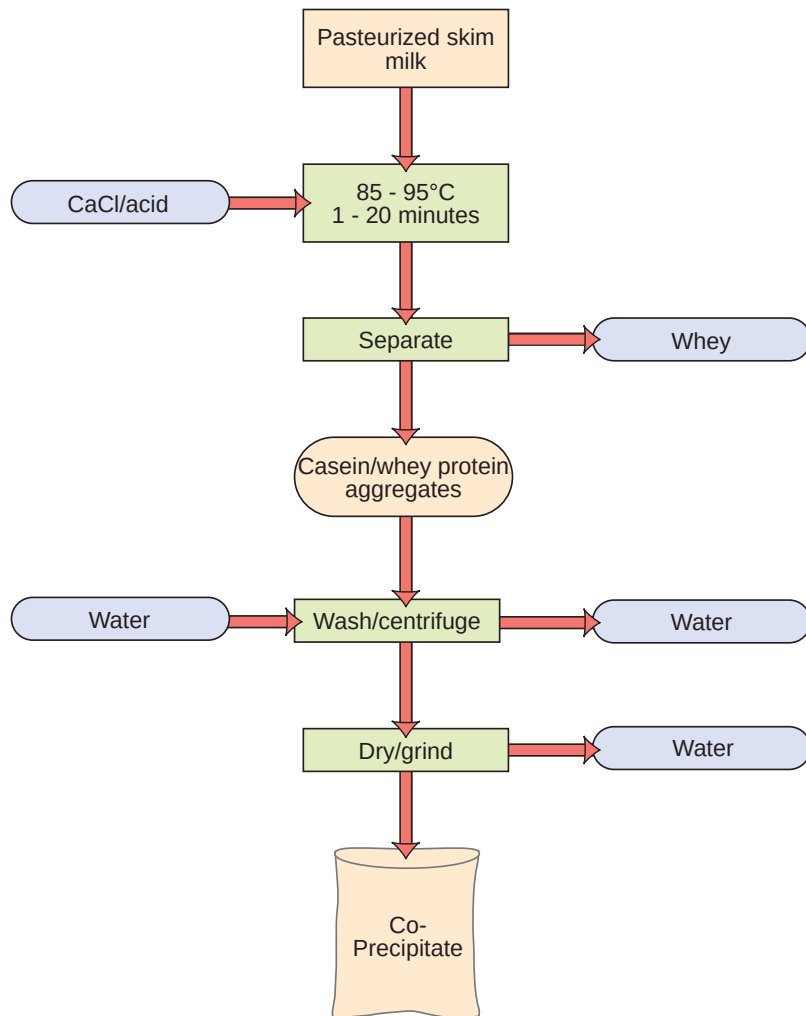
Co-precipitate composition



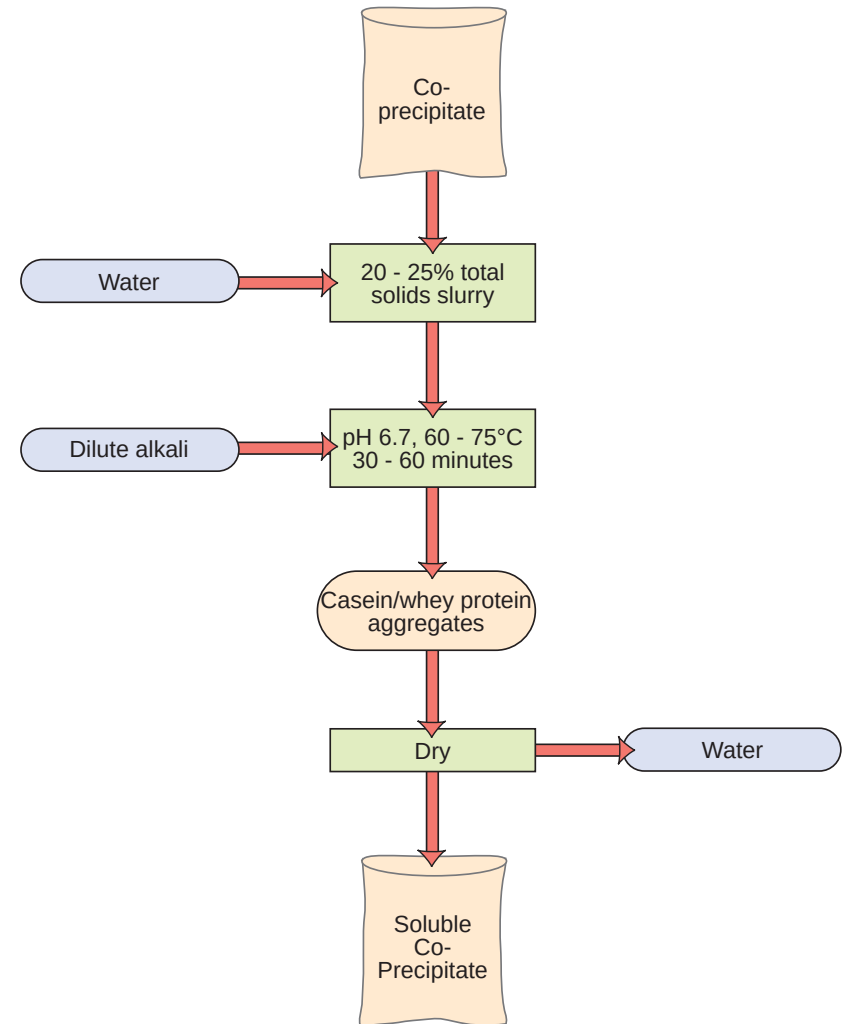
General composition of co-precipitate

Component	Co-precipitate type		
	Acid	Medium calcium	High calcium
	----- % -----		
Protein	86.7	85.6	81.7
Lactose	0.5	0.5	0.5
Ash	2.4	3.7	7.7
Fat	0.9	0.7	0.6
Moisture	9.5	9.5	9.5
Calcium	0.54	1.13	2.81
pH	5.4 - 5.8	5.6 - 6.2	6.5 - 7.2

Manufacture of Co-precipitate



Manufacture of Soluble Co-precipitate



Typical composition and characteristics

Not available

Milk Protein Concentrate (MPC) and Milk Protein Isolate (MPI)

Milk protein concentrates are not defined. For the purposes of this handbook, however, the following definitions will be used:

UF milk – liquid milk that has a portion of the lactose and mineral removed. The ratio of casein to whey protein is relatively unchanged from the original milk.

Milk protein concentrate (MPC) and Milk protein isolate (MPI) – the dry form of UF milk. MPCs typically range from 42 to 85% protein (dry basis). An MPC having 90% protein is referred to as a milk protein isolate (MPI).

MPCs/MPIs are produced by a pressure driven process using semipermeable membranes known as ultrafiltration (UF). Lactose and minerals are removed by UF until the desired protein content is reached. The portion that remains, that is, the concentrated protein fraction, is referred to as retentate, while the lactose and mineral stream is known as permeate.

Proteins are not denatured by the UF process, therefore, MPCs/MPIs are very soluble. Skim or whole milk may be used; however, MPCs/MPIs typically are produced with skim milk.

Concentrated Milk Proteins (ADPI definition) - are obtained by concentrating bovine skim milk through filtration processes so that the finished dry product contains 40% or more protein by weight. Concentrated Milk Protein products may be produced by filtration, dialysis or any other safe and suitable process by which all or part of the lactose and minerals may be removed. Products cannot be produced by combining separately produced casein (caseinate) and whey proteins.

Milk Protein Concentrate (MPC) (ADPI definition) - are produced by filtration methods (Ultrafiltration and Diafiltration) which capture essentially all the casein and whey proteins contained in the raw material stream in the finished product, resulting in a casein-to-whey protein ratio equivalent to that of the original milk, generally a value of 80:20. MPC has a protein content between 40 - 89.5%.

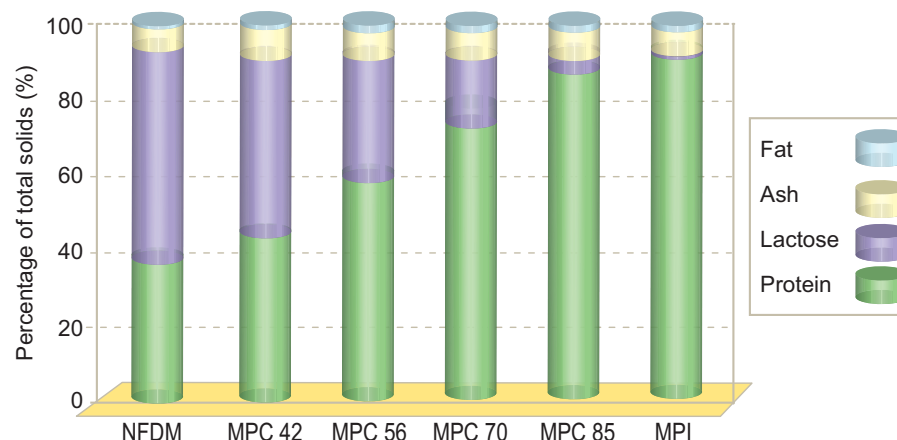
Milk Protein Isolate (MPI) (ADPI definition) - is produced by filtration methods (Ultrafiltration and Diafiltration) which capture essentially all the casein and whey proteins contained in the raw material stream in the finished product, resulting in a casein-to-whey protein ratio equivalent to that of the original milk, generally a value of 80:20. MPI has a minimum protein content of 89.5%.

Regulations

♦ None, product not defined

ADPI Industry Standard

MPC composition



General composition of MPC

	MPC 42	MPC 56	MPC 70	MPC 85	MPI
Component	----- % -----				
Protein	40.6	54.4	68.3	83.1	87.1
Lactose	45.5	31.7	18.2	3.5	0.5
Ash	7.9	7.6	7.3	6.9	5.9
Fat	0.9	1.2	1.2	1.5	1.5
Moisture	5	5	5	5	5

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ADPI industry standard for milk protein concentrate (MPC)/ milk protein isolate (MPI)

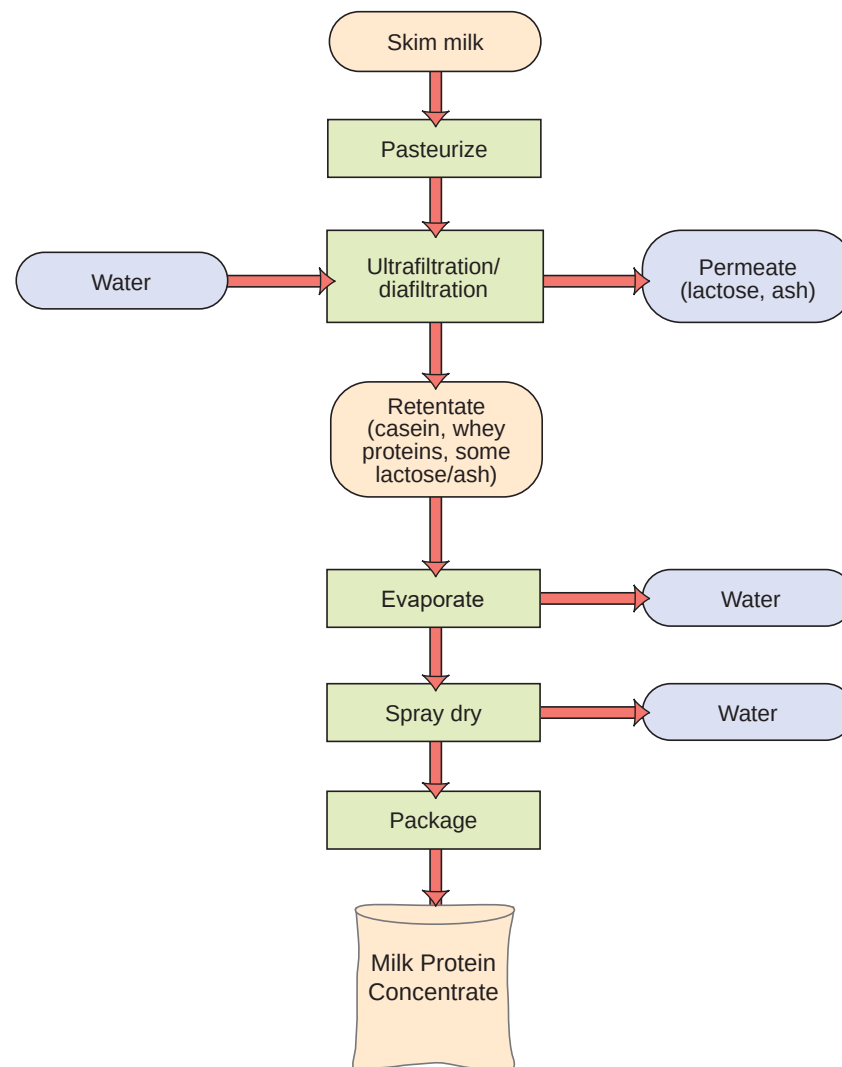
Component	Minimum/ maximum	MPC40	MPC42	MPC56	MPC70
		----- % -----			
Protein	minimum	39.5	41.5	55.5	69.5
Lactose	maximum	52.0	51.0	36.0	20.0
Ash	maximum	10.0	10.0	10.0	10.0
Fat	maximum	1.25	1.25	1.50	2.50
Moisture	maximum	5.0	5.0	5.0	6.0

ADPI industry standard for milk protein concentrate (MPC)/ milk protein isolate (MPI)

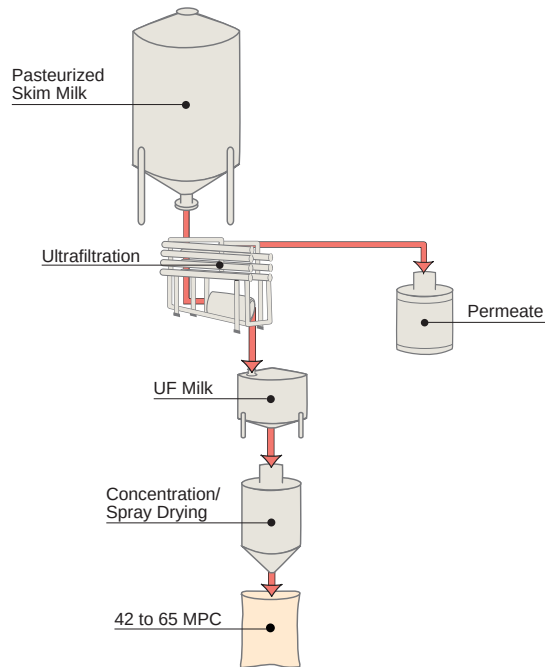
Component	Minimum/ maximum	MPC80	MPC85	MPI
		----- % -----		
Protein*	minimum	79.5	85.0	89.5
Lactose	maximum	9.0	8.0	5.0
Ash	maximum	8.0	8.0	8.0
Fat	maximum	2.50	2.50	2.50
Moisture	maximum	6.0	6.0	6.0

* Protein for MPC85 and MPI reported on a dry basis

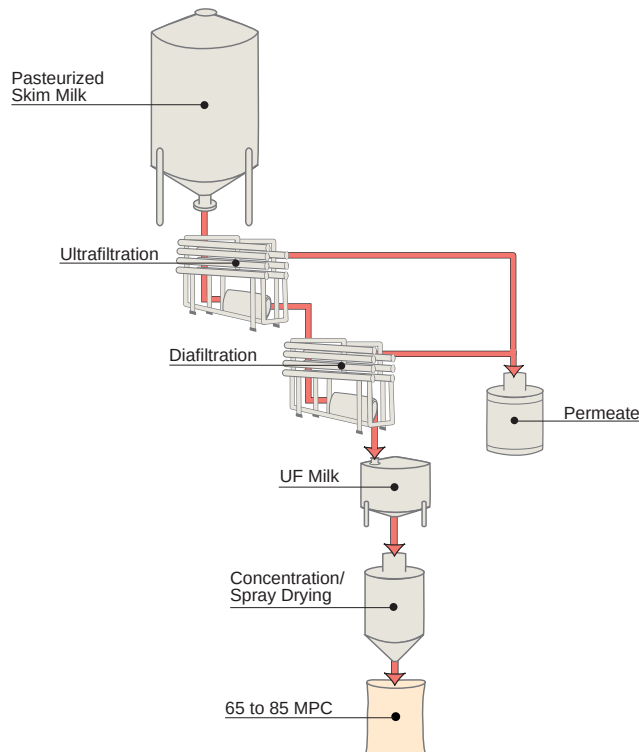
Manufacture of MPC



Manufacture of MPC 42 to 65



Manufacture of MPC 65 to 85



Typical composition and characteristics

MPC 42

- ♦ Typical composition

Protein (db)	42%
Moisture	5%
Lactose	46%
Fat	1%
Ash	8%
- ♦ Characteristics
 - Color: white to light cream
 - Flavor: clean, dairy
 - pH (5% solution) 6.5
- ♦ Storage
 - <25 C, <65% rh
 - 12 - 18 months

MPC 70

- ♦ Typical composition

Protein (db)	70%
Moisture	5%
Lactose	17%
Fat	1.4%
Ash	7%
- ♦ Characteristics
 - Color: white to light cream
 - Flavor: clean, dairy
 - pH (5% solution) 6.5
- ♦ Storage
 - <25 C, <65% rh
 - 12 - 18 months

MPC 85

- ♦ Typical composition

Protein (db)	85%
Moisture	5%
Lactose	3%
Fat	1.5%
Ash	7%
- ♦ Characteristics
 - Color: white to light cream
 - Flavor: clean, dairy
 - pH (5% solution) 6.5
- ♦ Storage
 - <25 C, <65% rh
 - 12 - 18 months

MPI

- ♦ Typical composition

Protein (db)	90%
Moisture	5%
Lactose	<1%
Fat	1.5%
Ash	6%
- ♦ Characteristics
 - Color: white to light cream
 - Flavor: clean, dairy
 - pH (5% solution) 6.5
- ♦ Storage
 - <25 C, <65% rh
 - 12 months

Reduced Calcium Milk Protein Concentrate

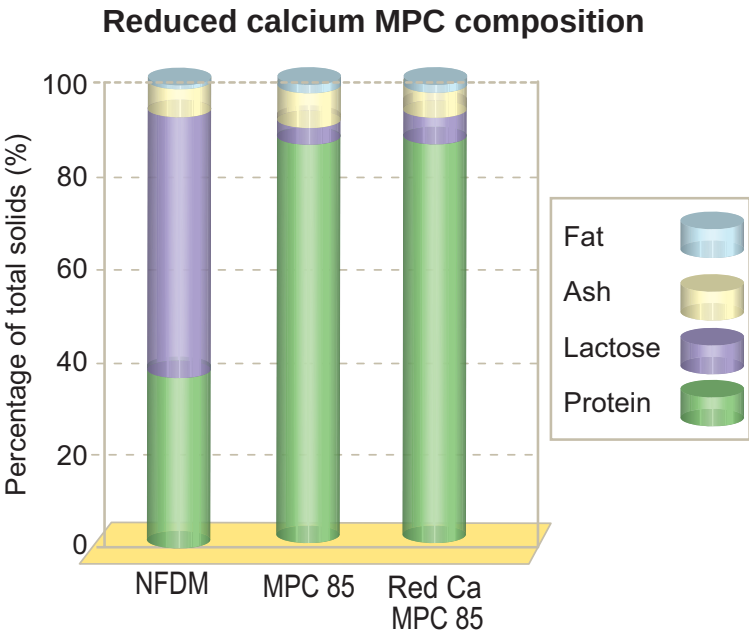
Reduced calcium milk protein concentrates are a relatively new dairy ingredient and are not defined.

A general process for manufacture of a reduced calcium MPC uses ultrafiltration to remove lactose and minerals until the desired protein content is reached in a process similar to that used to produce regular MPCs. Because calcium typically is associated with the casein micelle, calcium does not permeate readily and therefore calcium concentrations in MPCs do not decrease as might otherwise be expected. Reducing the pH of milk causes calcium to be released from the casein micelle. One method for reducing the calcium content of a MPC would be to lower the pH of the milk through addition of acid followed by ultrafiltration to remove lactose, minerals (including calcium).

Proteins are not denatured by the UF process, therefore, reduced calcium MPCs are very soluble. The ratio of casein to whey proteins also is not altered. The product claims greater heat stability and a longer shelf life as compared to a regular MPC.

Regulations

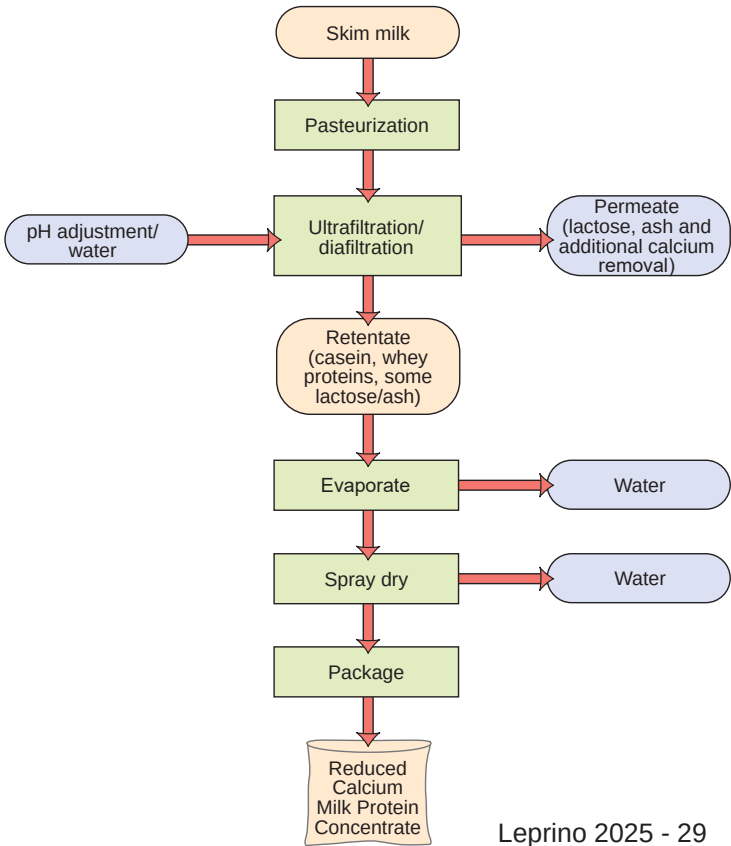
◆ None, product not defined



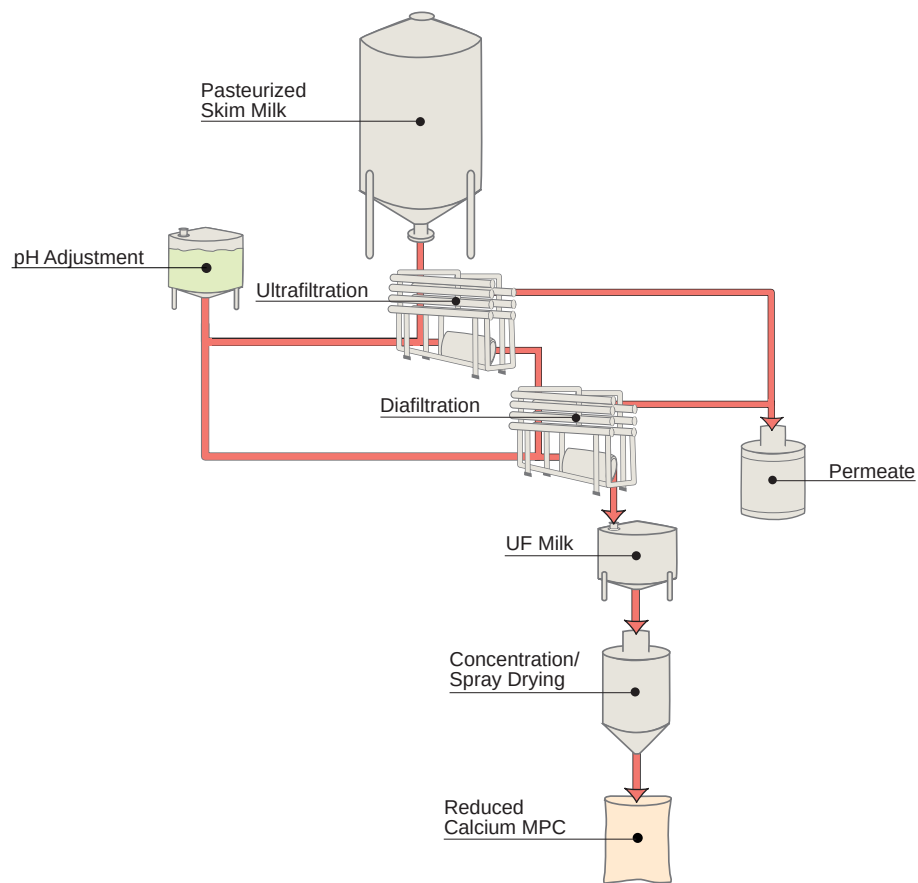
General composition of Reduced Calcium MPC

Component	MPC 85	Red Ca MPC 85
	----- % -----	
Protein	83.1	82
Lactose	3.5	5
Ash	6.9	6.4
Fat	1.5	1.3
Moisture	5	5.3
	----- mg/100g -----	
Calcium	2,200	1,750

Manufacture of Reduced Calcium MPC



Manufacture of Reduced Calcium MPC



Typical composition and characteristics

Reduced calcium MPC*

- ♦ Typical composition

Protein (db)	87%
Moisture	5%
Lactose	5%
Fat	1%
Ash	6%
- ♦ Characteristics
 - Color: white to light cream
 - Flavor: clean, sweet
 - pH 6.7
- ♦ Storage
 - Ambient, <65% rh
 - 24 months

*Exact composition depends on manufacturer

Milk Permeate

Milk permeate is not defined. For purposes of this handbook, however, the following definition will be used:

Milk permeate - portion of the milk that crosses or permeates an ultrafiltration (UF) membrane. Milk permeate contains lactose, minerals and nonprotein nitrogen (NPN). True protein typically is not present in significant amounts although some manufacturers include small molecular weight compounds that contain nitrogen as part of the protein content.

Milk permeate is a by product of MPC production.

Small molecular weight compounds such as galactose and lactic acid that are produced during cheese production are not present in milk permeate as compared to permeate produced from whey.

Manufacturers often do not distinguish permeate from milk as opposed to whey and unless listed otherwise it should be assumed that permeate is from whey rather than milk.

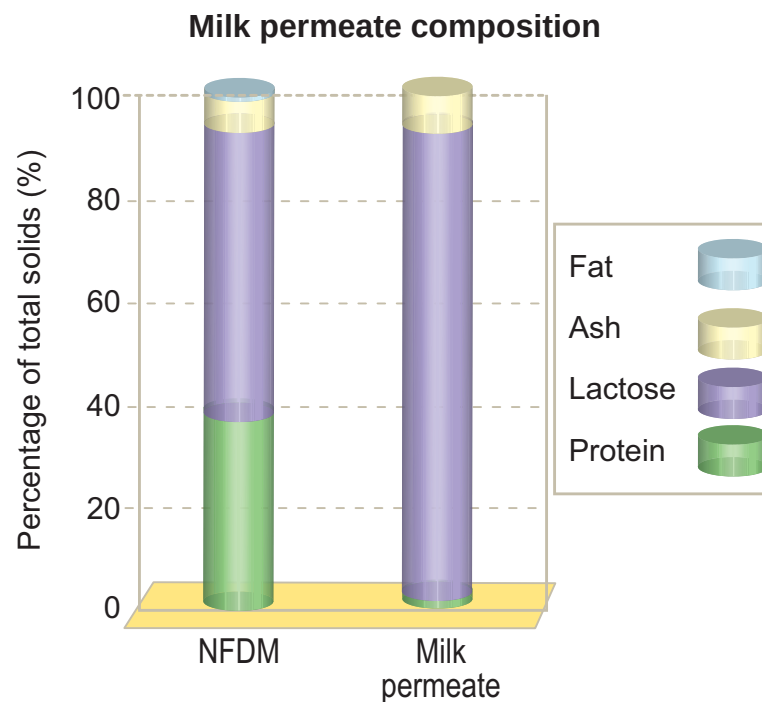
Product may be identified on the label as milk permeate or dairy product solids.

Dairy permeate (ADPI definition) - produced by the removal of protein and other solids from milk or whey resulting in a product with a high concentration of lactose. Removal of the dairy constituents is accomplished by physical separation techniques such as filtration and diafiltration. The acidity of Dairy Permeate may be adjusted by the addition of safe and suitable pH adjusting ingredients. Dairy Permeate meets the definition of Dairy Product Solids, which is the subject of a GRAS notification to the U.S. Food and Drug Administration and complies with all provisions of the U.S. Federal Food, Drug and Cosmetic Act.

Regulations

- ♦None, product not defined
- ♦GRAS status

ADPI Industry Standard
Codex Standard CXS 331-2017



General composition of milk permeate

Component	Milk permeate
	----- % -----
Protein	< 3
Lactose	85
Ash	9
Fat	0
Moisture	3

CODEX standard for permeate

Component	Minimum/ maximum	Dairy permeate	Milk permeate	Whey permeate
		----- % (m/m) -----		
Lactose, anhydrous	minimum	76.0	76.0	76.0
Nitrogen	maximum	1.1	0.8	1.1
Milk fat	maximum	1.5	1.5	1.5
Ash	maximum	14.0	12.0	12.0
Moisture	maximum	5.0	5.0	5.0

Dairy permeate - milk, whey, cream, sweet buttermilk permeates or similar lactose-containing milk products

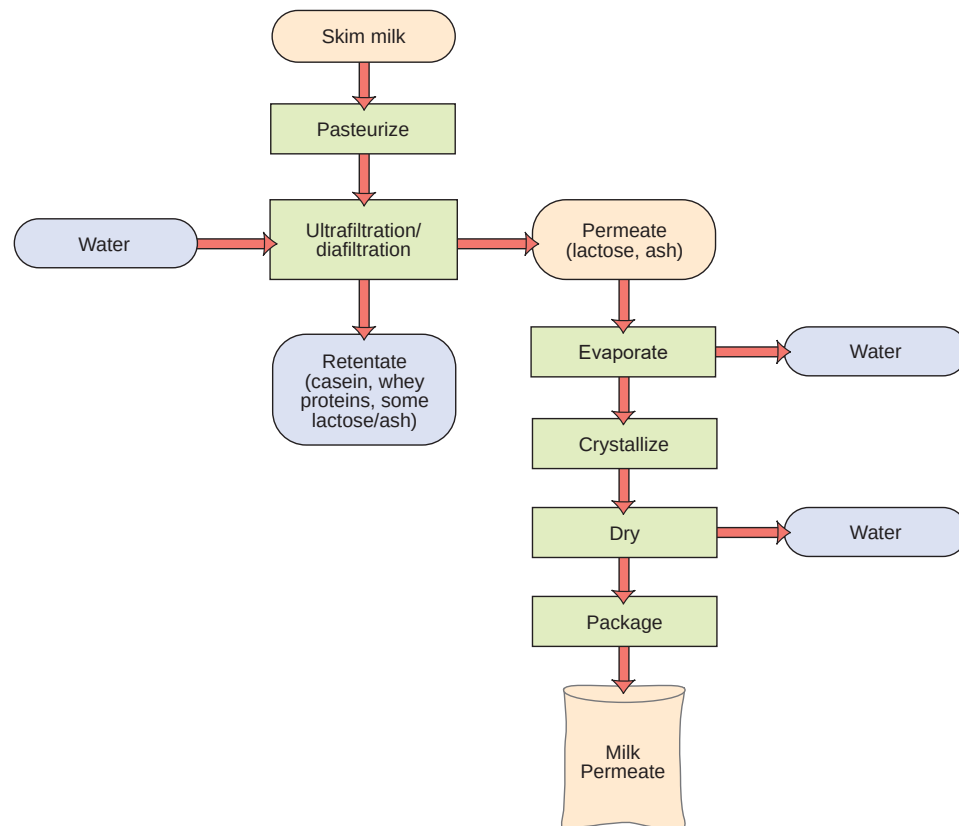
Milk permeate - milk permeate

Whey permeate - whey permeate

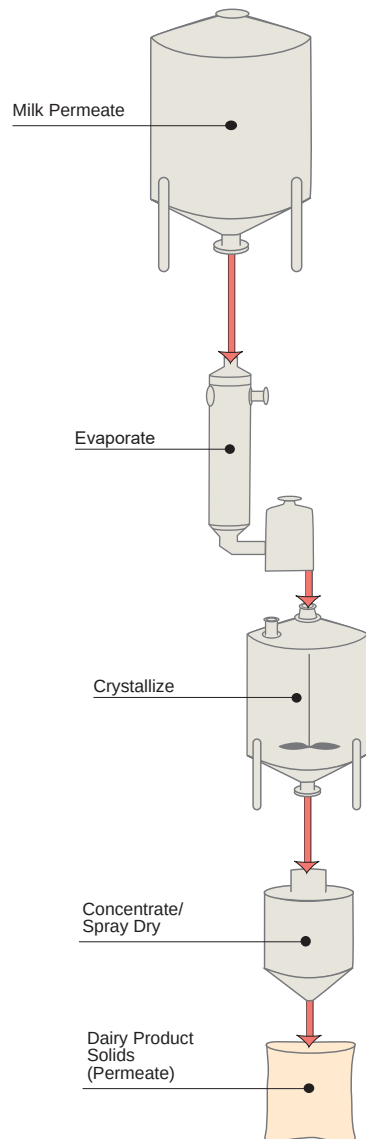
ADPI industry standard for milk permeate

Component	Typical	Minimum	Maximum
	----- % -----		
Protein	3 - 5	2	-
Lactose	78 - 88	76	-
Ash	8 - 11	-	14
Fat	0 - 1.0	-	1.5
Moisture	3 - 4.5	-	5.0

Manufacture of Milk Permeate



Manufacture of Milk Permeate



Typical composition and characteristics

Milk Permeate

♦ Typical composition*

Protein (db)	3%
Moisture	2%
Lactose	85%
Fat	0%
Ash	9%

♦ Characteristics

Color: white to yellow cream
 Flavor: slightly milky, slightly sweet

pH 6.3

♦ Storage

<25 C, <65% rh
 12 months

* Non protein nitrogen included in this value. May or may not contain true protein.

Micellar Casein

Micellar casein is not defined. For the purposes of this handbook, however, the following definitions will be used:

Microfiltered (MF) milk – liquid milk that has a portion of the whey protein, lactose and mineral removed. The ratio of casein to whey proteins is altered such that a greater portion of casein is present in MF milk than in typical milk.

Micellar casein (MC) – the dry form of MF milk.

Other terms for micellar casein may be native phosphocasein and microfiltered milk protein (MMP).

Micellar casein is produced by a pressure driven process using semipermeable membranes known as microfiltration (MF). Whey proteins, lactose and minerals are removed until the desired casein content is reached. The portion that remains, that is, the concentrated casein fraction, is referred to as retentate, while the whey protein, lactose and mineral stream is known as permeate. Because whey proteins are removed the ratio of casein to whey proteins is altered from that found in milk.

Casein is present in milk in the form of micelles. The MF process does not alter the structure of the micelles; therefore, MF milk with micellar casein is very soluble.

Micellar casein typically is produced from skim milk.

The permeate produced by the MF process has a very different composition from UF permeate.

Native whey proteins are a byproduct of this process.

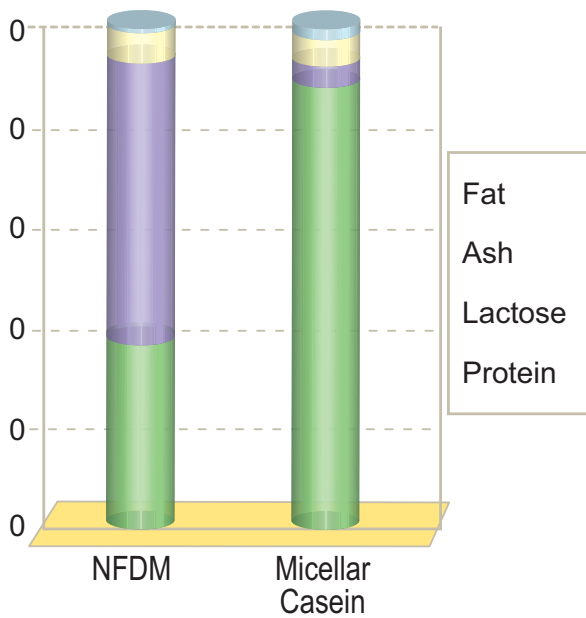
Micellar Casein (ADPI definition) - is produced using Microfiltration, which will alter the casein-to-whey protein ratio compared to that found in milk. The casein-to-whey protein ratio typically ranges between 82:18 and 95:5 for commercially available products.

Regulations

- ◆None, product not defined

ADPI Industry Standard

Micellar casein composition

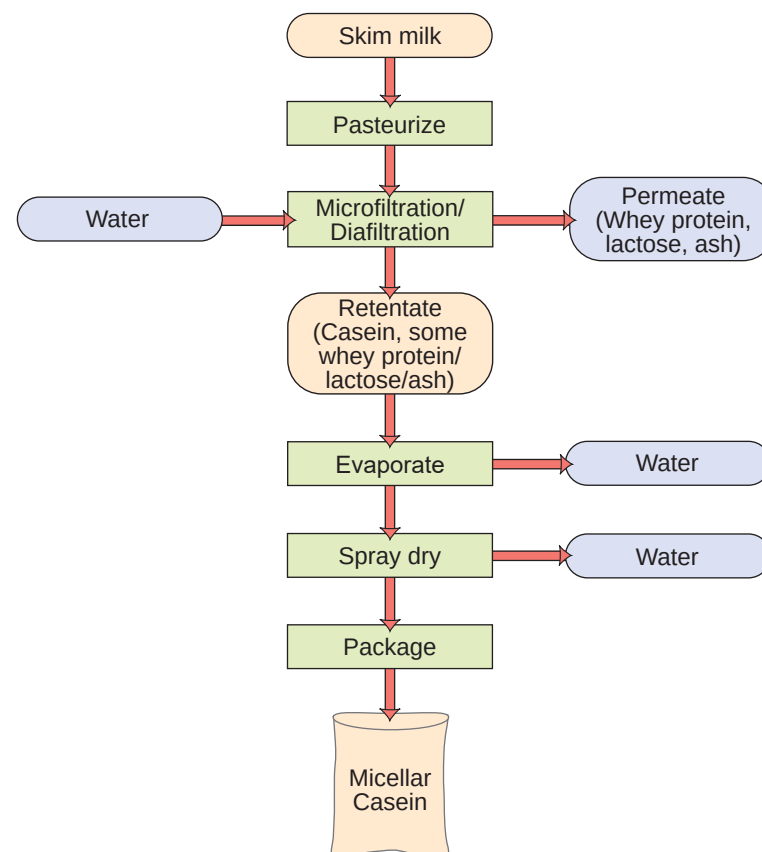


ADPI industry standard for microfiltered milk protein (MMP) or micellar casein (MC)

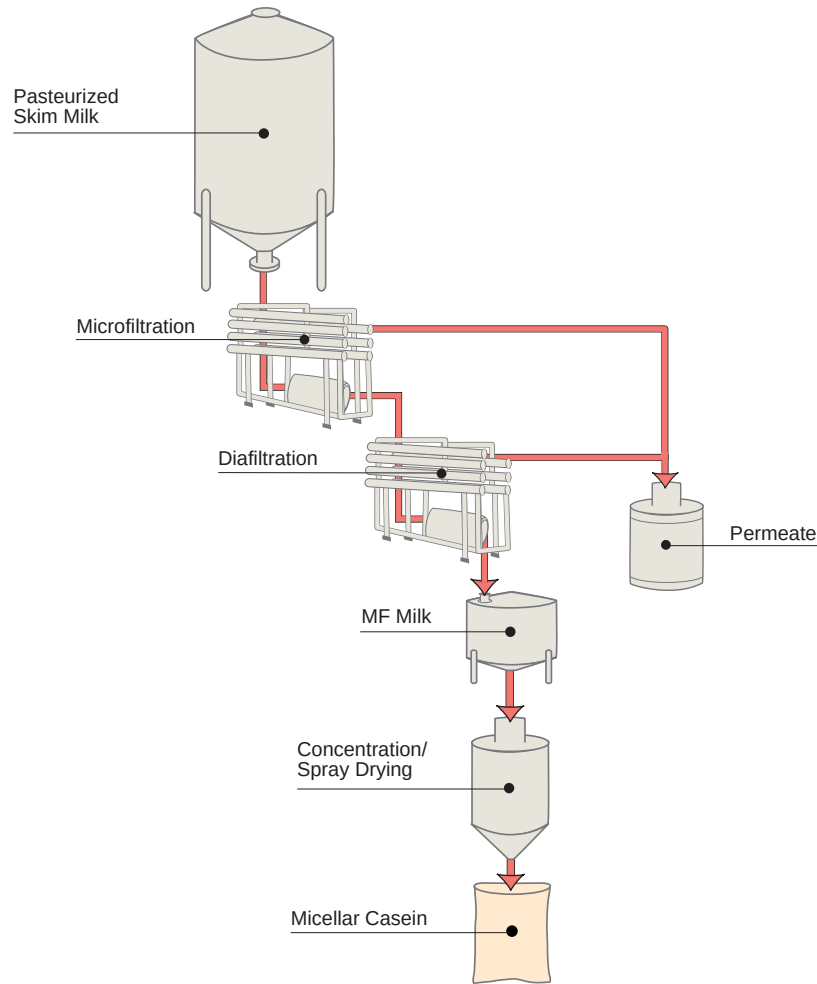
Component*	Minimum/ maximum	MC42	MC70	MC80	MC85	MC90
		----- % -----				
Protein	minimum	41.5	69.5	79.5	85.0	89.5
Lactose	maximum	51.0	16.0	10.0	3.0	1.0
Ash	maximum	6.0	8.0	8.0	8.0	8.0
Fat	maximum	1.25	2.50	3.00	3.00	3.00
Moisture	maximum	5.0	6.0	6.0	6.0	7.0

* Protein content $\geq 85.0\%$ is reported on a dry basis, all other parameters are reported "as is"

Manufacture of Micellar Casein



Manufacture of Micellar Casein



Typical composition and characteristics

Micellar Casein # 1*

- ♦ Typical composition

Protein (db)	86%
Moisture	5%
Lactose	4%
Fat	1%
Ash	8%
Casein to total protein	92%
- ♦ Characteristics
 - Color: white to light cream
 - Flavor: clean, dairy
 - Solubility: 99%
 - pH (10% solution) 6.5
- ♦ Storage
 - <25 C, <65% rh
 - 24 months

Micellar Casein # 2*

- ♦ Typical composition

Protein (db)	89%
Moisture	5%
Lactose	<0.5%
Fat	2%
Ash	8%
Casein to total protein	na
- ♦ Characteristics
 - Color: white to light cream
 - Flavor: clean, dairy
 - Solubility: 99%
 - pH (10% solution) 7.1
- ♦ Storage
 - <25 C, <65% rh

*Exact composition depends on manufacturer

Native Whey Protein

Native whey proteins are not defined. For the purposes of this handbook, however, the following definition will be used:

Native whey protein – whey proteins that have been removed from milk by the process of MF/UF. Native whey proteins have not been through the cheese making process.

Other terms for native whey proteins may include serum proteins, milk derived whey protein, milk soluble protein and ideal whey although none of these terms have a standard definition. The ADPI standard name is milk whey protein.

Native whey proteins are a by product of micellar casein production.

Native whey proteins may be concentrated by UF, through removal of lactose and minerals, to any desired protein level.

Regulations

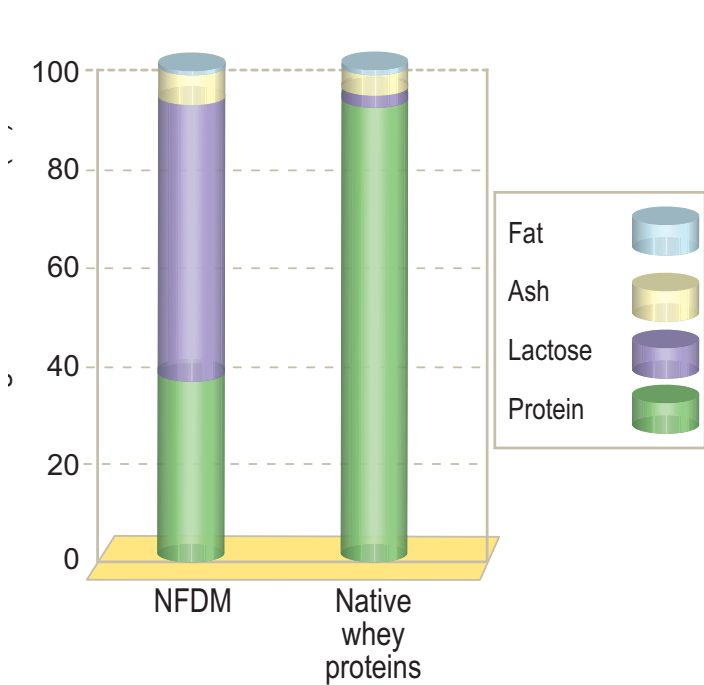
- ♦ None, product not defined

ADPI Industry Standard

Presence of components in cheese whey versus MF permeate whey

Component	Cheese whey	MF permeate whey
Starter cultures	Yes	No
Rennet	Yes	No
Glycomacropeptide	Yes	No
Pasteurization steps	2	1
Fat/phospholipids	Yes	Negligible
pH	<6.5	6.6

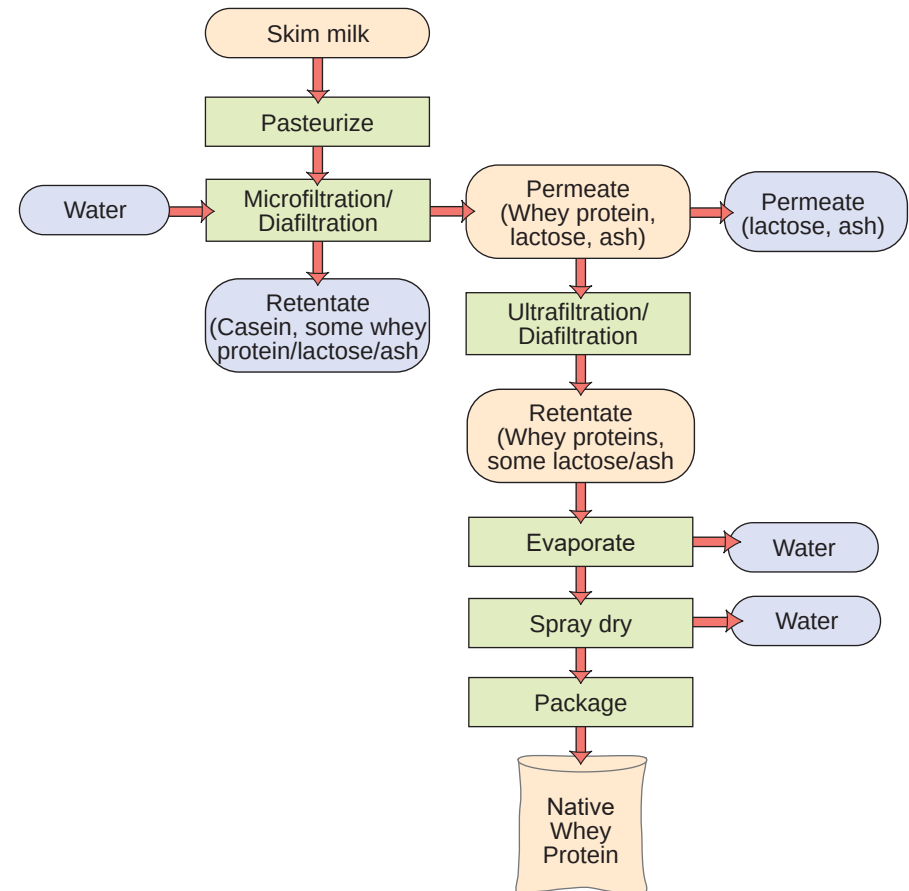
Native whey protein composition



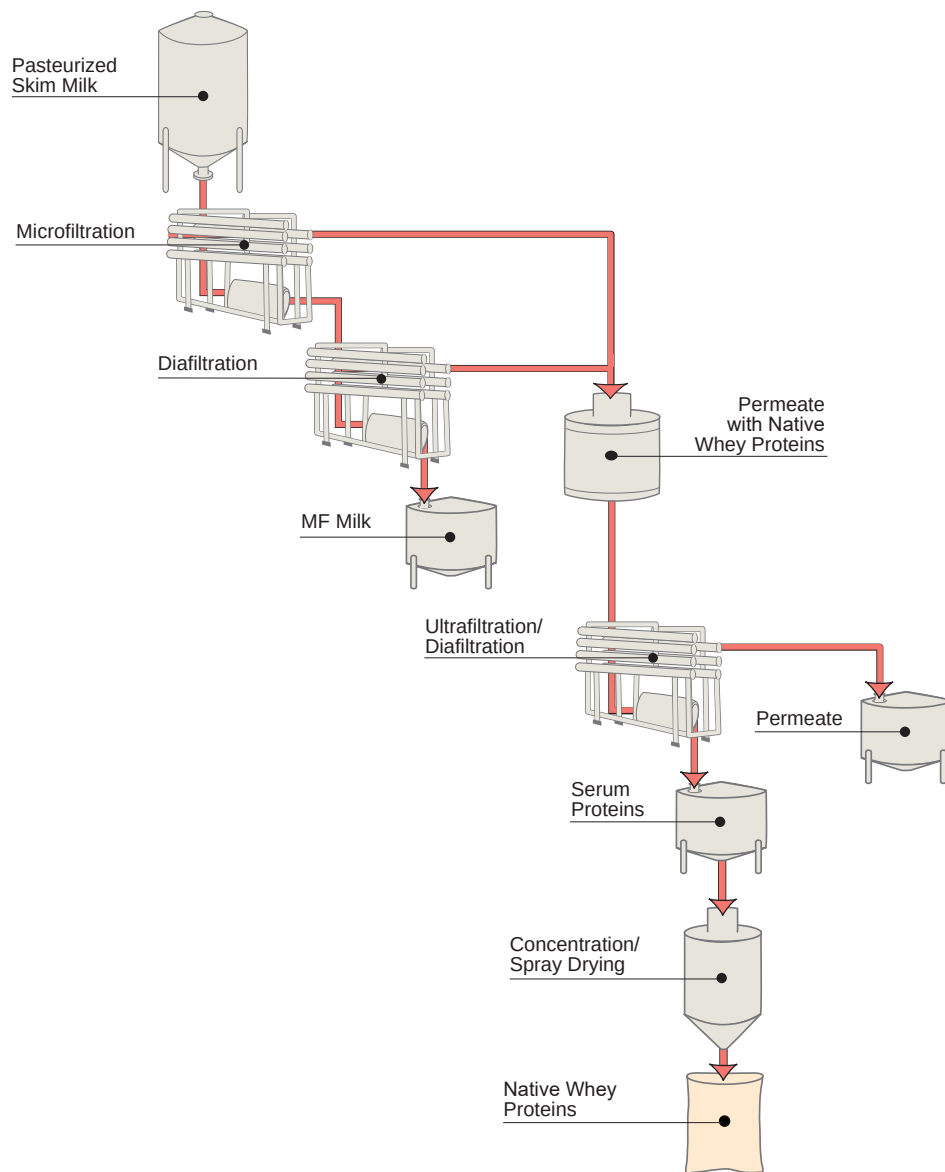
ADPI industry standard for native whey protein (mWPC)

Component*	Minimum/ maximum	mWPC34	mWPC80	mWPC90
		----- % -----		
Protein	minimum	33.5	79.5	89.5
Lactose	maximum	55.0	13.0	4.0
Ash	maximum	7.50	5.0	4.5
Fat	maximum	2.0	2.0	1.5
Moisture	maximum	6.0	6.0	6.0

Manufacture of Native Whey Protein



Manufacture of Native Whey Protein



Typical composition and characteristics

Native whey protein

♦ Typical composition

Protein (db)	92%
Moisture	5%
Lactose	2%
Fat	0.5%
Ash	3%

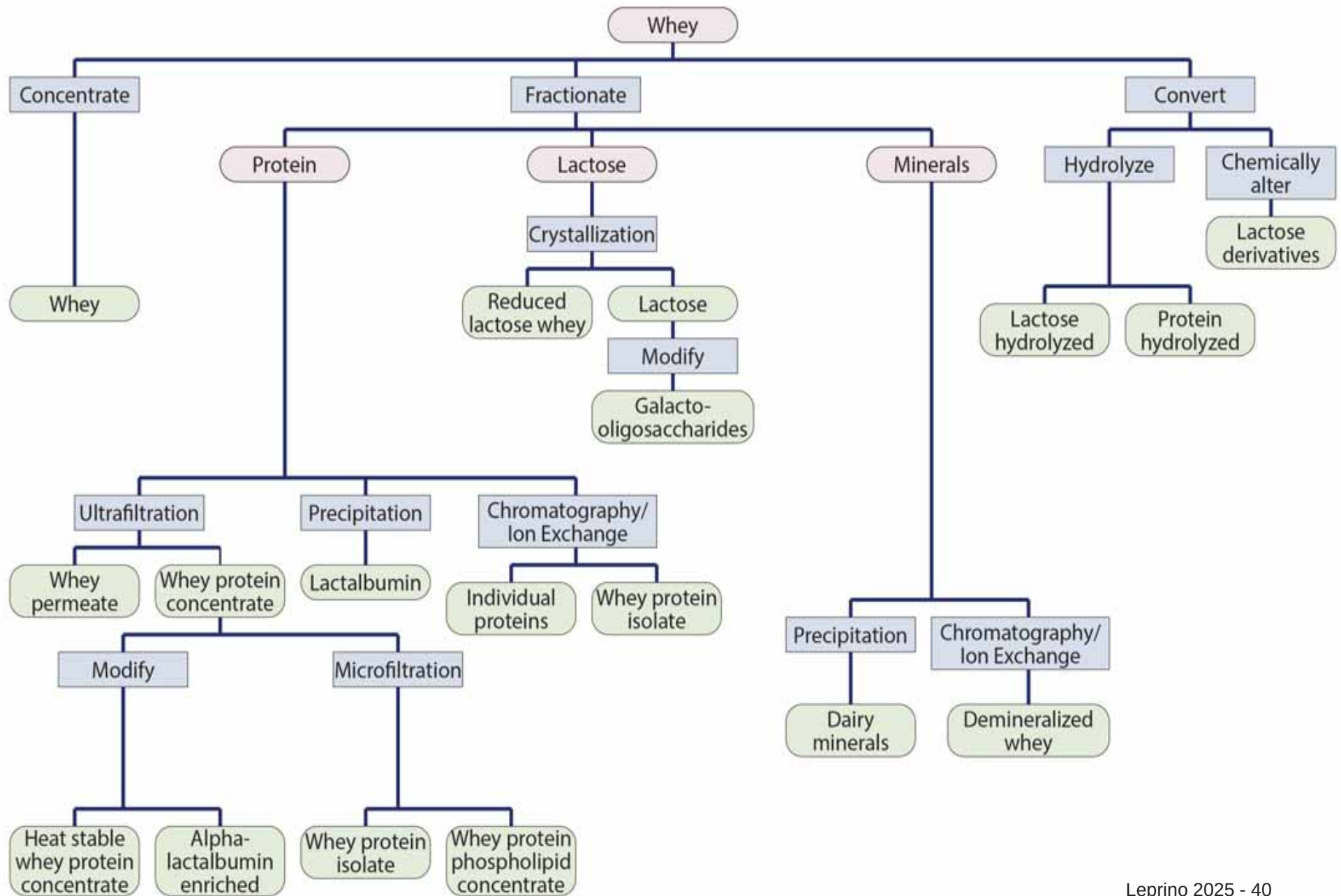
♦ Characteristics

Color: white to light cream
 Flavor: clean, dairy
 Solubility: 99%
 pH (10% solution) 6.0

♦ Storage

Not available

Manufacturing Dairy Ingredients from Whey



Whey

Cheesemaking and whey production

Whey is a by product of cheese manufacture. Approximately 9 pounds of whey are produced for every 1 pound of cheese. Although there are many types of cheese the resulting wheys often are quite similar.

Cheese may be produced through use of enzymes, such as rennet, that clot casein or addition of acid to lower the pH of the milk so that casein will precipitate. Some types of cheese use both methods to clot the casein.

Cheese and the resulting whey can be grouped into one of two general categories depending on whether the curd was formed by rennet which clots the casein or acid which precipitates the casein.

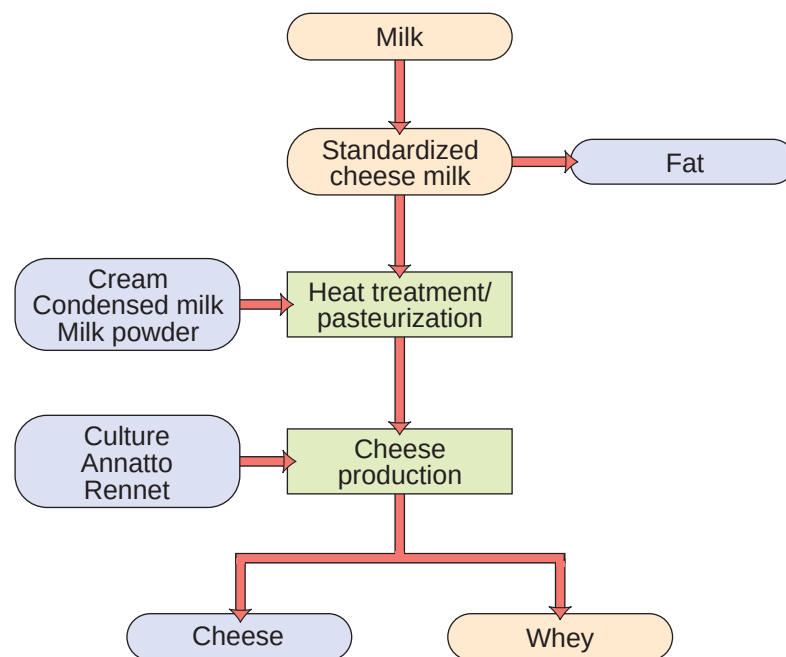
Sweet whey cheeses – most cheese types including Cheddar, Mozzarella, Swiss and Brick.

Acid whey cheeses – Cottage, ricotta, quark and cream cheese and industrial casein made by acid coagulation

When looking at the products from the standpoint of whey, whey drawn from curd that is clotted by rennet only will have a higher pH and is considered to be sweet whey. Whey drawn from curd that has formed through the use of acid (with or without added rennet) will have a lower pH and is referred to as acid whey.

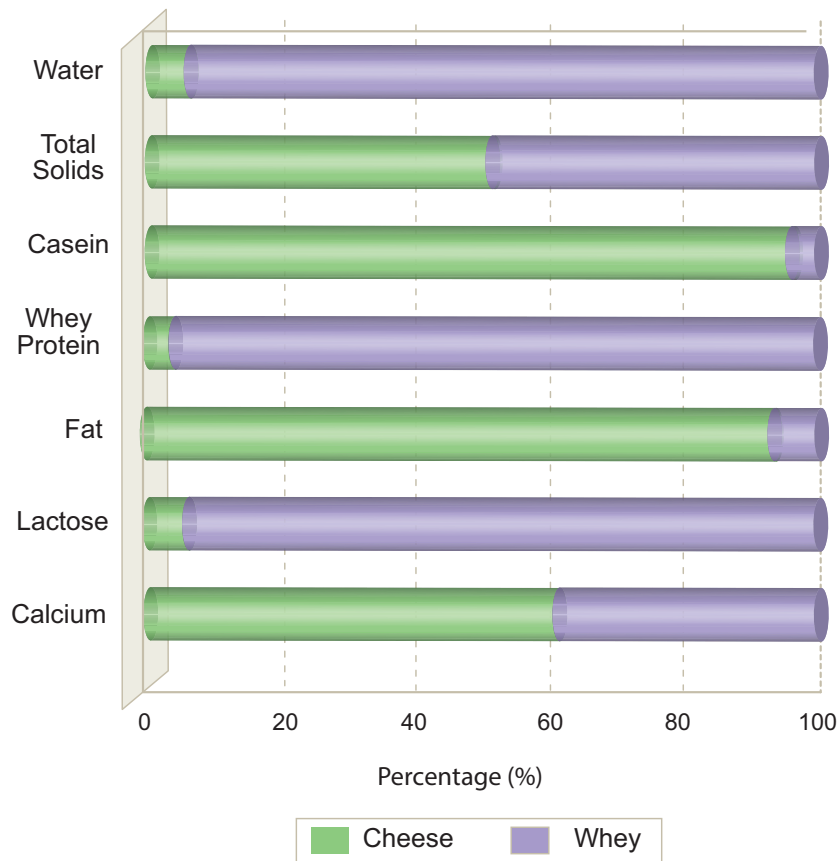
An additional type of whey would be fermented whey. Fermented whey is sweet whey that has a lower pH due to the action of cheese starter culture. Fermented whey is not typically produced but rather results from undesired continued acid production by starter cultures.

Production of Cheese and Whey from Milk



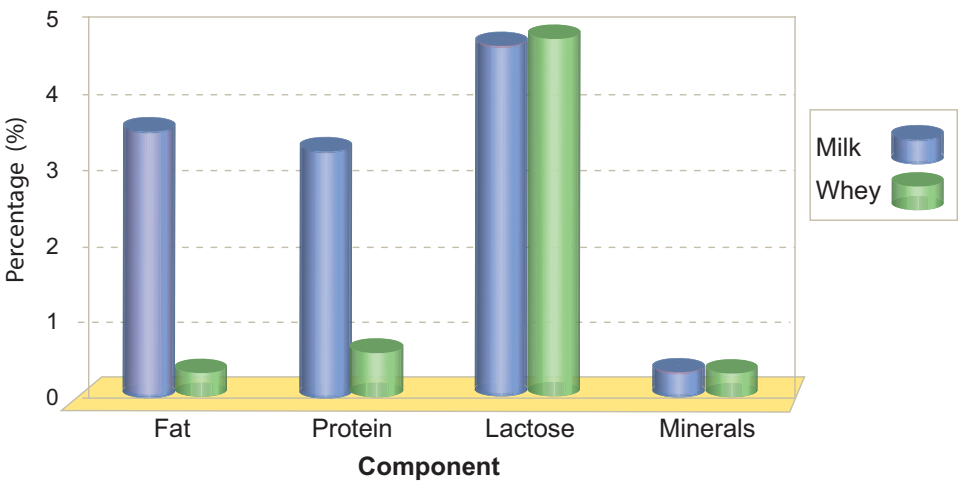
The distribution of milk components between cheese and whey is given below. Casein and fat are found largely in the cheese, while lactose, whey proteins and water partition mainly into the whey. It should be noted that the total solids of the milk are divided almost evenly between the cheese and resulting whey.

Distribution of milk components during cheese manufacture



The following figure is a comparison of solids composition of milk and whey. Milk contains greater amounts of fat and protein while milk and whey are similar in lactose and mineral content.

Composition of milk and whey



A comparison of milk, sweet whey and acid whey on an as is basis is given in the next table. Milk typically has twice the total solids, 4.5 times the protein and 10 times the fat as sweet or acid wheys. Lactose and mineral contents of all three are relatively similar. The lactic acid content of acid whey is greater than either milk or sweet whey because of the production of acid by cheese cultures during formation of the cheese curd.

Comparison of milk and sweet and acid whey

Component	Milk	Sweet whey	Acid whey
	----- % -----		
Total solids	12.5	6.5	6.5
Protein	3.5	0.8	0.7
Lactose	4.8	4.8	4.4
Ash	0.7	0.5	0.6
Fat	3.5	0.3	0.3
Lactic acid	—	0.1	0.5
----- mg/100 g -----			
Calcium	120	45	103
Phosphorous	9	45	78

Compositional differences

The composition of the sweet and acid whey differs because of the pH of the whey and the use of rennet.

Sweet whey will contain glycomacropeptide (GMP). Rennet cleaves κ -casein thereby producing a protein fragment known as GMP. Glycomacropeptide can be 20% of the protein in sweet whey and it is not present in acid whey unless rennet is used. GMP is also known as casein macropeptide (CMP).

Acid whey will have higher levels of calcium than sweet whey. Calcium phosphate is more soluble at lower pHs therefore the lower pH of acid whey will draw more calcium from the cheese curd into the whey than sweet whey.

Sweet or acid whey that was produced from cheese where the pH was reduced by microbial cultures will contain byproducts of the fermentations such as galactose and lactic acid. Whey produced from cheese that used direct addition of acid will contain the acid used rather than fermentation byproducts. Acids typically used include: glucono- δ -lactone, lactic, sulfuric, phosphoric, hydrochloric and citric.

Fermented whey will not have higher calcium levels but will contain by products of starter culture fermentations.

Greek yogurt acid whey is a byproduct of Greek yogurt manufacture and is a special type of acid whey. Because of the high heat used to incorporate the whey proteins into the structure of the yogurt, Greek yogurt acid whey typically contains little to no true protein. The pH of the Greek yogurt when the whey is removed is lower than the pH of an acid cheese at whey removal so Greek yogurt acid whey will have a higher calcium content than either sweet or acid whey.

Comparison of sweet, acid and Greek yogurt acid wheys

Component	Sweet	Acid	Greek yogurt
	----- % -----		
Total solids	6.3	6.4	5.7
Protein*	0.8	0.5	0.3*
Lactose	4.9	4.4	4.2
Minerals	0.5	0.6	0.7
----- mg/100 g -----			
Calcium	45	103	123
pH	~6.0	< 5.5	~ 4.2

* Based on nitrogen content so nonprotein nitrogen included.

Whey processing

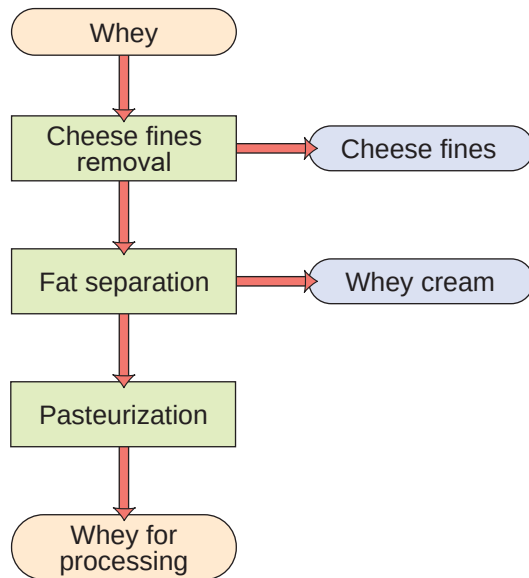
The cheese maker typically removes cheese fines and whey cream from the whey before it is processed.

Cheese fines are small pieces of cheese that were not captured in the curd. Cheese fines consist of coagulated casein and are not soluble, therefore their presence in whey is not desired.

Whey cream consists of small fat globules that were not trapped within the cheese matrix. These fat globules can cause off flavors during storage of whey based powders; therefore, it is important that as much of the whey cream be removed as possible.

The majority of whey is produced from pasteurized milk. Regardless of whether the whey came from raw or pasteurized milk, all whey must be pasteurized before it may be further processed into a dairy ingredient.

Production of Whey for Further Processing



Optional steps

Bleaching – benzoyl or hydrogen peroxide may be added to reduce the yellow/orange color of whey resulting from the use of annatto color during cheese manufacture.

Neutralizing – addition of caustic to increase the pH of the whey. Neutralizing typically would be used only for acid or fermented whey.

Crystallization – concentrated whey is allowed to cool so that lactose crystallizes. Lactose can exist in several forms - α -monohydrate, β and glass or amorphous. The glass or amorphous form of lactose is very hygroscopic (water loving) and tends to pick up water during storage that can lead to clumping of the powder. Lactose crystallized in the α -monohydrate form is less hygroscopic than lactose in glass form. The majority of whey powder produced in the US has a crystallization step so that the resulting powder is non hygroscopic.

Type of dryer used

Whey powder functionality is affected by the type of dryer used.

Majority of whey powder is produced by spray drying which is a less severe process than roller drying.

Roller drying is relatively uncommon because of the amount of protein denaturation that results. Roller dried product will have a flaked appearance, browner color and more cooked flavor as compared to sprayed dried powder.

Final form of powder

Agglomeration is used to increase particle size and is a step in the instantizing process.

Instantizing improves the ability of powder to disperse and dissolve quickly. A surfactant such as lecithin may be added to improve the ability of water to contact powder particles in the presence of lipids (fat).

Agglomeration and instantizing do not improve powder solubility. Rather they increase the rate of powder dispersing and dissolving. Powder that is insoluble will not be made soluble if agglomerated or instantized.

Agglomerated/instantized powder typically will have a shorter shelf life as compared to ordinary powder because of the additional heat used during processing.

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IPR2025-01199

Assumptions used in this booklet when describing whey for further processing

- * Cheese fines removed
- * Whey cream removed
- * Whey has been pasteurized

Types

- ♦ Sweet whey
- ♦ Acid whey

Grade

- ♦ Extra
- ♦ Grade not assignable

Dryer used

- ♦ Roller
- ♦ Spray

Final form

- ♦ Ordinary, hygroscopic
- ♦ Ordinary, non hygroscopic
(non-agglomerated, non-instant)
- ♦ Agglomerated
- ♦ Instantized

Regulations

- ♦ Liquid whey
21 CFR 184.1979
- ♦ Concentrated whey
21 CFR 184.1979
- ♦ Dry whey
21 CFR 184.1979

United States Standards for Dry Whey
USDA, AMS - Dairy Division, December 14,
2000

Codex Stan A-15-1995, Rev 1-2003, Amd 2006

ADPI Industry Standard

Whey Definitions

(summarized from Code of Federal Regulations)

Whey is the liquid obtained by separating the coagulum from milk, cream, or skim milk in cheese making. Acidity may be adjusted with safe and suitable pH adjusting ingredients.

Sweet whey is whey that has an insignificant conversion of lactose to lactic acid. Maximum titratable acidity of not greater than 0.16% and alkalinity of ash not greater than 225 ml of 0.1 HCl.

Concentrated whey is whey where a portion of the water has been removed leaving all other constituents in the same relative proportions.

Dry whey is fresh whey that has been pasteurized and contains all constituents, except water, in the same proportions as found in the original whey. Preservatives are not permitted.

Dry sweet whey shall not have greater than 0.16 percent titratable acidity on a reconstituted basis.

Dry acid whey shall have greater than 0.35 percent titratable acidity on a reconstituted basis.

Animal Feed Definitions (Association of Animal Feed Control Officials)

Whey is the product obtained as a fluid by separating the coagulum from milk, cream, or skim milk and from which a portion of the milkfat may have been removed.

Dried Whey is the product obtained by removing water from whey. It contains not less than 11% protein nor less than 61% lactose.

Dried Cultured Whey Product is the product obtained by drying whey from which a portion of the lactose, protein and/or minerals has been removed and which has been cultured.

Possible Certifications for Whey

There are additional categories or certifications possible for whey including organic, Grade A, cow/sheep/goat/mixed, kosher and halal. Sweet, acid and fermented whey may fall into any, several or none of these categories.

Organic

Organic whey must meet regulations for organic products as defined by the United States Department of Agriculture (USDA) in the Code of Federal Regulations (CFR). Auditors ensure compliance. Practices are designed to ensure segregation of organic and nonorganic product within a processing plant and use of organic ingredients, such as defoamer, in organic whey products.



Grade "A"

Grade "A" whey products must be produced from Grade "A" milk. The plant that produces the products also must be Grade "A". The designation of Grade "A" focuses on aspects such as design of equipment, product sampling, water quality and handling, dairy farm construction, cleaning/sanitizing procedures, product testing, employee training, etc., with plant inspections to ensure compliance.

Grade "A" is outlined in the "Grade "A" Pasteurized Milk Ordinance. The document is produced by the United States Public Health Services (USPHS) and Food and Drug Association (FDA).

Mixed

Cow, sheep and goat refer to the type of milk used to manufacture the cheese and resulting whey. Mixed means the cheese/whey was made from milk from more than one species. For example, cow and sheep milk may have been blended together to produce the cheese and whey.

Kosher

Kosher refers to foods that conform to the rules of kashrut (Jewish dietary law). Kosher whey must meet the rules of the rabbinical organization giving approval. Several organizations oversee the application of kosher requirements. Circle K and Circle U are two examples. The letter "D" along with the symbol for the rabbinical organization indicates the product is dairy.



Kosher whey often comes from cheese that is not designated as kosher. All of the components of the cheese are kosher, however, the cheese itself has not been certified as kosher. The whey from such cheese is still considered kosher. The majority of the whey in the U.S. is kosher.

Halal

Halal refers to things that are permitted under Islamic law. Milk is considered halal although the addition of certain ingredients can make it forbidden or haram. An example of a forbidden ingredient would be flavorings that contain alcohol.

Whey and whey products produced in the U.S. typically are certified halal. An example of a group involved in halal certification of dairy products is the Islamic Food and Nutrition Council of America (IFNCA). Symbols on dairy packages representing halal certification often contain the crescent moon image.



Grass Fed

The designation "Grass Fed" for dairy products is relatively new. The term grass fed implies that the animals used to produce the meat and dairy products were fed only grass. As a labeling claim it is intended to indicate that the animals were raised on pasture during the growing season and fed only grass and forage. .



The FDA and USDA, which oversee labeling of dairy products, do not have a definition for grass fed and currently do not set standards for producers who make a grass fed label claim. On-farm inspections or verifications are not required by the FDA at this time for grass fed claims. A symbol for a FDA product may include wording such as "USDA Process Verified".

Several other groups have established programs and standards for grass fed products. Some of these programs also require adherence to organic and non GMO standards. Among these programs are Pennsylvania Certified Organic (PCO), American Grassfed Association (AGA), Animal Welfare Approved (AWA) and Northeast Organic Farming Association of New York (NOFA-NY).

PCO requires organic certification in addition to feeding only grass and forage (no grain). Verification includes on-farm inspections.



The AGA requires grass feeding after weaning with no grain allowed. Animals must not be raised in confinement or fed GMO products. On-farm inspections are required.



A Greener World (AGW) oversees the Animal Welfare Approved (AWA) Grassfed symbol. A 100% grass or forage diet is required. In addition to no grain in the diet, producers also must meet Animal Welfare Approved standards. On-farm inspections are included with AGW certification.



The NOFA-NY Certified 100% Grass Fed symbol is given below. The NOFA-NY certification requires that the farm be certified organic as well as feeding grass or grass-based feed for the life of the animal to be sold for meat and for at least 90 days to qualify the milk as grass fed. On-farm inspections are part of the certification.



Non Genetically Modified Organisms (Non-GMO)

Genetically Modified Organisms (GMO) refers to the use of bioengineering in the production of plants and animals. A Non-GMO product therefore would not include genetically engineered plants, animals produced through genetic engineering or material (such as milk) from a genetically engineered animal or material produced through the use of a genetically engineered material. An example of a genetically engineered material would be the use of recombinant bovine somatotrophin (rBST) in dairy cows to increase milk production.

There is a new federal law requiring the USDA to issue regulations requiring disclosure of bioengineered foods. Although the USDA is developing a definition of bioengineered food as part of this federal law there currently is no definition for "non-GMO" products.

Product certified as organic would be considered Non-GMO. Beyond organic certification it is less clear as to what is a Non-GMO product. Groups such as the Non-GMO Project and NSF International (originally known as National Sanitation Foundation) are involved in verifying

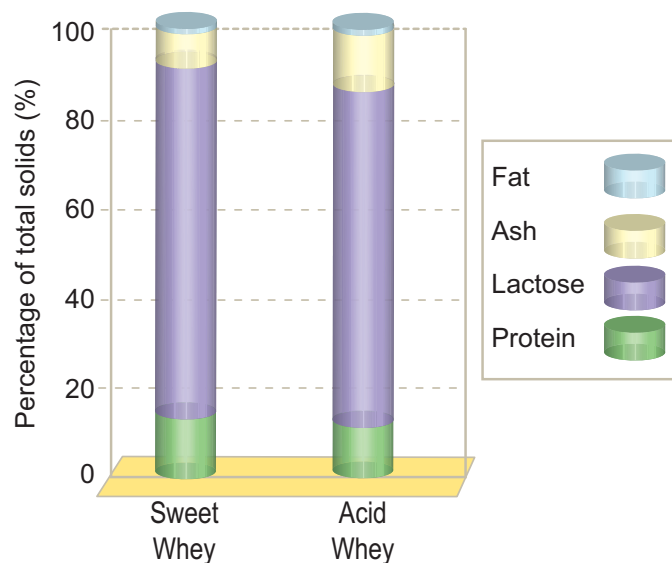
products according to standards that they have developed. The symbol for the Non-GMO Project is given below.



There are a number of symbols that may be used to indicate a Non-GMO product. Several of those symbols are given below. Note that there is not a standardized symbol for Non-GMO.



Sweet and acid whey composition



General composition of whey powders

Component	Sweet whey	Acid whey
	----- % -----	
Protein	12.5	12.0
Lactose	73	70
Ash	8.5	12
Fat	1	1
Moisture	5	5

USDA specifications for US Grades of dry whey*

Component	Extra grade	
	not less than	not greater than
Milkfat	-	1.5%
Moisture	-	5.0%
Titrateable acidity sweet (dry) acid (dry)	- 0.35%	0.16% -
Scorch	-	15.0 mg
Bacteria (spc/g)	-	30,000
Coliform (10/g)	-	10
Optional test requirements		
Protein	11%	-
Alkalinity of ash (sweet)	- -	225 ml/100 g (0.1 N NaOH)

* United States Standards for Dry Whey
USDA, AMS - Dairy Division, December 14, 2000

Additional Requirements

Physical Appearance - Uniform color, free flowing, free from lumps that do not break up under slight pressure and practically free from visible dark particles.

Flavor - Normal whey flavor and free from undesirable flavors. May have the following flavors to a slight degree: bitter, fermented, storage and utensil. May have the following flavors to a definite degree: feed and weedy.

Grade A whey products must comply with the requirements in the United States Public Health/Food and Drug Association (USPH/ FDA) Grade A Pasteurized Milk Ordinance (PMO). Grade A whey products must come from cheese made with Grade A raw milk and processed to meet the standards given in the PMO.

Requirements for Grade A dry whey

Standard	Requirement
Temperature	Cooled to 45°F or less during crystallization within 18 h of condensing
Phosphatase	Less than 1 microgram/ml
Bacterial limit	30,000/g
Coliform limit	10/g
Drugs	No zone equal to or greater than 16 mm

Codex specifications for sweet whey powder*

	Minimum	Reference content	Maximum
Component	----- % (m/m) -----		
Lactose	-	61.0	-
Milk protein	10.0	-	-
Milk fat	-	2.0	-
Water	-	-	5.0
Ash	-	-	9.5
pH (in 10% solution) or titratable acidity	> 5.1 -	- -	- 0.35%

* Codex Stan A-15-1995, Rev 1-2003, Amd 2006, 2010

Codex specifications for acid whey powder*

	Minimum	Reference content	Maximum
Component	----- % (m/m) -----		
Lactose	-	61.0	-
Milk protein	7.0	-	-
Milk fat	-	2.0	-
Water	-	-	4.5
Ash	-	-	15.0
pH (in 10% solution) or titratable acidity	- 0.35%	- -	5.1 -

* Codex Stan A-15-1995, Rev 1-2003, Amd 2006, 2010

CFR specifications for dry whey*

Component	Not less than	Not greater than
	----- % -----	
Milkfat	0.2	2
Protein	10	15
Lactose	61	75
Ash	7	14
Moisture	1	8

* 21 CFR 184.1979

ADPI industry standard for extra grade for dry sweet whey

Component	Not less than	Not greater than
	----- % -----	
Milkfat	-	1.5
Moisture	-	5
Titrateable acidity*	-	0.16

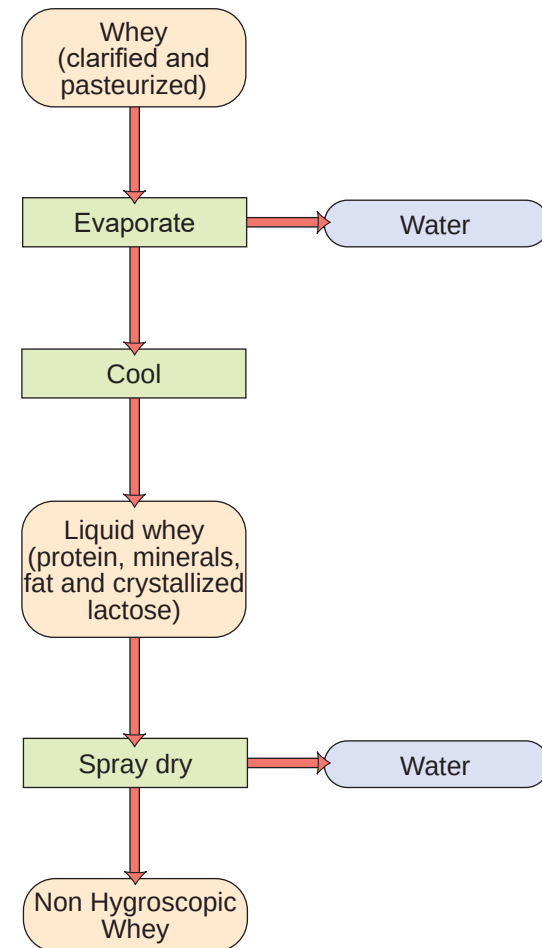
* Used for classification purposes only. Not for grade determination.

ADPI industry standard for extra grade for dry acid whey

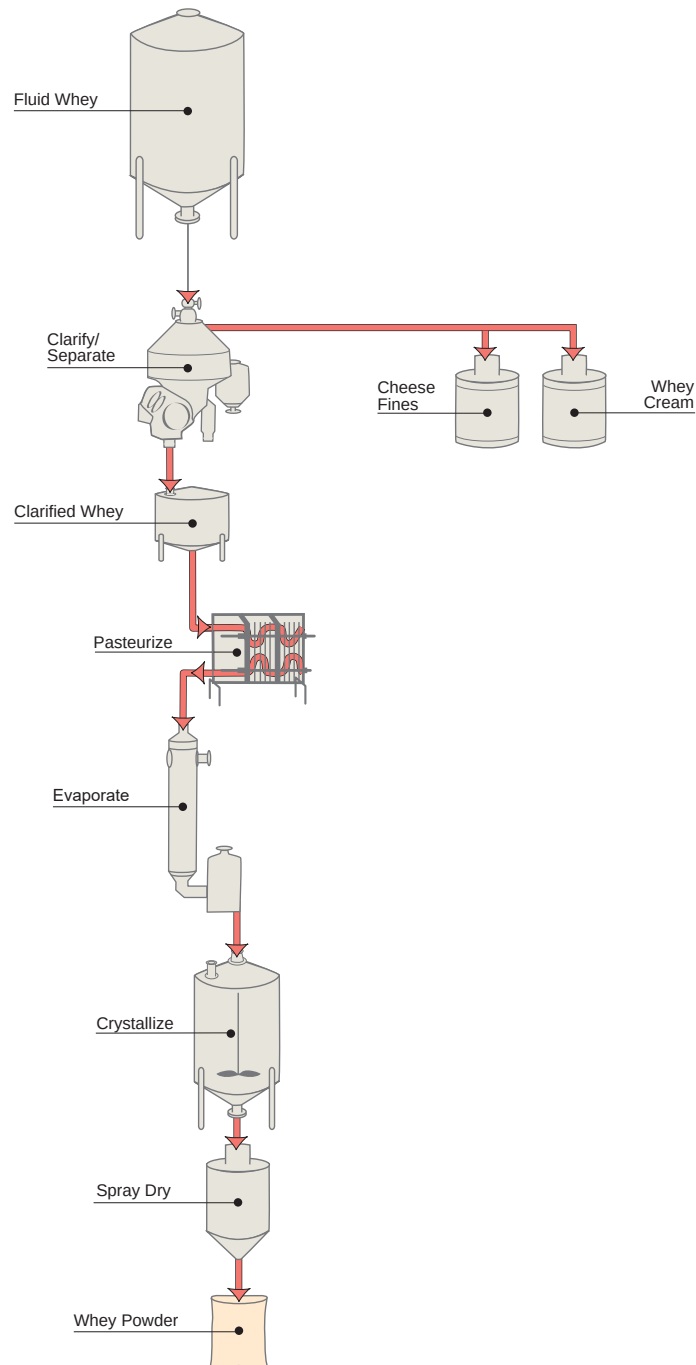
Component	Not less than	Not greater than
	----- % -----	
Milkfat	-	1.5
Moisture	-	5
Titrateable acidity*	0.35	-

* Used for classification purposes only. Not for grade determination.

General Process for Manufacture of Whey



Manufacture of Sweet and Acid Whey



Typical composition and characteristics

Sweet whey

♦ Typical composition

Protein (db)	13%
Moisture	5%
Lactose	73%
Fat	1%
Ash	8%

♦ Characteristics

Color: off white to cream
Flavor: whey, slight salty
pH 5.7 - 6.0

♦ Storage

<27 C, <65% rh
6 - 12 months

Acid whey

♦ Typical composition

Protein (db)	13%
Moisture	5%
Lactose	70%
Fat	1%
Ash	12%

♦ Characteristics

Color: off white to cream
Flavor: whey, slight salty
pH 4.5
TA 0.35 - 0.44%

♦ Storage

<27 C, <65% rh
6 - 12 months

Product Labeling

Dry Sweet Whey or Dry Acid Whey or Dry Whey _____ % titratable acidity (for dry whey over 0.16% but below 0.35% titratable acidity on a reconstituted basis)

Demineralized or Reduced Minerals Whey (RMW)

Processes such as precipitation, ion exchange, electrodialysis and membrane filtration may be used to remove minerals from whey. Membrane filtration, ion exchange and electrodialysis do not denature proteins thereby preserving protein solubility in demineralized whey produced by such methods. The exact process used will determine the mineral profile of the final product. Demineralized whey often will have a less salty flavor because of the reduced mineral concentration.

Demineralized or reduced minerals whey (ADPI definition) - Whey with a portion of the minerals removed by physical separation techniques such as precipitation, filtration or dialysis. The dry product cannot contain more than 7% ash. Acidity may be adjusted with safe and suitable pH adjusting ingredients.

CFR requires product to be listed as reduced minerals whey.

Types

- ♦ 25, 50 and 90% demineralization is typical

Regulations

- ♦ 21 CFR 184.1979

ADPI Industry Standard

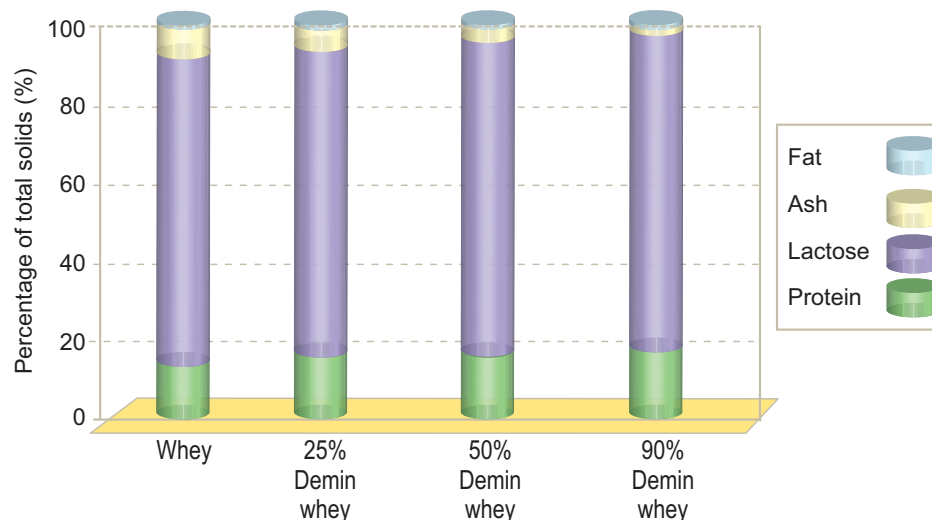
Animal Feed Definition (Association of Animal Feed Control Officials)
Dried (dry) whey product - is the product obtained by drying whey from which a portion of the lactose, protein and/or minerals have been removed. The minimum percent of crude protein and lactose and maximum percent ash must be prominently declared on the label. May also be labeled as "dried reduced minerals whey" or "dried reduced lactose whey," if appropriate.

Composition of demineralized whey*

Component	Whey	25% Demin	50% Demin	90% Demin
	grams			
Water	10	10	10	10
Fat	2.5	2.5	2.5	2.5
Protein	30	30	30	30
Lactose	186	186	186	186
Ash	21	17	11	2
Total	250	245	239	230
%				
Ash in whey	8.6	7.0	4.6	0.9

* Values are in grams to illustrate the effect of mineral reduction on composition

Demineralized whey composition



General composition of demineralized whey

Component	25% Demin	50% Demin	90% Demin
	----- % -----		
Protein	12	13	13
Lactose	77	78	80
Ash	5	3	1
Fat	1	1	1
Moisture	5	5	5

CFR specifications for reduced minerals whey*

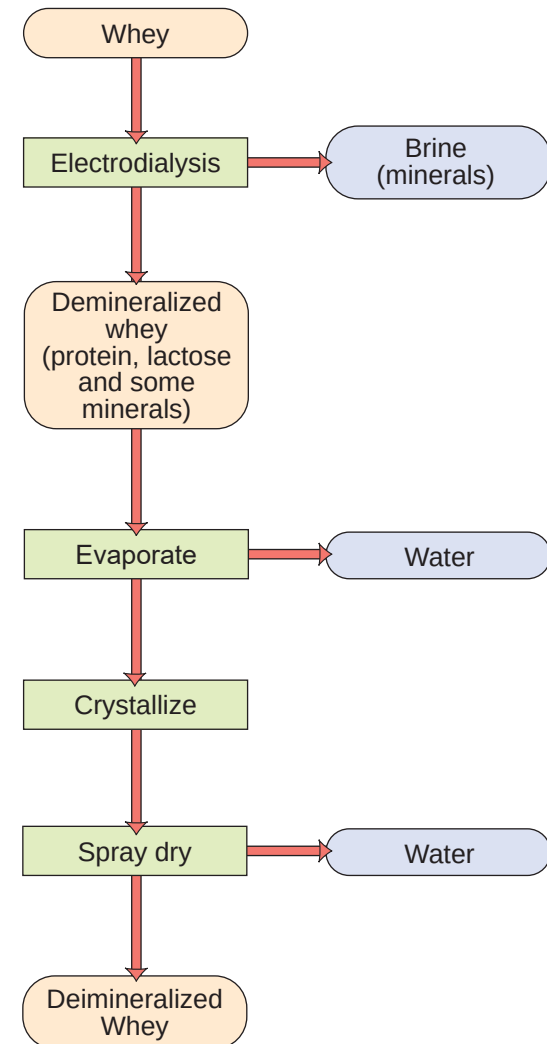
Component	Not less than	Not greater than
	----- % -----	
Milkfat	1	4
Protein	10	24
Lactose	-	85
Ash	-	7
Moisture	1	6

* 21 CFR 184.1979

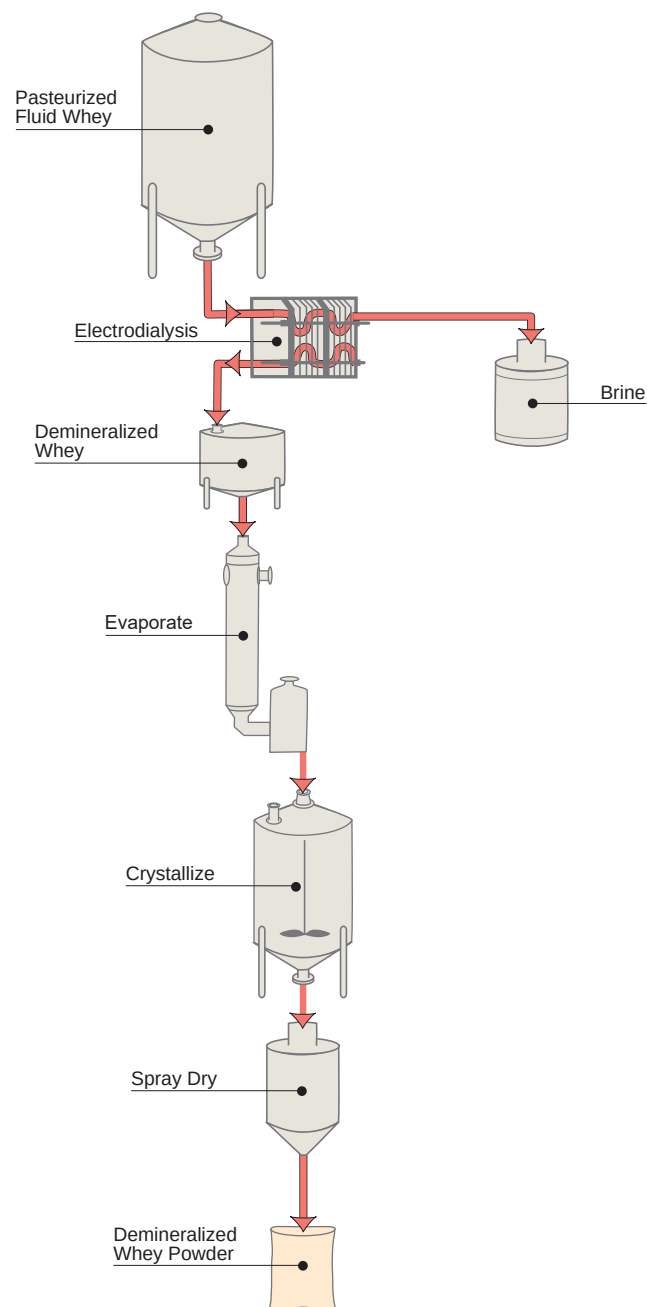
ADPI industry standard for demineralized whey

Component	Typical	Minimum	Maximum
	----- % -----		
Protein	11.0 - 15.0	-	17
Lactose	70.0 - 80.0	-	82
Ash	1.0 - 7.0	-	7
Fat	0.5 - 1.8	-	4
Moisture	3.0 - 4.0	-	5

General Process for Manufacture of Demineralized Whey



Manufacture of Demineralized Whey



Typical composition and characteristics

25% demineralized whey

♦ Typical composition

Protein (db)	11.4%
Moisture	5%
Lactose	78%
Fat	1%
Ash	5%

♦ Characteristics

Color: cream to dark cream
Flavor: less salty whey flavor

♦ Storage

<27 C, <75% rh
24 months

50% demineralized whey

♦ Typical composition

Protein (db)	11.5%
Moisture	5%
Lactose	80%
Fat	1%
Ash	3%

♦ Characteristics

Color: cream to dark cream
Flavor: not salty whey flavor
pH 6.0 – 6.5

♦ Storage

<27 C, <75% rh
24 months

90% demineralized whey

♦ Typical composition

Protein (db)	13.7%
Moisture	5%
Lactose	80%
Fat	1%
Ash	1%

♦ Characteristics

Color: cream to dark cream
Flavor: not salty whey flavor
pH 6.7

♦ Storage

<27 C, <75% rh
24 months

Product Labeling

Reduced Minerals Whey (____ % minerals)

The percent of minerals is declared in 2% increments OR as actual percentage provided an analysis of the product is supplied.

Reduced Lactose Whey

Reduced lactose whey is produced by removing a portion of the lactose in the whey. Crystalline lactose is a byproduct. The mineral components of the whey are not altered.

Reduced lactose whey differs from whey protein concentrate (WPC) in that the minerals are not removed while production of WPCs involves removal of both lactose and minerals.

Because only lactose is removed, lactose reduced whey may also be referred to as mineral concentrated whey or fractionated whey.

Reduced lactose whey (ADPI definition) - Lactose content of the final dry product cannot exceed 60%. Removal of lactose may be accomplished by physical separation techniques such as precipitation, filtration or dialysis. Acidity may be adjusted with safe and suitable pH adjusting ingredients.

Regulations

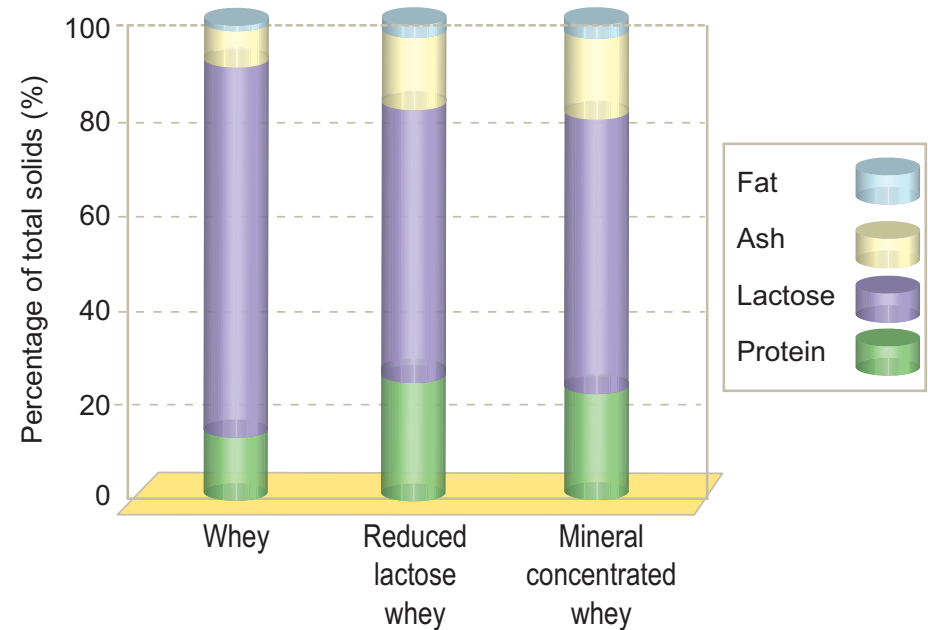
- ♦ 21 CFR 184.1979

ADPI Industry Standard

Animal Feed Definition (Association of Animal Feed Control Officials)

Dry hydrolyzed whey - is the product obtained by drying whey from which a portion of the lactose, protein and/or minerals have been removed. The minimum percent of crude protein and lactose and maximum percent ash must be prominently declared on the label. May also be labeled as "dried reduced minerals whey" or "dried reduced lactose whey," if appropriate.

Reduced lactose whey composition



General composition of reduced lactose whey

Component	Reduced lactose	Mineral concentrated
	----- % -----	
Protein	23	22
Lactose	56	56
Ash	16	17
Fat	2	2
Moisture	3	3

CFR specifications for reduced lactose whey*

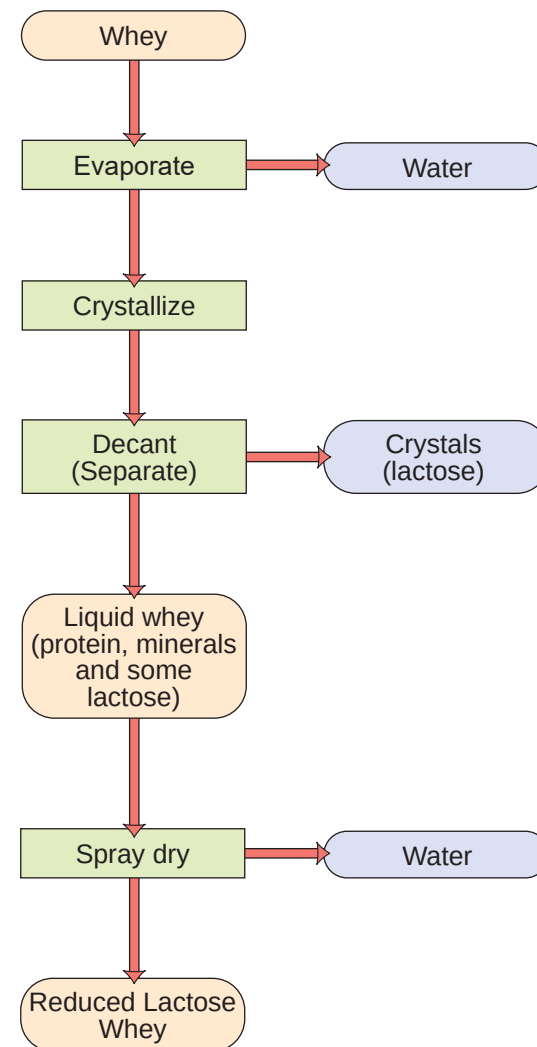
Component	Not less than	Not greater than
	----- % -----	
Milkfat	1	4
Protein	16	24
Lactose	-	60
Ash	11	27
Moisture	1	6

* 21 CFR 184.1979

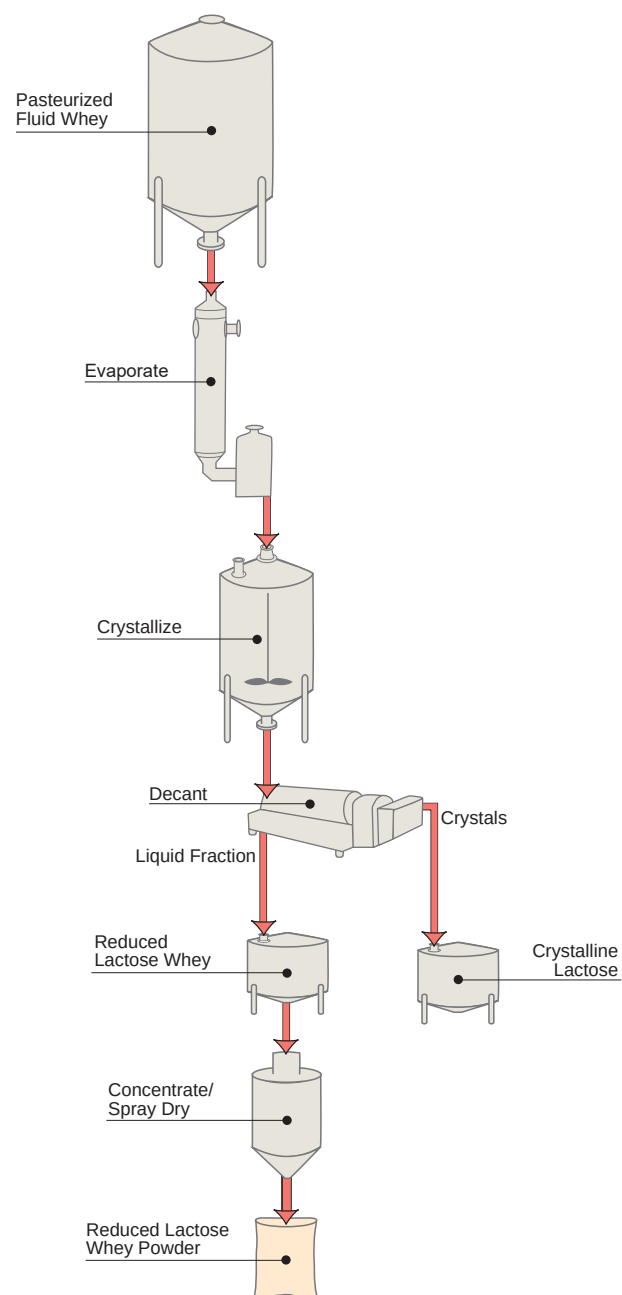
ADPI industry standard for reduced lactose whey

Component	Typical	Minimum	Maximum
	----- % -----		
Protein	18.0 - 24.0	-	25
Lactose	52.0 - 58.0	-	60
Ash	11.0 - 22.0	-	5
Fat	1.0 - 4.0	-	24
Moisture	3.0 - 4.0	-	5

General Process for Manufacture of Reduced Lactose Whey



Manufacture of Reduced Lactose Whey



Typical composition and characteristics

Reduced lactose whey*

♦ Typical composition

Protein (db)	24%
Moisture	4%
Lactose	56%
Fat	2%
Ash	15%

♦ Characteristics

Color: cream to dark cream
Flavor: typical whey

♦ Storage

<27 C, <65% rh
12 months

Mineral concentrated whey*

♦ Typical composition

Protein (db)	21.3%
Moisture	3%
Lactose	56%
Fat	2%
Ash	17%

♦ Characteristics

Color: cream to dark cream
Flavor: typical whey

♦ Storage

<27 C, <65% rh
12 months

*Exact composition depends on specifications

Product Labeling

Reduced Lactose Whey (_____ % lactose)

The percent of lactose is declared in 5% increments OR as actual percentage provided an analysis of the product is supplied.

Lactose Hydrolyzed Whey

Lactose hydrolyzed whey is produced by hydrolyzing a portion of the lactose to glucose and galactose by addition of lactase enzyme. The product will have increased sweetness and decreased tendency for lactose crystallization as compared to whey. The amount of lactose converted to glucose and galactose depends on product specifications.

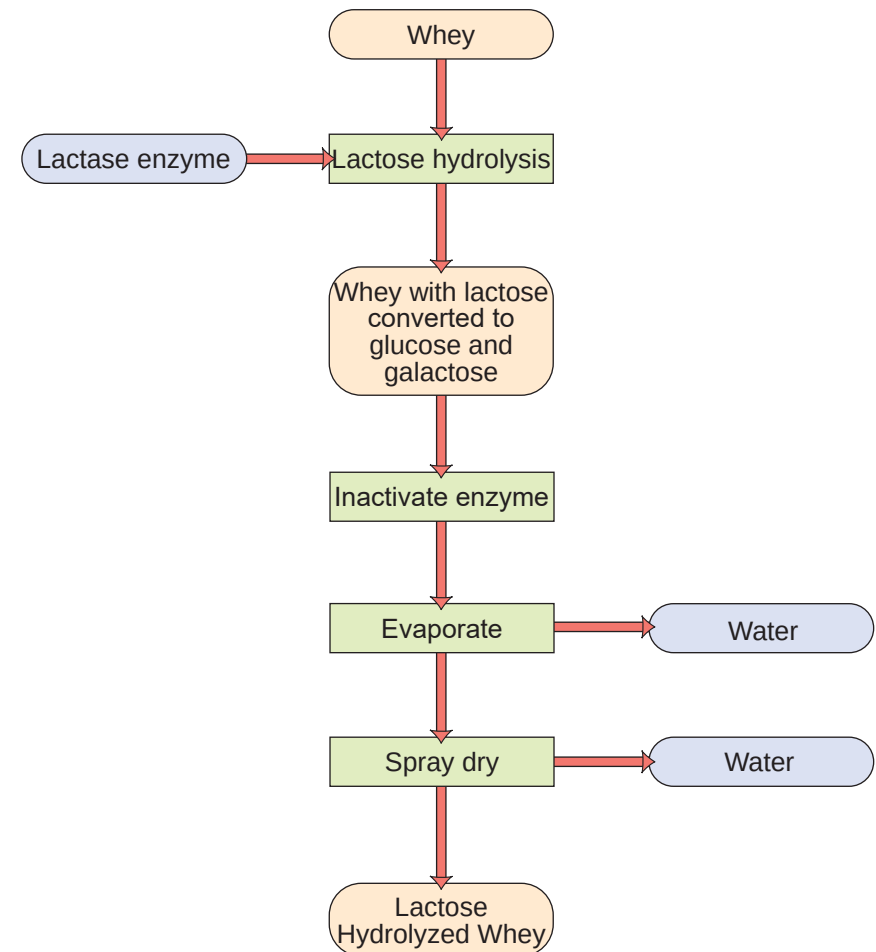
Lactose hydrolyzed whey is difficult to dry and the powder may tend to become sticky with storage.

Regulations

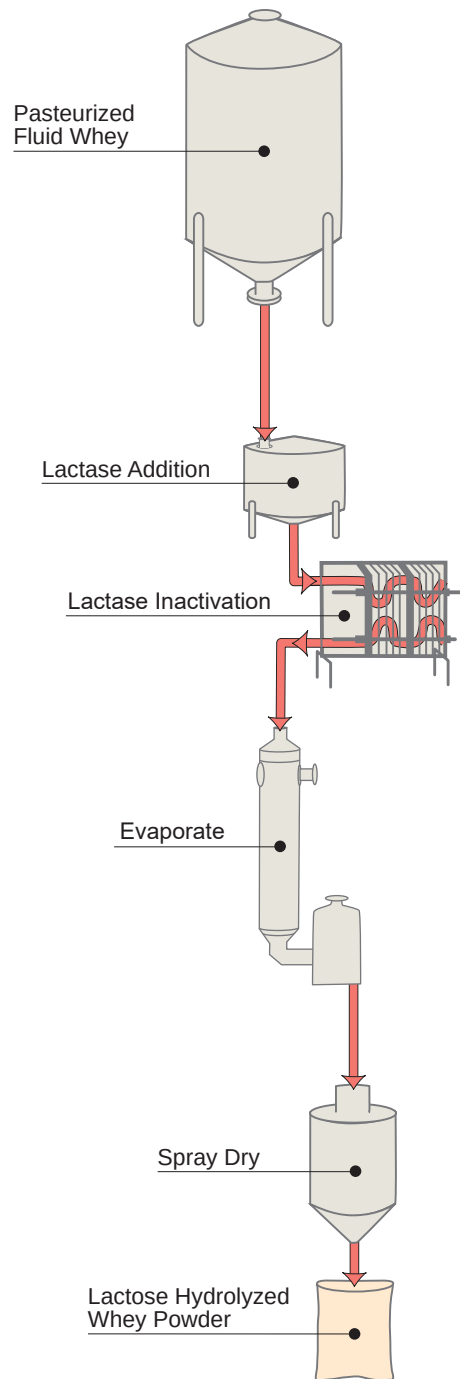
- ♦ None, product not defined

Animal Feed Definition (Association of Animal Feed Control Officials)
Dried Hydrolyzed Whey - is the residue obtained by drying lactase enzyme hydrolyzed whey. It contains a minimum of 30% total of glucose and galactose.

General Process for Manufacture of Lactose Hydrolyzed Whey



Manufacture of Lactose Hydrolyzed Whey



Typical composition and characteristics
Not available

Protein Hydrolyzed Whey

Protein hydrolyzed whey has a portion of the whey protein hydrolyzed into smaller fragments. Enzymes such as trypsin, chymotrypsin, etc. are used.

There is considerable variation in the product profile which typically is application driven. Protein hydrolyzed whey products designed for heat stability often will have less hydrolysis (larger molecular weight fragments) than products for infant nutrition.

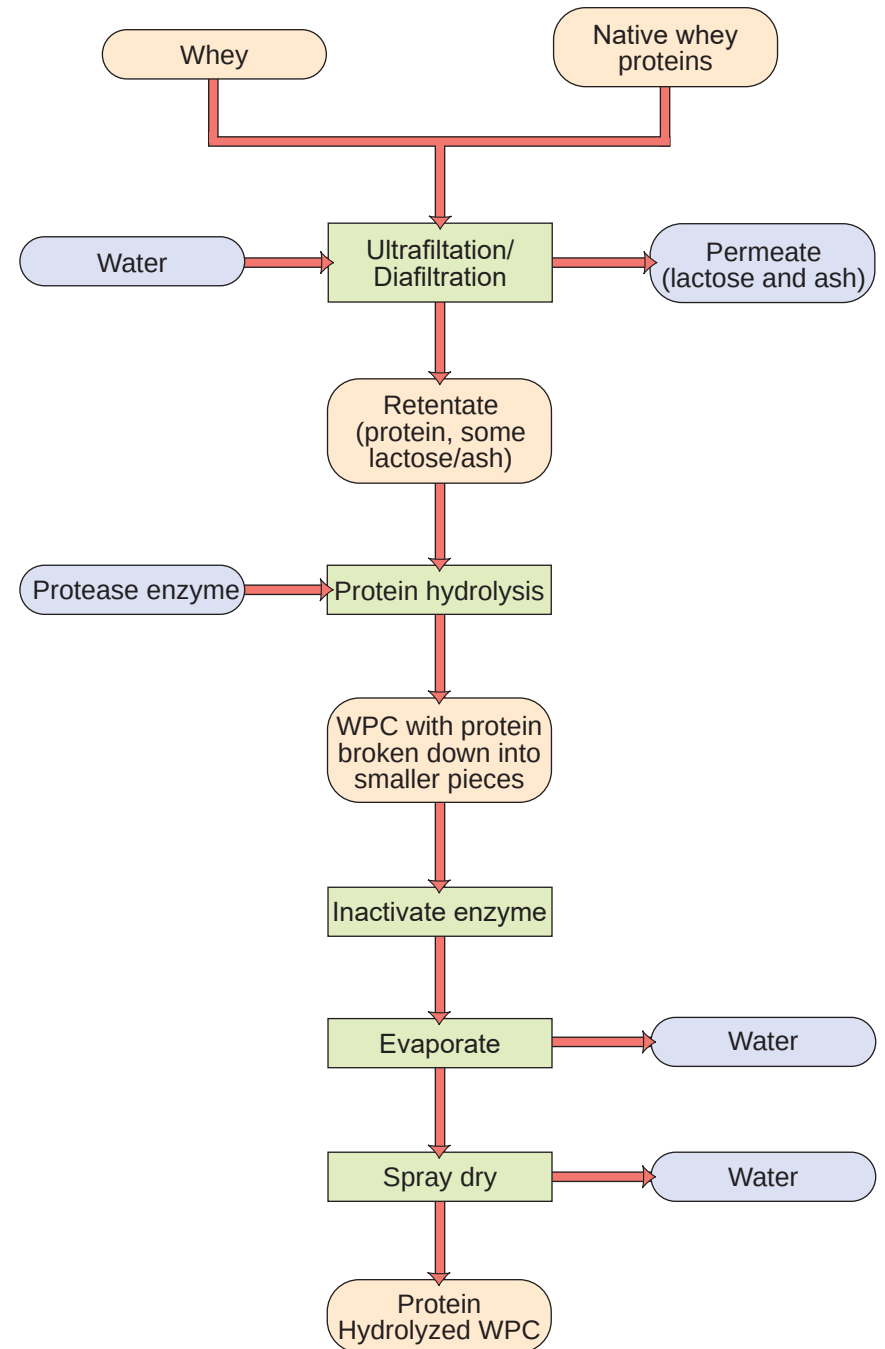
The specific enzymes used, sequence of enzymes, reaction time, reaction temperature, etc are all important and can affect the type of protein fragments produced.

Manufacturers typically use whey protein concentrates (WPC) as starting material to produce protein hydrolyzed products with higher protein contents. The whey protein concentrates may be derived from either whey or milk (native whey protein)

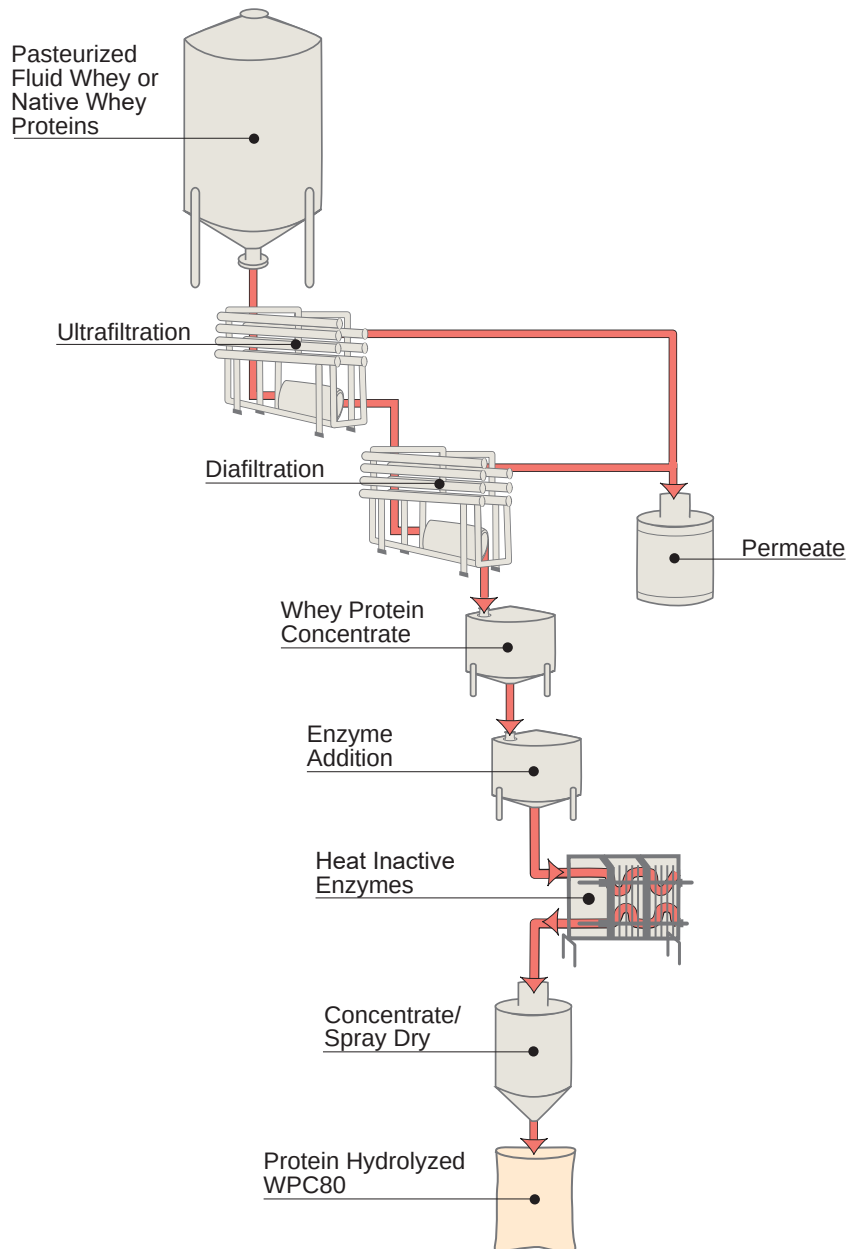
Regulations

- ♦ None, product not defined

General Process for Manufacture of Protein Hydrolyzed Whey



Manufacture of Protein Hydrolyzed Whey



Typical composition and characteristics

Hydrolyzed WPC 80 #1*

♦ Typical composition

Protein (db)	81%
Moisture	4%
Lactose	4%
Fat	6%
Ash	4%

♦ Characteristics

Color: cream
Flavor: na

♦ Storage

<25 C, <75% rh
24 months

Hydrolyzed WPC 80 #2*

♦ Typical composition

Protein (db)	81%
Moisture	4%
Lactose	na%
Fat	5%
Ash	3%

♦ Characteristics

Color: cream
Flavor: na
pH 8.0

♦ Storage

<27 C, <75% rh

Hydrolyzed WPI*

♦ Typical composition

Protein (db)	91%
Moisture	4%
Lactose	3%
Fat	<1%
Ash	2%

♦ Characteristics

Color: cream to dark cream
Flavor: na
pH 6.5

♦ Storage

na

*Exact composition depends on manufacturer

Typical Product Labeling

Whey protein hydrolysate, Whey protein concentrate

Lactalbumin

Lactalbumin is produced by precipitating whey proteins. Heat and changes in pH may be used to denature the whey proteins so that they aggregate and separate from the other whey constituents.

Lactalbumin is different from α -lactalbumin.

Proteins are not soluble because they have been denatured.

Although some products in the US are referred to as lactalbumin these products are different in composition and functionality than the product described here. Lactalbumin in this form is typically a European product and is not produced in the US.

Final product composition and functionality depends on:

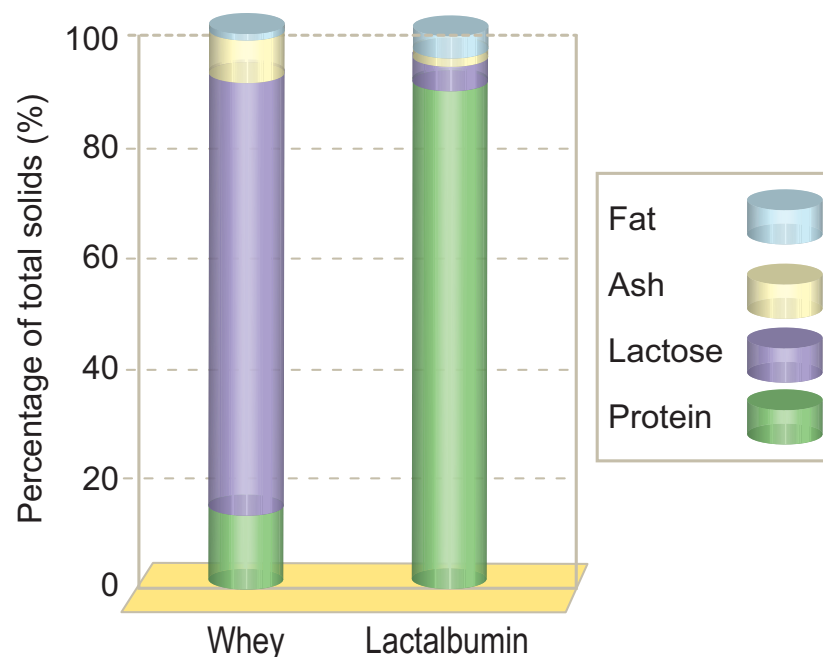
- ◆ Temperature/holding time
- ◆ pH
- ◆ Whey type
- ◆ Calcium concentration
- ◆ Dryer used

Regulations

- ◆ None, product not defined

Animal Feed Definition (Association of Animal Feed Control Officials)
Dried Lactalbumin - is obtained from drying coagulated protein from whey. It contains a minimum of 80% crude protein on a moisture-free basis.

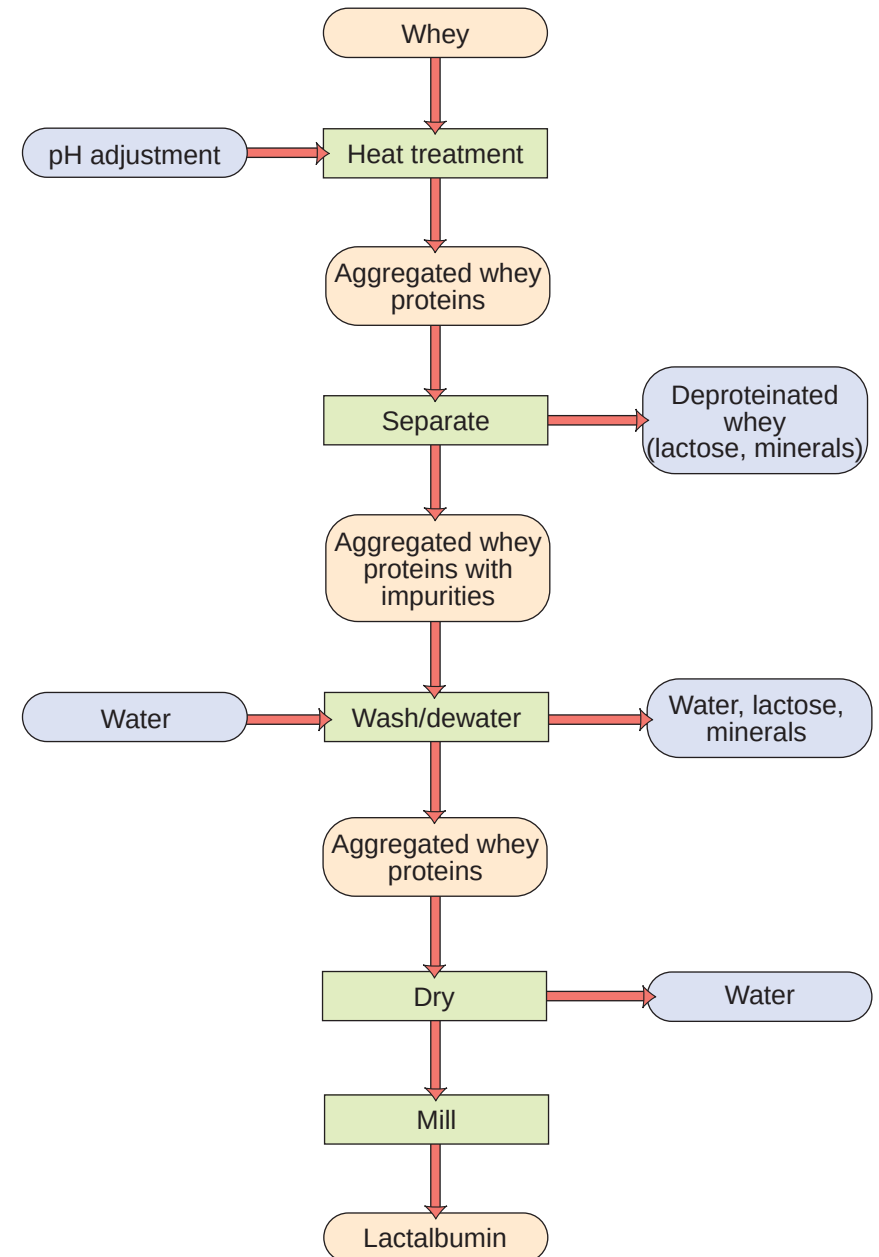
Lactalbumin composition



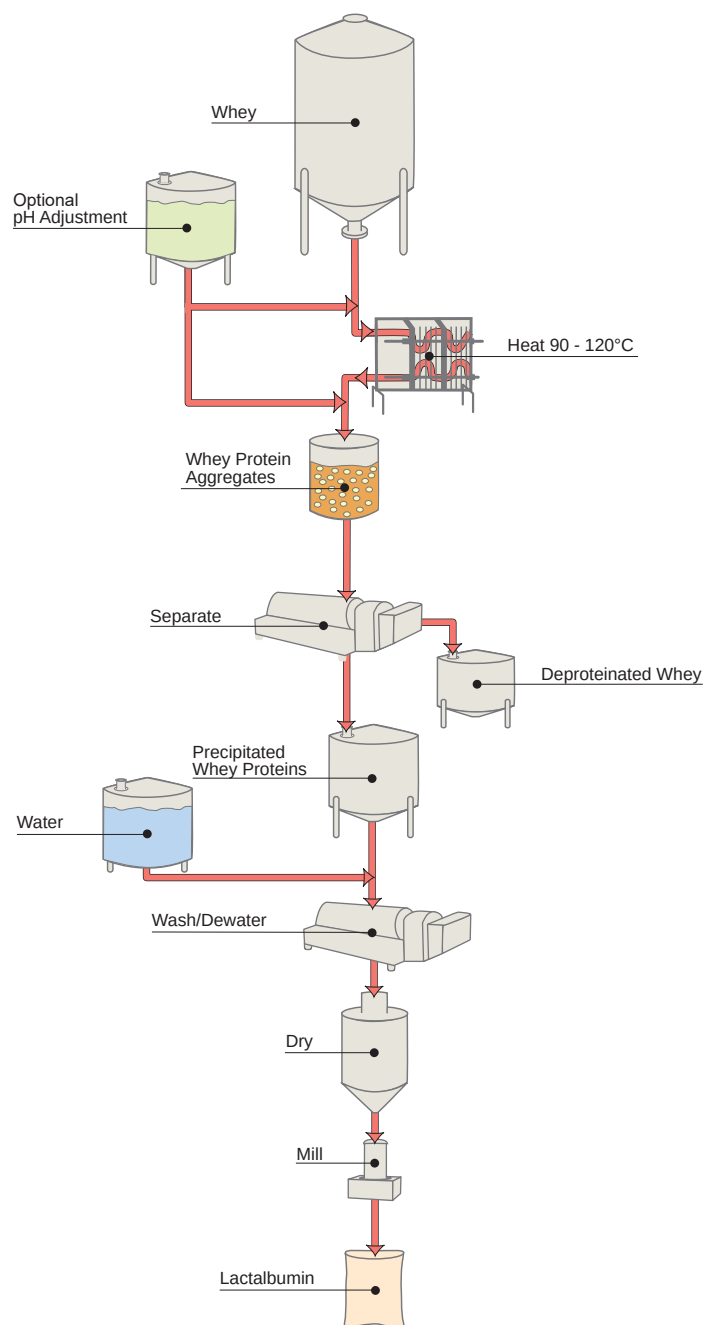
General composition of lactalbumin

Component	Lactalbumin
	----- % -----
Protein	85
Lactose	6
Ash	3
Fat	2
Moisture	4

General Process for Manufacture of Lactalbumin



Manufacture of Lactalbumin



Typical composition and characteristics

Lactalbumin

♦ Typical composition		♦ Characteristics
Protein (db)	89%	not available
Moisture	4%	
Lactose	5%	♦ Storage
Fat	2%	not available
Ash	3%	

Whey Protein Concentrate (WPC)

Produced by a pressure driven process known as ultrafiltration (UF). Ultrafiltration uses semipermeable membranes to separate the components in whey.

Lactose and minerals are removed until the desired protein content is reached. Permeate is a by product of this process. Higher protein WPCs require the use of water, in a process known as diafiltration (DF), to remove greater amounts of lactose and ash.

Proteins are not denatured by the UF process therefore WPCs can be very soluble.

Sweet or acid whey may be used, however, WPCs typically are produced from sweet whey.

Whey protein concentrates (ADPI/CFR definition) - is the substance obtained by the removal of sufficient non-protein constituents from whey so that the finished dry product contains not less than 25% protein. Whey protein concentrate is produced by physical separation techniques such as precipitation, filtration or dialysis. The acidity of the whey protein concentrate may be adjusted by addition of safe and suitable pH adjusting ingredients.

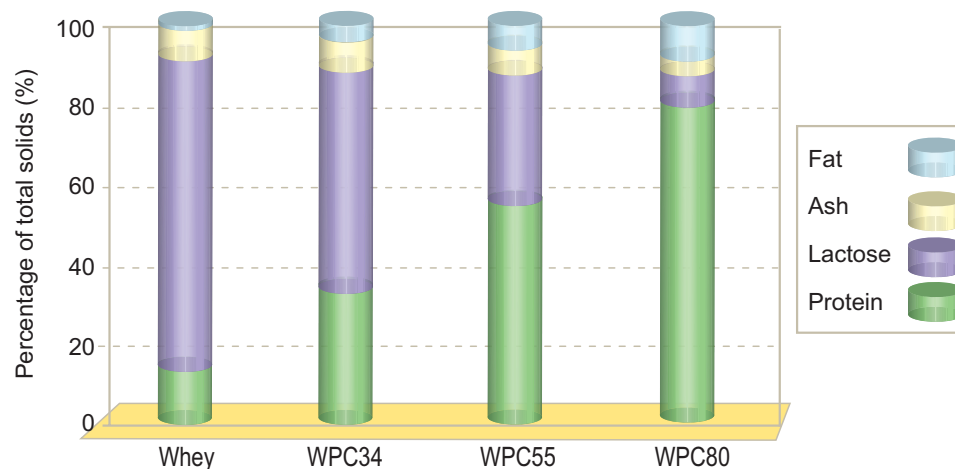
Regulations

- ♦ 21 CFR 184.1979c

ADPI Industry Standard

Animal Feed Definition (Association of Animal Feed Control Officials) Dried (Dry) Whey Protein Concentrate - is the product is obtained by removal or separation of water, lactose and/or minerals from whey by ultra-filtration, dehydration or other processes. It shall contain 25% minimum crude protein. The minimum percentage of crude protein and lactose and the maximum percentage of lactose must be prominently declared on the label.

Whey protein concentrate composition



General composition of whey protein concentrates (WPC)

Component	WPC 34	WPC 55	WPC 80
	----- % -----		
Protein	33	53	77
Lactose	52	31	9
Ash	7	6	4
Fat	4	6	6
Moisture	4	4	4

CFR specifications for whey protein concentrate (WPC)*

Component	Not less than	Not greater than
	----- % -----	
Milkfat	1	10
Protein	25	—
Lactose	—	60
Ash	2	15
Moisture	1	6

* 21 CFR 184.1979

ADPI industry standard for whey protein concentrate 34 (WPC 34)

Component	Typical	Minimum	Maximum
	----- % -----		
Protein*	34.0 - 36.0	33.5	-
Lactose	48.0 - 55.0	-	-
Ash	6.5 - 8.0	-	-
Fat	3.0 - 4.5	-	5
Moisture	3.0 - 5.0	-	6

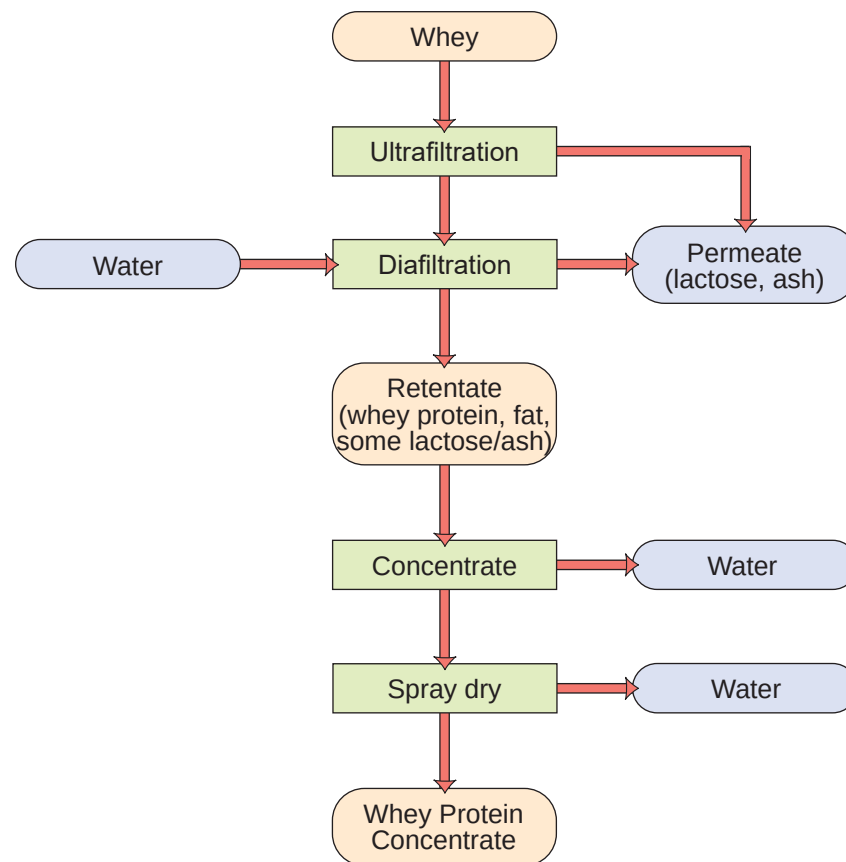
* Protein is reported on a dry basis. All other components are reported "as is".

ADPI industry standard for whey protein concentrate 80 (WPC 80)

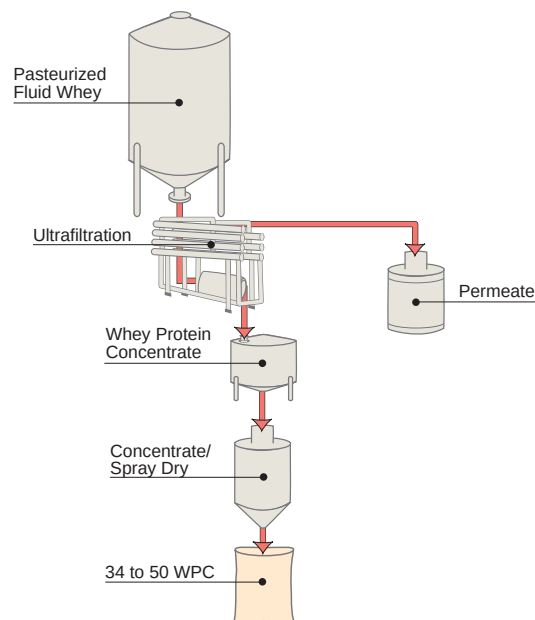
Component	Typical	Minimum	Maximum
	----- % -----		
Protein*	80.0 - 82.0	79.5	-
Lactose	4.0 - 10.0	-	-
Ash	3.0 - 5.0	-	-
Fat	4.0 - 8.0	-	10.0
Moisture	3.5 - 5.0	-	6.0

* Protein is reported on a dry basis. All other components are reported "as is".

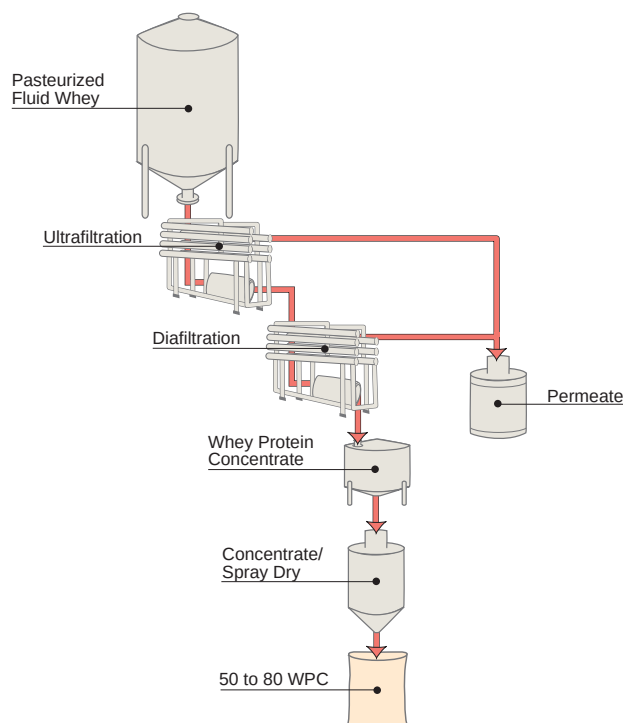
General Process for the Manufacture of Whey Protein Concentrate (WPC)



Manufacture of WPC 34 to 50



Manufacture of WPC 50 to 80



Typical composition and characteristics

WPC 34

- ♦ Typical composition

Protein (db)	34%
Moisture	4%
Lactose	52%
Fat	4%
Ash	7%
- ♦ Characteristics
 - Color: white to light cream
 - Flavor: bland, clean
 - pH 6.0 - 6.7
- ♦ Storage
 - <27 C, <65% rh
 - 9 - 12 months

WPC 55

- ♦ Typical composition

Protein (db)	55%
Moisture	4%
Lactose	31%
Fat	6%
Ash	6%
- ♦ Characteristics
 - Color: white to light cream
 - Flavor: bland, clean
 - pH 6.0 - 6.7
- ♦ Storage
 - <27 C, <65% rh
 - 9 - 12 months

WPC 80

- ♦ Typical composition

Protein (db)	80%
Moisture	4%
Lactose	9%
Fat	6%
Ash	4%
- ♦ Characteristics
 - Color: white to light cream
 - Flavor: bland, clean
 - pH 6.0 - 6.7
- ♦ Storage
 - <27 C, <65% rh
 - 9 - 12 months

Product Labeling

Whey Protein Concentrate (____ % protein)

The percent of protein is declared in 5% increments OR as actual percentage provided an analysis of the product is supplied.

Whey Protein Isolate (WPI)

Whey protein concentrates with protein contents on a dry basis greater than 90% are referred to as whey protein isolates (WPI).

WPIs are produced by one of two methods:

- ♦ MF/UF
- ♦ Ion exchange

Protein composition of the WPI will depend on the method used. A significant difference is the presence of glycomacropeptide (GMP). GMP is a protein fragment resulting from the action of rennet on casein during cheesemaking. The ion exchange process does not capture GMP and therefore GMP is absent from WPI produced by ion exchange unless it is added back. MF/UF process retains GMP so that it is present in the resulting WPI.

Reports in the literature indicate the ratio of specific whey proteins also may differ between MF/UF and ion exchange produced WPIs. The producer of the specific WPI should be contacted for further information should the precise protein profile be important to the end user.

Whey protein isolate (ADPI definition) - is the substance produced by the removal of sufficient non-protein components from whey so that the finished dry product contains not less than 90% protein on a dry basis. Whey protein isolate is produced by separation techniques such as precipitation, membrane filtration and/or ion exchange. Whey protein isolate can be used as liquid or as a dry product. The acidity of whey protein isolate may be adjusted by the addition of safe and suitable pH-adjusting ingredients.

Types

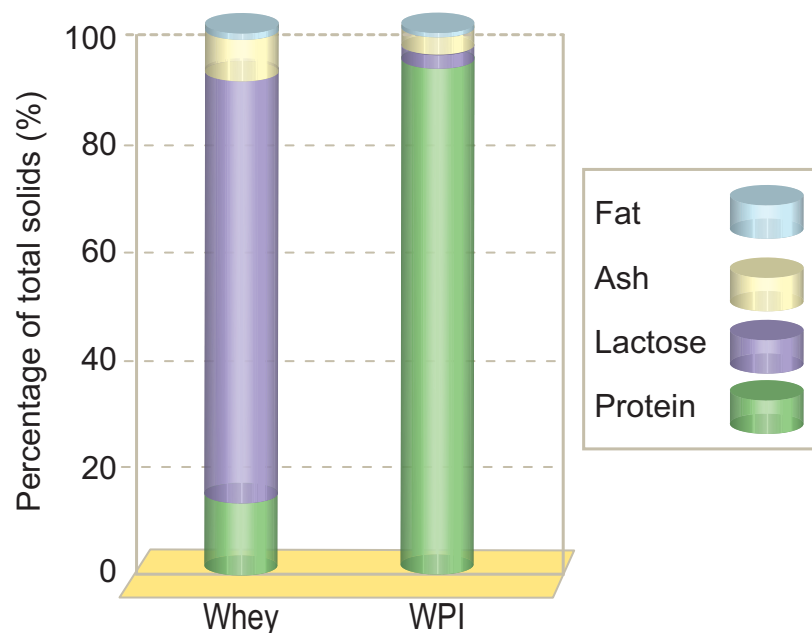
- ♦ Process used
 - MF/UF
 - Ion exchange
- ♦ Final form
 - Ordinary (non-agglomerated, non-instantized)
 - Instantized

Regulations

FDA GRAS Notice No. 37 (2000)

ADPI Industry Standard

Whey protein isolate composition (WPI)



General composition of whey protein isolate (WPI)

Component	WPI
	----- % -----
Protein	89
Lactose	2
Ash	3
Fat	1
Moisture	5

FDA specifications for whey protein isolate (WPI)*

Component	Not less than	Not greater than
	----- % -----	----- % -----
Milkfat	na	na
Protein	90	-
Lactose	-	6
Ash	-	6
Moisture	-	6

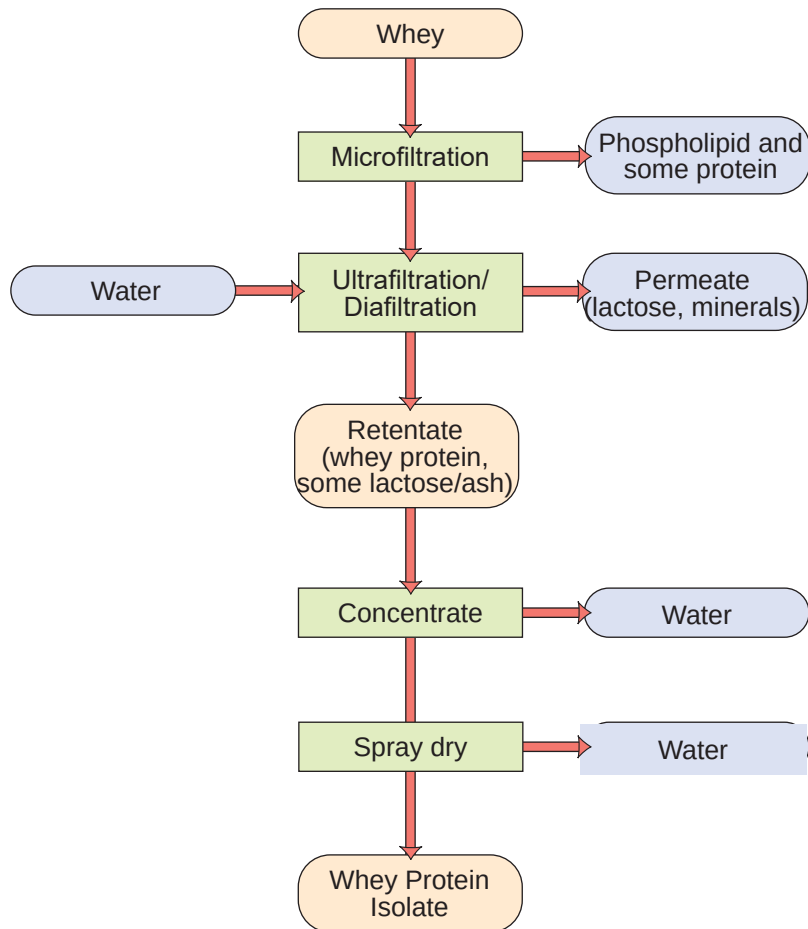
* FDA GRAS Notice No. 37 (2000)

ADPI industry standard for whey protein isolate (WPI)

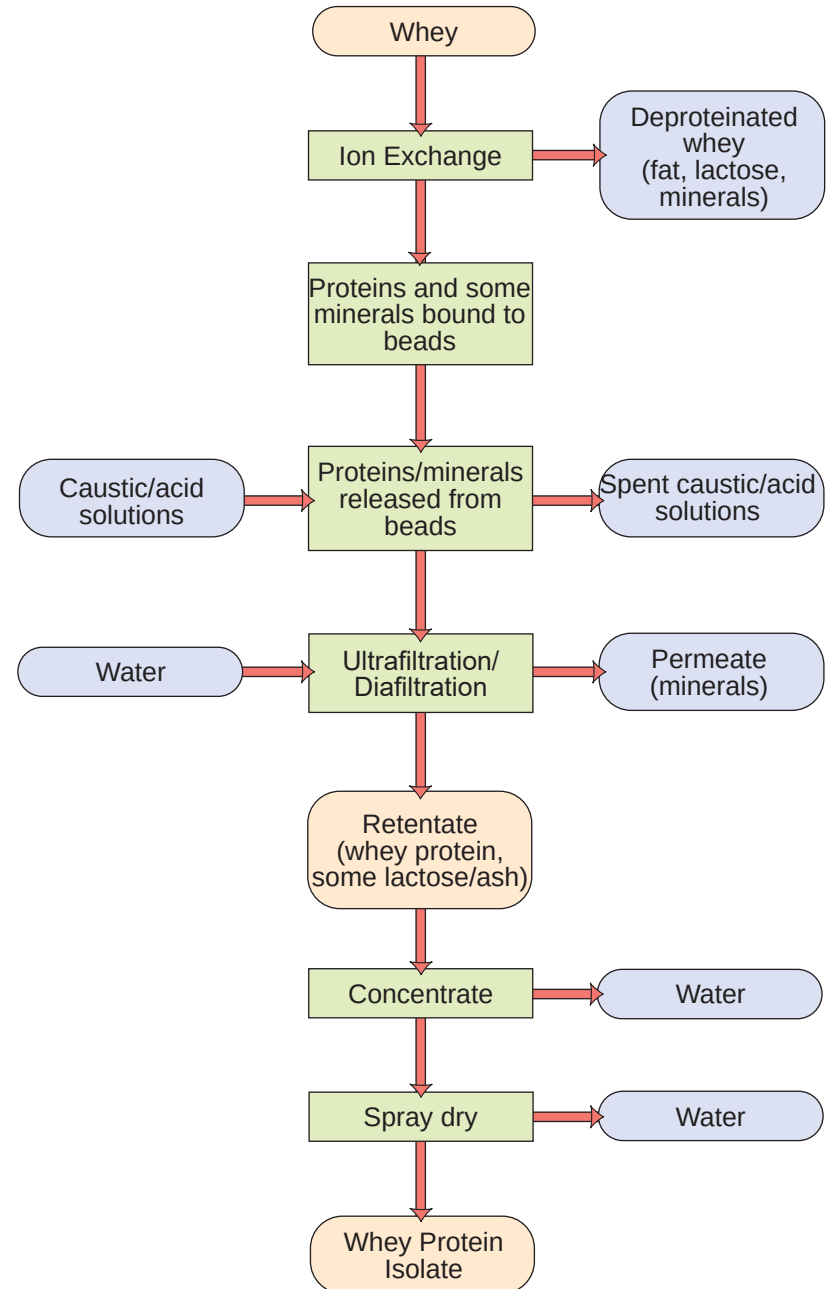
Component	Typical	Minimum	Maximum
	----- % -----	----- % -----	----- % -----
Protein*	90.0 - 92.0	89.5	-
Lactose	0.5 - 1.0	-	-
Ash	2.0 - 3.0	-	-
Fat	0.5 - 1.0	-	1.5
Moisture	4.0 - 5.0	-	6.0

* Protein is reported on a dry basis. All other components are reported "as is".

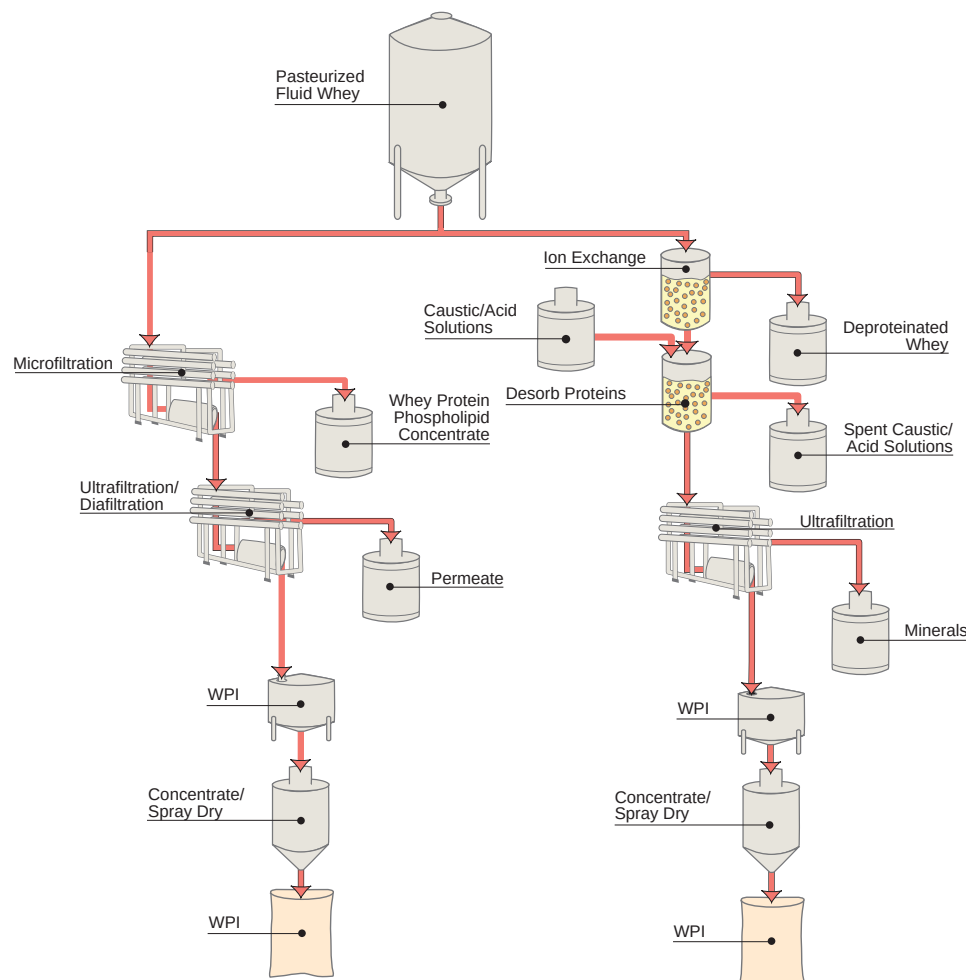
General Process for the Manufacture of Whey Protein Isolate (WPI) by Membranes



General Process for the Manufacture of Whey Protein Isolate (WPI) by Chromatography



Manufacture of Whey Protein Isolate (WPI)



Typical composition and characteristics

Whey Protein Isolate (WPI)

- ♦ Typical composition

Protein (db)	93%
Moisture	5%
Lactose	3%
Fat	1%
Ash	2%
- ♦ Characteristics
 - Color: white to cream
 - Flavor: bland, clean
- ♦ Storage
 - <27 C, <65% rh
 - 12 months

Whey Protein Isolate (WPI) - Instantized

- ♦ Typical composition

Protein (db)	93%
Moisture	5%
Lactose	3%
Fat	1%
Ash	2%
- ♦ Characteristics
 - Color: off white to cream
 - Flavor: bland, clean
- ♦ Storage
 - <27 C, <65% rh
 - 12 months

* Composition does not include soy lecithin (<1.5%) added to instantized product.

Product Labeling

Whey Protein Isolate (_____ % protein)

The percent of protein is declared in 2% increments OR as actual percentage provided an analysis of the product is supplied.

Heat Stable Whey Protein Concentrate

Heat stable whey protein concentrates have increased tolerance to temperatures that would lead to denaturation/floculation of whey proteins. The method used to achieve increased stability often is a proprietary process. Whey protein concentrates modified for heat stability typically have a protein content between 34 and 80%.

General approaches to increased heat stability:

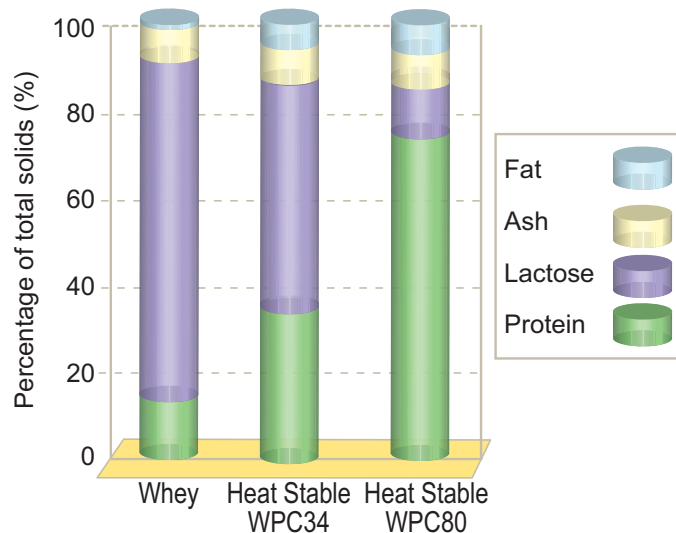
- ♦ Addition of phosphate salts
- ♦ Protein hydrolysis

Phosphate salts limit the ability of whey proteins to interact and flocculate by chelating calcium and increasing pH. Hydrolysis of whey proteins results in protein fragments that are too small to appear as floc.

Regulations

- ♦ None, product not defined

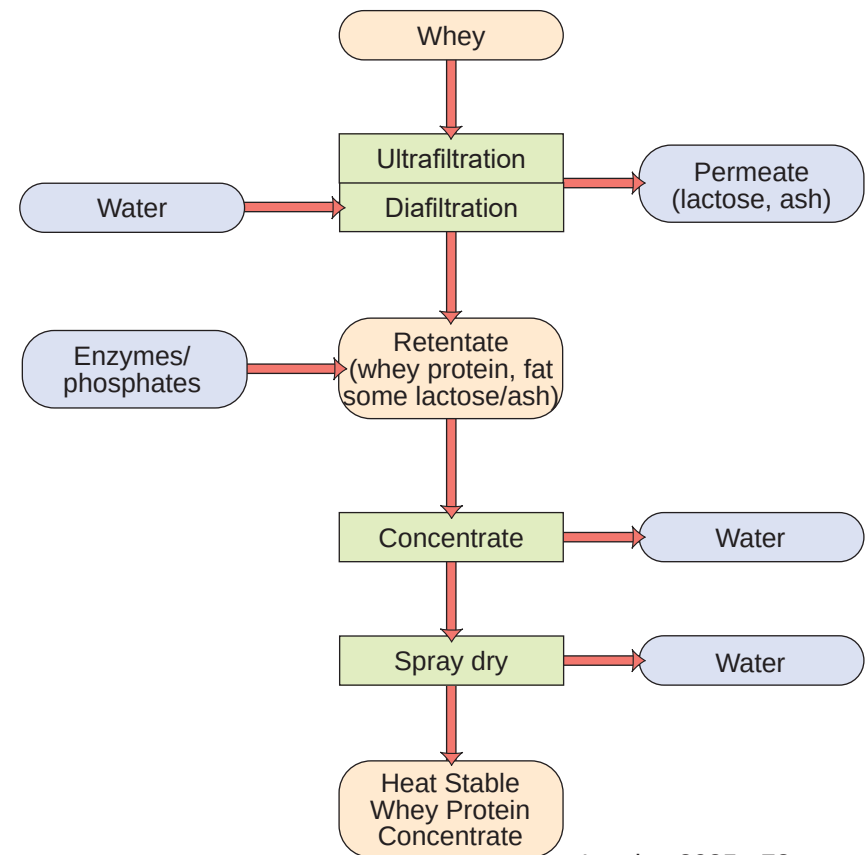
Heat stable whey protein concentrate composition



General composition of heat stable whey protein concentrate

Component	Heat stable WPC34	Heat stable WPC80
	----- % -----	
Protein	34	77
Lactose	51	8
Ash	7	6
Fat	4	5
Moisture	4	4

General Process for the Manufacture of Heat Stable Whey Protein Concentrate



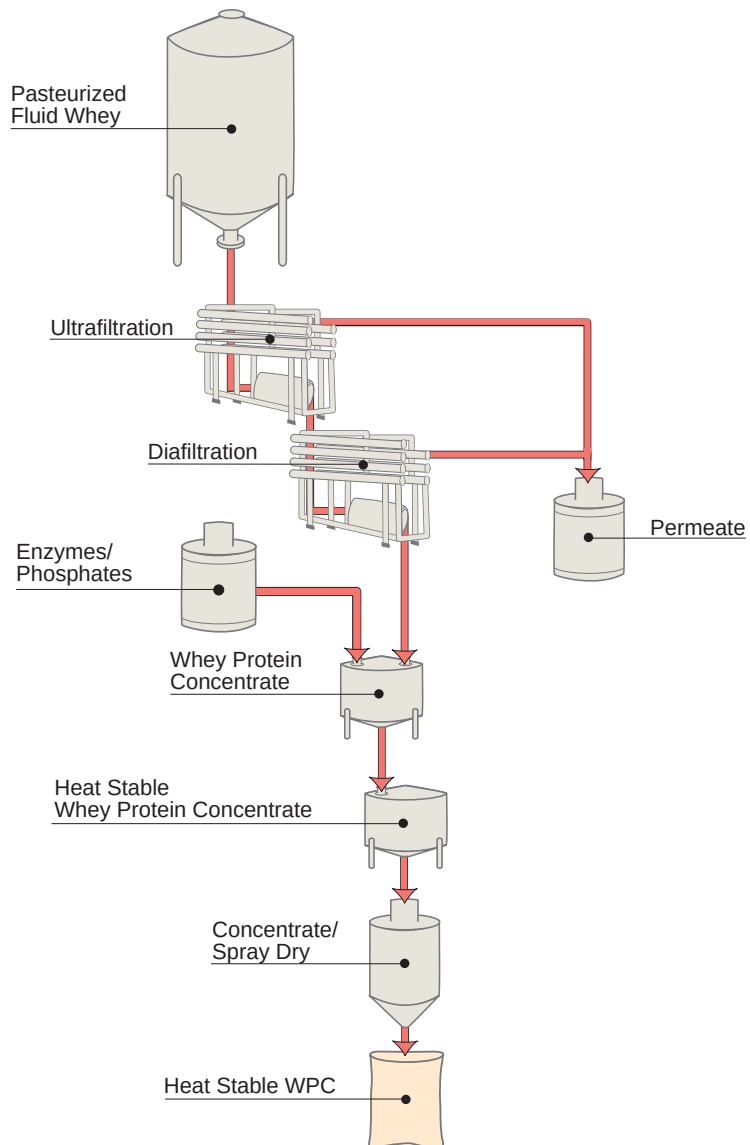
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Manufacture of Heat Stable Whey Protein Concentrate



Typical composition and characteristics

Heat stable WPC34*

♦ Typical composition

Protein (db)	35%
Moisture	4%
Lactose	51%
Fat	4%
Ash	7%

♦ Characteristics

Color: cream
Flavor: typical dairy
pH 6.9

♦ Storage

<27 C, <65% rh
18 months

Heat stable WPC80*

♦ Typical composition

Protein (db)	81%
Moisture	4%
Lactose	7%
Fat	5%
Ash	6%

♦ Characteristics

Color: cream
Flavor: typical dairy
pH 6.8

♦ Storage

<27 C, <75% rh

* Exact composition depends on manufacturer

Whey Protein Phospholipid Concentrate (WPPC)

Whey protein phospholipid concentrates (WPPC) are a relatively new dairy ingredient and are not defined. They also are known as procream, reduced lactose concentrated whey and concentrated whey protein.

Whey protein phospholipid concentrates are a co-product of WPI production. Producing WPI by ultrafiltration requires an additional fat removal step since the amount of residual fat in whey would limit the possible protein content of the WPI to less than 90%. One method of fat removal is microfiltration. The MF process retains the undesired residual fat with the resulting permeate continuing on for manufacture into WPI. Some of the protein in the whey is retained along with the residual fat. It is this mixture of fat and protein that is known as whey protein phospholipid concentrate. The ratio of protein to fat will vary depending on the conditions used during microfiltration.

Proteins are not denatured by either UF or MF, therefore, the proteins remain soluble. The composition of the fat will more closely resemble the composition of whey cream as compared to the fat profile found in milk.

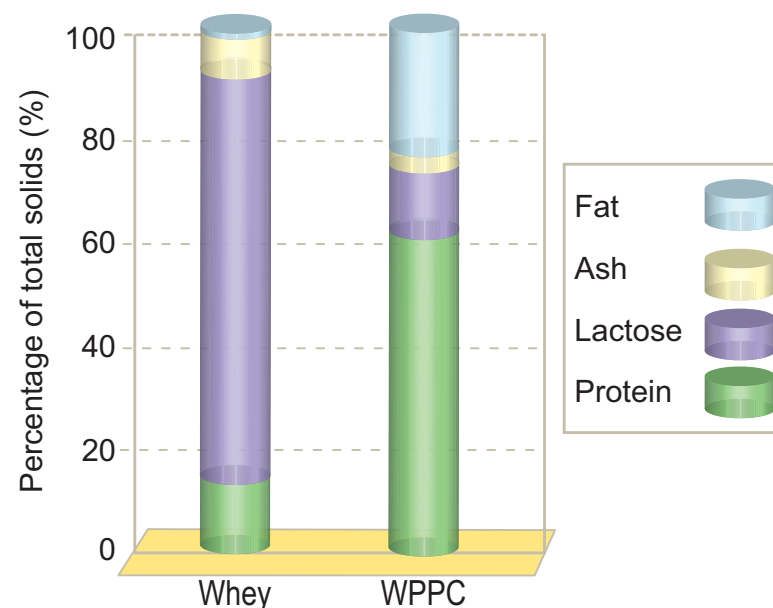
Whey protein phospholipid concentrate (ADPI definition) - is a product obtained through microfiltration of whey which concentrates whey proteins and whey phospholipids. The acidity of WPPC may be adjusted by addition of safe and suitable pH-adjusting ingredients.

Regulations

♦ None, product not defined

ADPI Industry Standard

Whey protein phospholipid concentrate composition (WPPC)



General composition of whey protein phospholipid concentrate (WPPC)

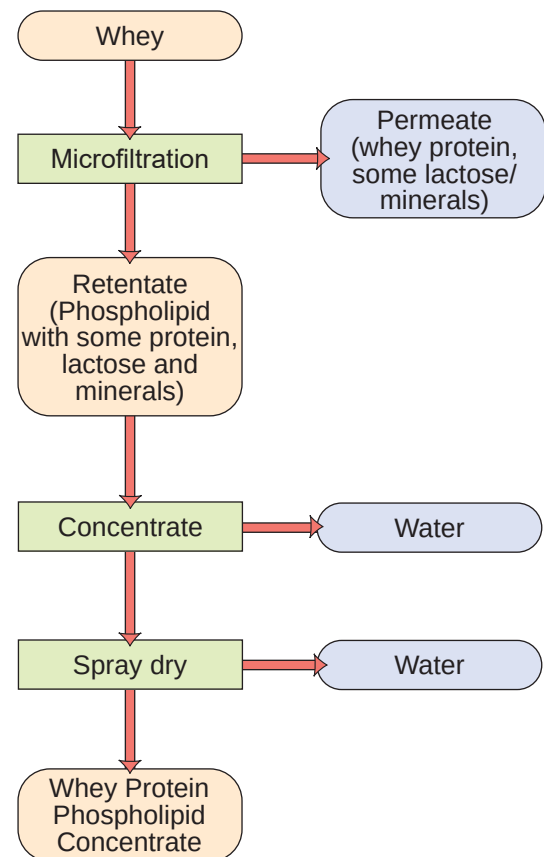
Component	WPPC
	----- % -----
Protein	60
Lactose	11
Ash	5
Fat	20
Moisture	4

ADPI industry standard for whey protein phospholipid concentrate (WPPC)

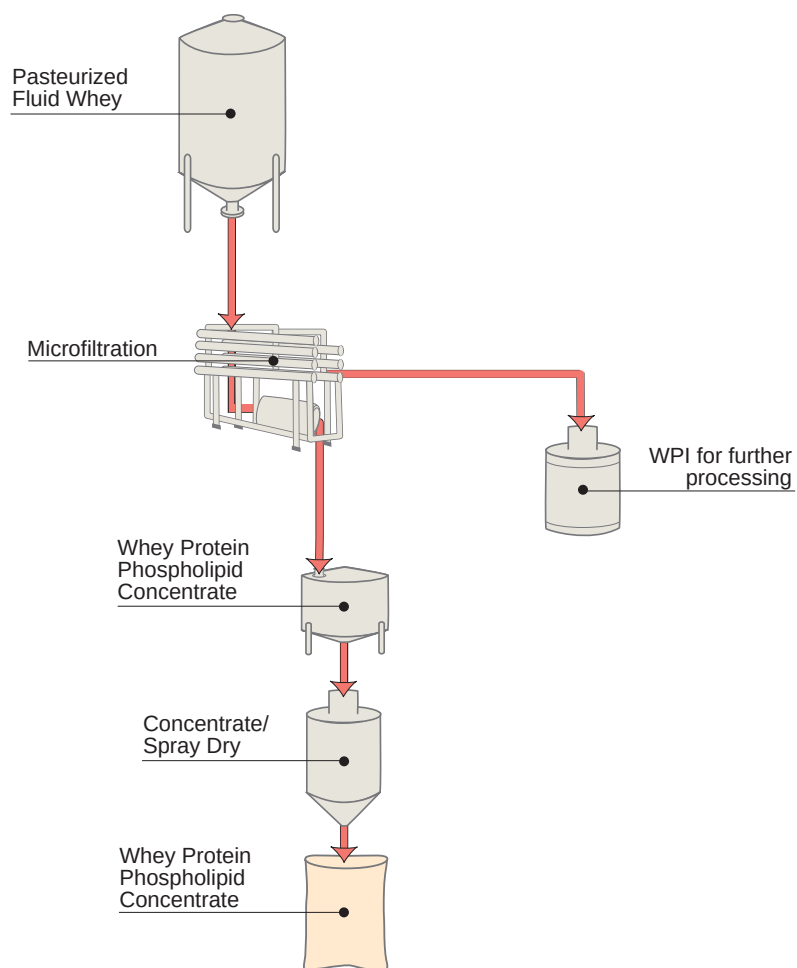
Component	Typical	Minimum	Maximum
	----- % -----		
Protein*	na	50	-
Lactose	na	-	-
Ash	na	-	8
Fat	na	12	-
Moisture	na	-	6

* Protein is reported on a dry basis. All other components are reported "as is".

General Process for the Manufacture of Whey Protein Phospholipid Concentrate (WPPC)



Manufacture of Whey Protein Phospholipid Concentrate (WPPC)



Typical composition and characteristics

WPPC*

♦ Typical composition		♦ Characteristics
Protein (db)	62%	Color: light cream
Moisture	4%	Flavor: clean, slightly sweet
Lactose	11%	
Fat	20%	♦ Storage
Ash	5%	<25 C, <65% rh
		12 months

*Exact composition depends on manufacturer

Product Labeling

It is recommended that the product be labeled as "Whey Protein Phospholipid Concentrate".

An alternate name could be High Fat Whey Protein Concentrate

Alpha-Lactalbumin Enriched Whey Protein Concentrate and Whey Protein Isolate

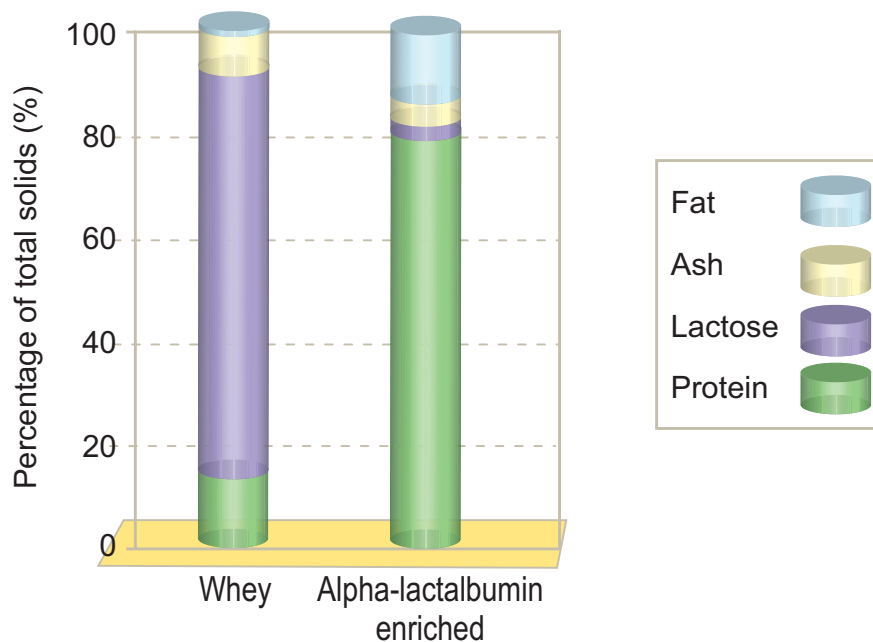
Alpha-lactalbumin enriched whey protein concentrate is a relatively new dairy ingredient and is not defined. The product is produced by a patented process that typically involves the use of membrane processes such as UF/MF. Proteins are not denatured by the UF/MF process, therefore, the proteins remain soluble.

Alpha-lactalbumin enriched whey protein concentrate has a higher concentration of alpha-lactalbumin as compared to beta-lactoglobulin (the other major protein in whey). The product is said to have high heat stability and solubility.

Regulations

- ♦ None, product not defined

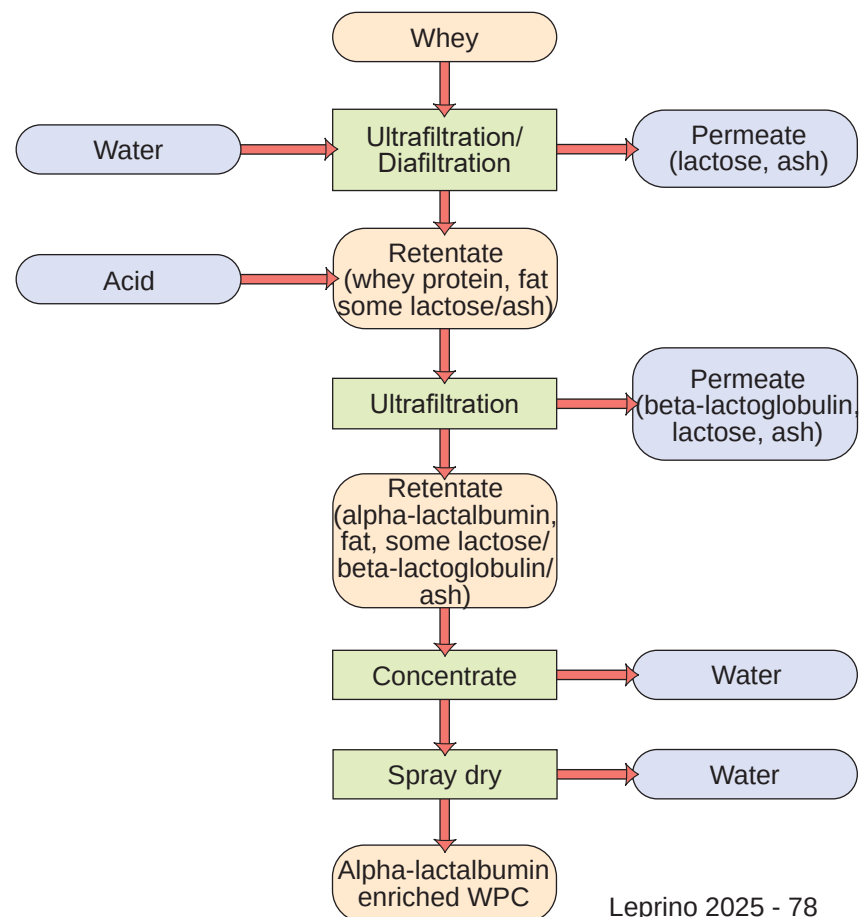
Alpha-lactalbumin enriched whey protein concentrate composition



General composition of alpha-lactalbumin enriched whey protein concentrate

Component	Alpha-Lac enriched
	----- % -----
Protein	79
Lactose	2
Ash	3
Fat	12
Moisture	4

General Process for the Manufacture of Alpha-Lactalbumin Enriched Whey Protein Concentrate



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ADPI industry standard for alpha-lactalbumin whey protein concentrate

Component	Typical	Minimum	Maximum
	----- % -----		
Protein*	34.0 and 80	33.5	
Alpha-lactalbumin**		28	
Lactose			60
Ash			10
Fat			15
Moisture	4 - 5		6

* Protein is reported on a dry basis. All other components are reported "as is".

** Reported as a % of protein

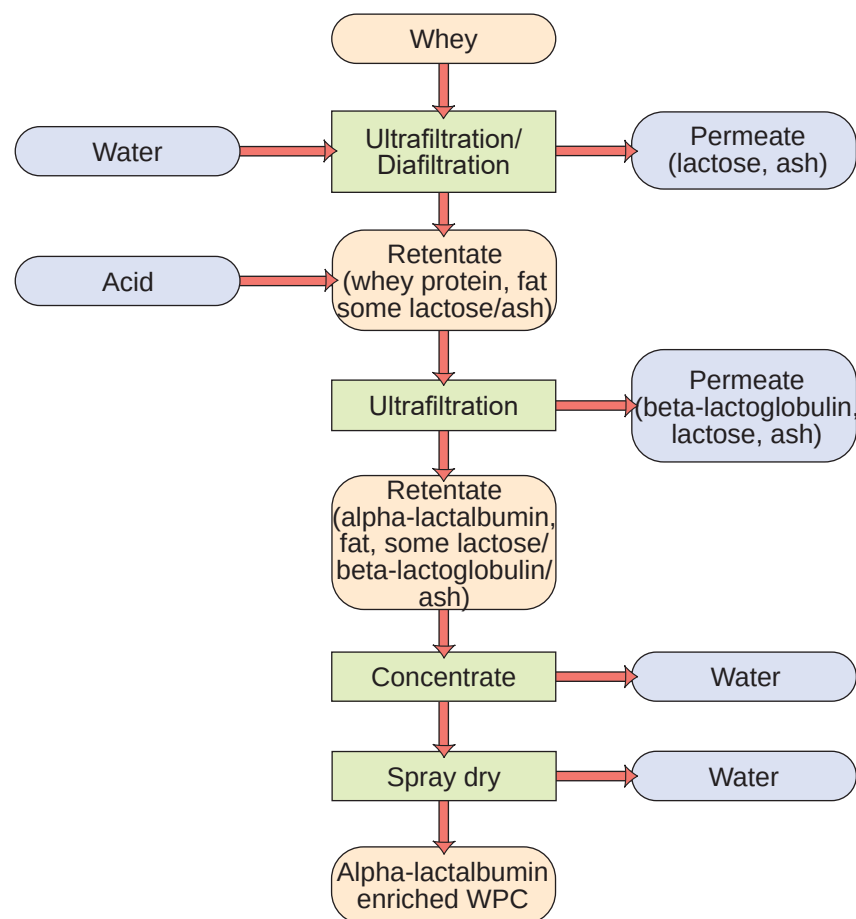
ADPI industry standard for alpha-lactalbumin whey protein isolate

Component	Typical	Minimum	Maximum
	----- % -----		
Protein*	90 - 92	89.5	
Alpha-lactalbumin**		28	
Lactose	0.5 - 1.0		
Ash	2.0 - 3.5		
Fat	0.5 - 1.0		1.5
Moisture	4 - 5		6

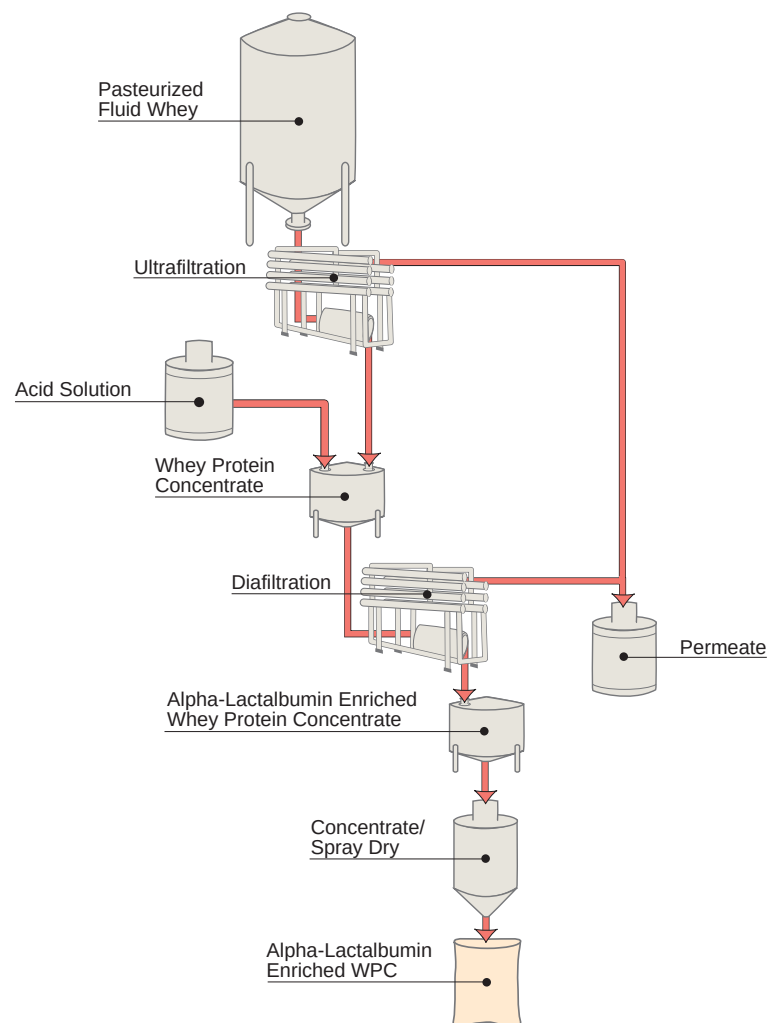
* Protein is reported on a dry basis. All other components are reported "as is".

** Reported as a % of protein

General Process for the Manufacture of Alpha-Lactalbumin Enriched Whey Protein Concentrate



Manufacture of Alpha-Lactalbumin Enriched Whey Protein Concentrate



Typical composition and characteristics

Alpha-Lactalbumin Enriched Whey Protein Concentrate

♦ Typical composition*		♦ Characteristics
Protein (db)	81%	Color: light cream
α-lactalbumin**	30%	Flavor: bland
β-lactoglobulin**	18%	
Moisture	4%	♦ Storage
Lactose	1%	<25 C, <75% rh
Fat	12%	24 months
Ash	3%	

* Exact composition depends on manufacturer

** As is basis

Typical ratio of α-lactalbumin to β-lactoglobulin 27:73

Enriched ratio of α-lactalbumin to β-lactoglobulin 62:38

Individual Whey Proteins

Individual proteins are produced by ion exchange/chromatographic methods. The desired protein typically is captured on special “beads” or membranes while the remainder of the whey proteins proceeds unhindered through the vessel. Special solutions are then used to release the captured proteins. The desired proteins typically have a very high purity especially as compared to enriched products that have increased concentrations of a particular protein or group of proteins.

α-Lactalbumin – makes up approximately 20 – 25% of the whey proteins. Denatures at 144°F (62°C). Binds calcium which stabilizes it against denaturation.

Lactoferrin - is an iron binding protein. Present at 30 – 100 mg/L in whey. Lactoferrin is not denatured by standard pasteurization (72°C for 15 seconds).

Lactoperoxidase – is an enzyme with antimicrobial ability. It is present in whey at approximately 1 – 30 mg/L and is considered to be relatively heat resistant.

Glycomacropeptide (GMP) – is a peptide that is also known as casein macropeptide (CMP). The peptide is formed when rennet clips off a piece of κ-casein during cheese manufacture. GMP therefore is present only in whey that is produced using rennet.

Types

- ♦ α-Lactalbumin
- ♦ Lactoferrin
- ♦ Lactoperoxidase
- ♦ Glycomacropeptide (GMP)

Regulations

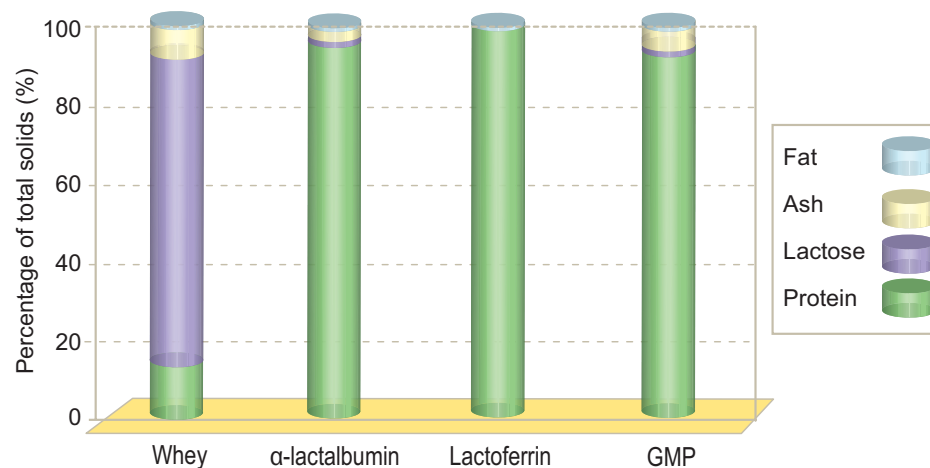
- ♦ Lactoferrin
FDA GRAS Notice No. 42 (2001)
- ♦ Other proteins
None, products not defined

ADPI Industry Standard for lactoferrin derived from colostrum or milk

Colostrum lactoferrin - lactoferrin derived from fresh colostrum

Lactoferrin - lactoferrin from fresh milk or fresh whey

Individual whey protein composition



General composition of individual whey proteins

Component	α -Lactalbumin	Lactoferrin	Lactoperoxidase	GMP
	----- % -----			
Protein	90	94	92	86
Lactose	1	0	0	1
Ash	3	1	3	6
Fat	1	0	0	1
Moisture	5	5	5	6

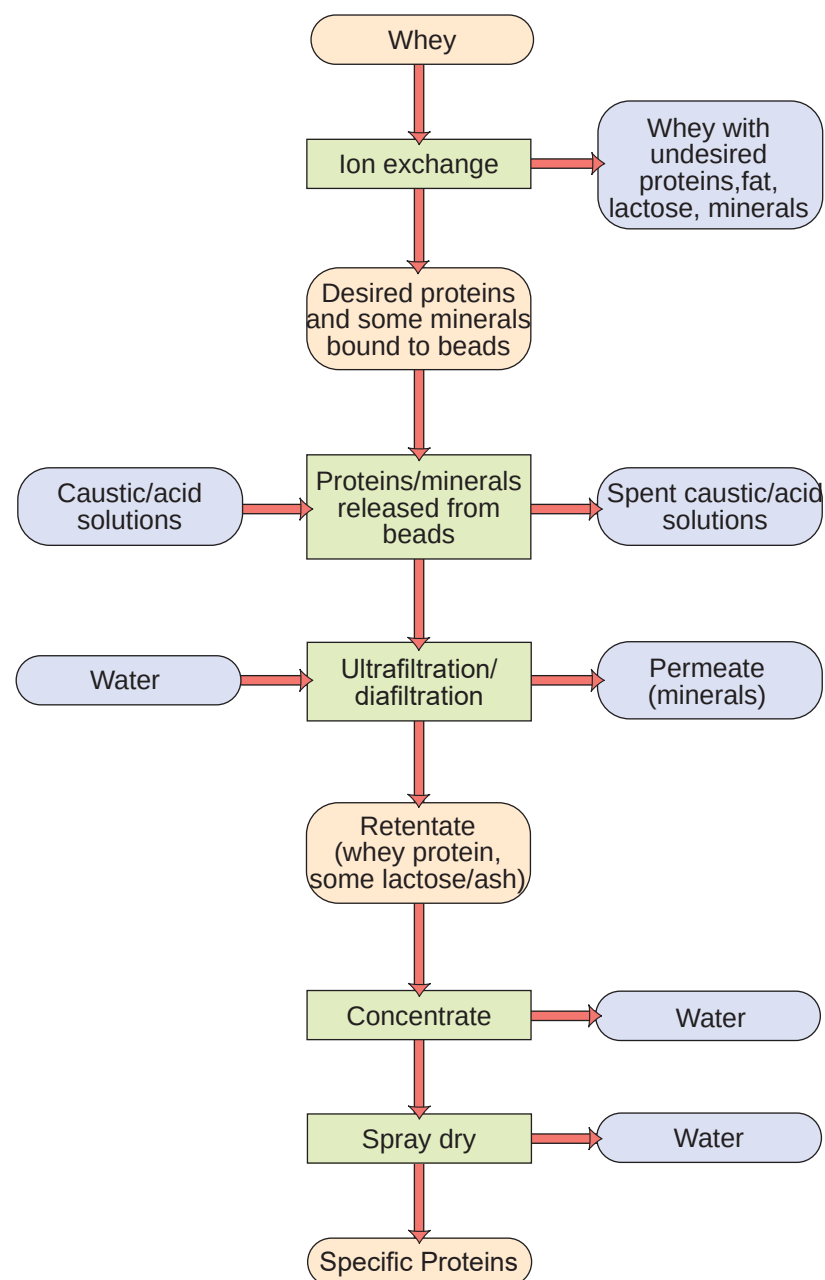
ADPI industry standard for lactoferrin

Component	Minimum/ maximum	Bovine lactoferrin	Colostal lactoferrin
		----- % -----	
Protein*	minimum	96	96
Lactoferrin**		90	90
Ash	maximum	2.0	2.0
Moisture	maximum	5.0	5.0

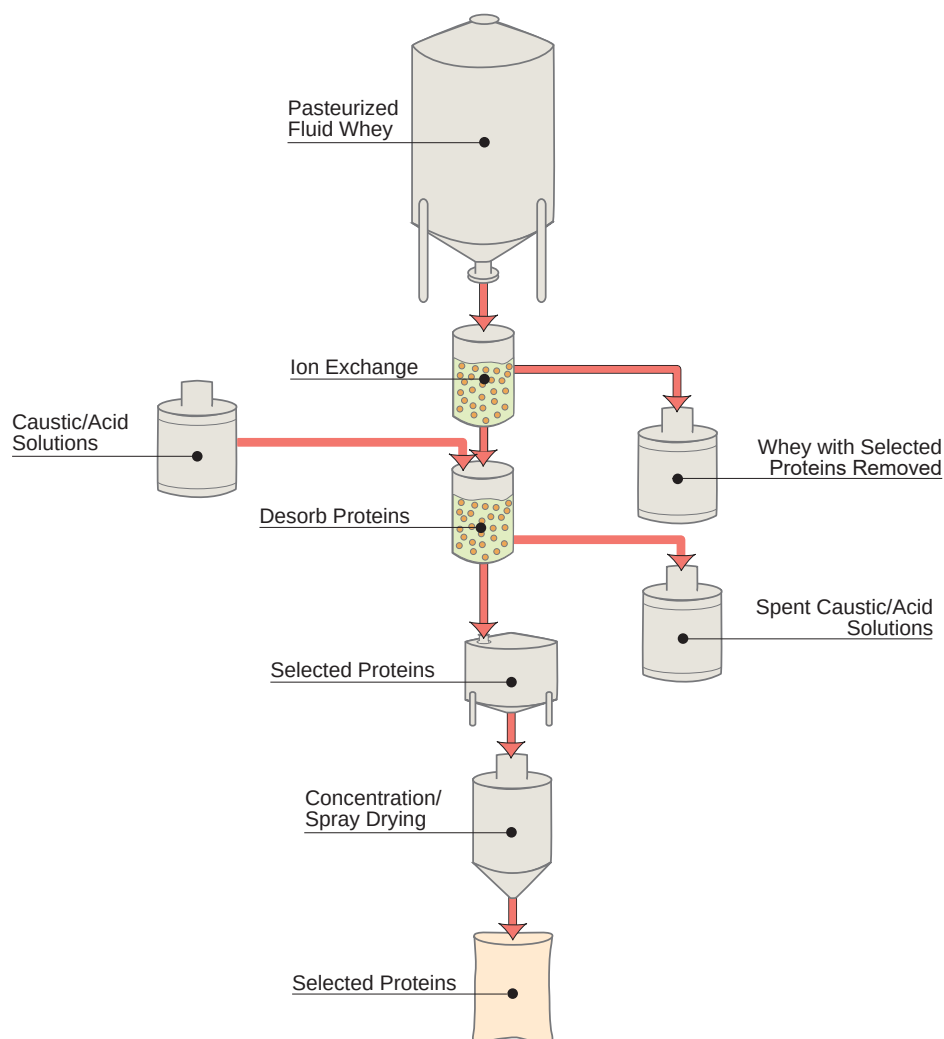
* Protein content is remported on a dry basis, all other parameters are reported "as is"

** Reported as a % of total protein

General Process for the Manufacture of Individual Whey Proteins



Manufacture of Individual Whey Proteins



Typical composition and characteristics

α -Lactalbumin

- ♦ Typical composition

Protein (db)	98%
Lactalbumin*	91%
Moisture	5%
Lactose	1%
Fat	1%
Ash	3%
- ♦ Characteristics
 - Color: light cream
 - Flavor: bland, clean
 - pH 7
 - Solubility: fully soluble
- ♦ Storage
 - <27 C, <65% rh
 - 12 months

Lactoferrin

- ♦ Typical composition

Protein (db)	99%
Lactoferrin*	96%
Moisture	5%
Lactose	na
Fat	na
Ash	1%
- ♦ Characteristics
 - Color: light red
 - Flavor: na
 - pH 6 - 7
 - Solubility: 99%
- ♦ Storage
 - <25 C, <65% rh
 - time period - na

Lactoperoxidase

- ♦ Typical composition

Protein (db)	97%
Lactoperoxidase*	na%
Moisture	5%
Lactose	na
Fat	na
Ash	3%
- ♦ Characteristics
 - Color: green/brown
 - Flavor: na
 - pH 7
 - Solubility: fully soluble
- ♦ Storage
 - 2 - 8 C, na rh
 - 6 months

Glycomacropeptide (GMP)

- ♦ Typical composition

Protein (db)	92%
GMP*	96%
Moisture	6%
Lactose	1%
Fat	1%
Ash	6%
- ♦ Characteristics
 - Color: light cream
 - Flavor: bland, clean
 - pH na
 - Solubility: na
- ♦ Storage
 - <27 C, <65% rh
 - 12 months

* Given as a percentage of total protein

Permeate (Whey)

Permeate is a by product of whey protein concentrate (WPC), whey protein isolate (WPI), milk protein concentrate (MPC) or milk protein isolate (MPI) production. Permeate actually is a term used to cover a family of products that have a minimum of 59% lactose, and a maximum of 10% protein and 27% ash. Manufacturers in the United States use the terms “dairy product solids”, “de-proteinized whey”, “modified whey”, “reduced protein whey” or “permeate” on the label.

Milk and sweet, acid, casein and rennet wheys may be used as starting materials. Composition of permeate will vary somewhat depending on the original material used. Sweet whey and milk are the most common starting materials for permeate production in the United States.

Permeate may contain a maximum of 10% protein according to product definition. Permeate typically has only trace amounts of protein, however, commercial specifications often list protein at 3.5 to 5%. The discrepancy is due to the method used to test for protein. The industry tests for total nitrogen and then multiplies the result by 6.38 to convert the result into a protein value. The nitrogen found by testing often actually is nonprotein nitrogen (NPN) rather than true protein. Examples of NPN compounds typically found in milk and whey include: urea; creatine; creatinine; uric acid; orotic acid; and ammonia. The net result of listing nitrogen as protein rather than NPN is an overestimation of the protein and underestimation of the lactose content of the powder. It should be noted that there are manufacturers of permeate who add protein to permeate to assist with drying.

Dairy Product Solids (ADPI definition) - are modified dairy products (permeates and products derived therefrom) obtained by the removal of protein and/or lactose, and/or minerals from milk or whey. The dry product shall contain at least 59% lactose, 10% protein maximum, and 27% ash maximum. Removal of the dairy constituents is accomplished by separation techniques such as precipitation, membrane filtration or dialysis. Dairy Product Solids can be used as a liquid or as a dry product. The acidity of dairy product solids may be adjusted by the addition of safe and suitable pH-adjusting ingredients.

Dairy permeate (ADPI definition) - produced by the removal of protein and other solids from milk or whey resulting in a product with a high concentration of lactose. Removal of the dairy constituents is accomplished by physical separation techniques such as filtration and diafiltration. The acidity of Dairy Permeate may be adjusted by the addition of safe and suitable pH adjusting ingredients. Dairy Permeate meets the definition of Dairy Product Solids, which is the subject of a GRAS notification to the U.S. Food and Drug Administration and complies with all provisions of the U.S. Federal Food, Drug and Cosmetic Act.

Types

- ◆ Milk
- ◆ Whey

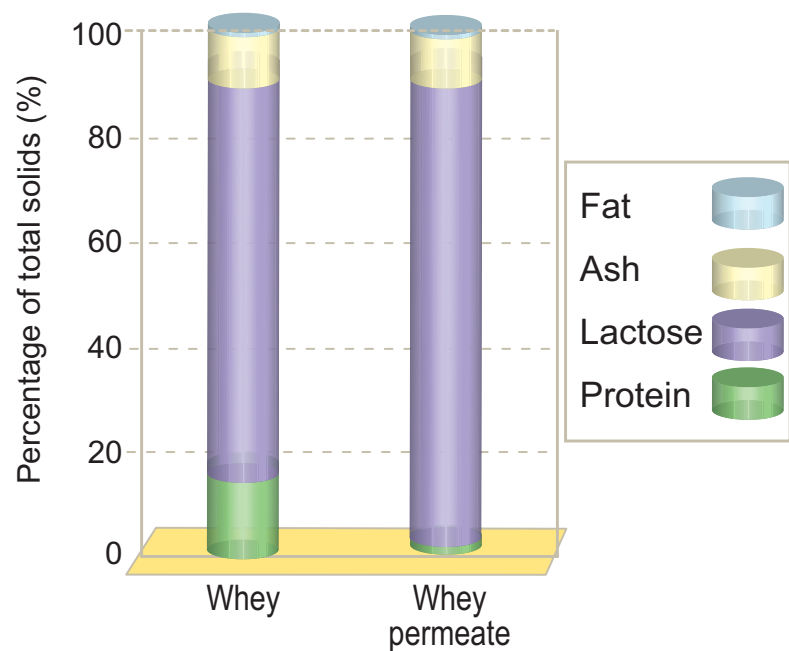
Regulations

- ◆ FDA GRAS Notice No. 37 (2000)
- ◆ FDA GRP 1G0371

ADPI Industry Standard
CODEX Standard CXS 331-2017

Animal Feed Definition (Association of American Feed Control Officials)
Dried (dry) whey solubles - is the product obtained by drying the whey residue after removal of whey protein, with or without partial removal of lactose. Minimum percent of crude protein and lactose and maximum percent ash must be prominently declared on the label.

Permeate composition



General composition of permeate from several sources

Component	Permeate from		
	Milk	Sweet whey	Acid whey
	----- % -----		
Total solids	5.8	5.8	5.8
Lactose	4.9	4.9	4.1
Ash	0.45	0.5	0.7
Crude protein	0.25	0.3	0.4
Lactic acid	—	0.15	0.5
----- mg/100grams -----			
Calcium	28	30	95
Phosphorous	33	40	55

General composition of permeate

Component	Permeate
	----- % -----
Protein*	3
Lactose	84
Ash	9
Fat	nil
Moisture	4

* Non protein nitrogen included in this value. May or may not contain true protein.

FDA specifications for permeate*

Component	Not less than	Not greater than
	----- % -----	
Milkfat	na	na
Protein	-	10
Lactose	59	-
Ash	-	27
Moisture	-	6

* FDA GRAS Notice No. 37 (2000) and FDA GRP No. 1G0371

ADPI industry standard for whey permeate

Component	Typical	Minimum	Maximum
	----- % -----		
Protein	2 - 7	-	7
Lactose	76 - 85	76	-
Ash	8 - 11	-	14
Fat	0 - 1.0	-	1.5
Moisture	3 - 4.5	-	5

CODEX standard for permeate

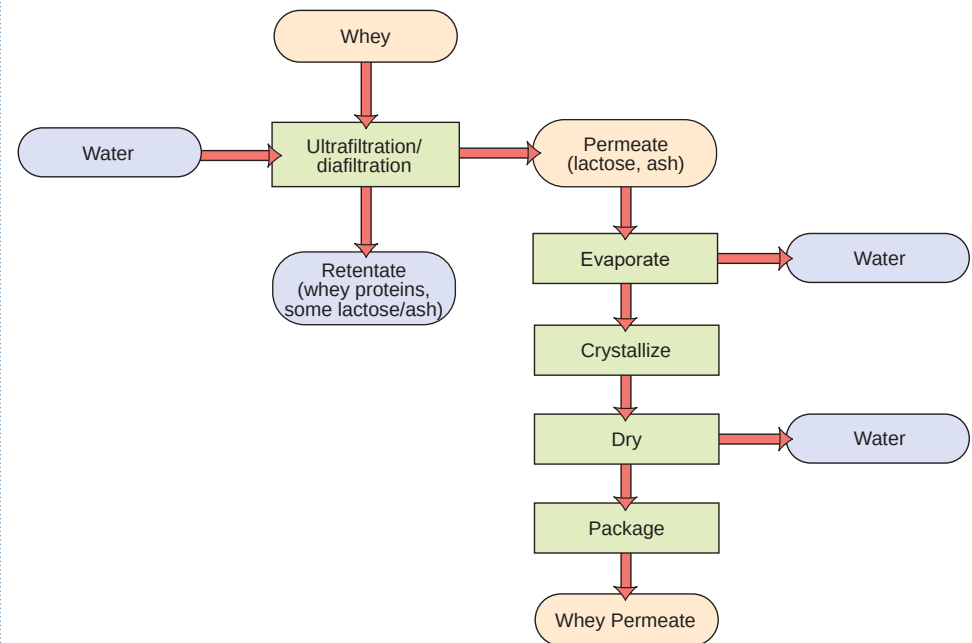
Component	Minimum/ maximum	Dairy permeate	Milk permeate	Whey permeate
		----- % (m/m) -----		
Lactose, anhydrous	minimum	76.0	76.0	76.0
Nitrogen	maximum	1.1	0.8	1.1
Milk fat	maximum	1.5	1.5	1.5
Ash	maximum	14.0	12.0	12.0
Moisture	maximum	5.0	5.0	5.0

Dairy permeate - milk, whey, cream, sweet buttermilk permeates or similar lactose-containing milk products

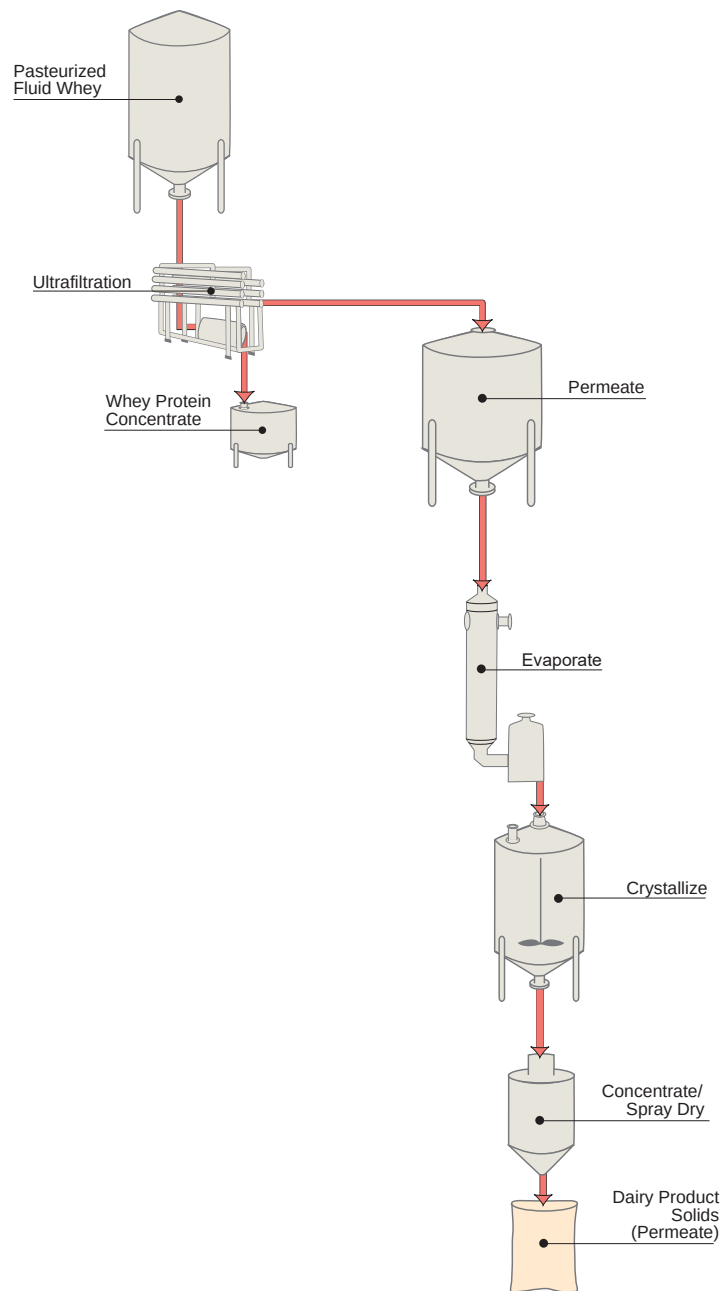
Milk permeate - milk permeate

Whey permeate - whey permeate

General Process for the Manufacture of Whey Permeate



Manufacture of Permeate from Whey



Typical composition and characteristics

Permeate

♦ Typical composition		♦ Characteristics
Protein (db)*	3%	Color: white to cream
Moisture	4%	Flavor: bland, clean
Lactose	85%	♦ Storage
Fat	<0.1%	<25 C, <65% rh
Ash	9%	12 months

* Non protein nitrogen included in this value. May or may not contain true protein.

Product Labeling

Product may be identified on the label as "Whey Permeate" or "Dairy Product Solids".

An alternate names could include "Modified Whey", "Deproteinized Whey", "Dried Whey Product" or "Dried Whey Solubles".

Galacto-Oligosaccharides (GOS)

Galacto-oligosaccharides (GOS) are comprised of galactose units chained together. Galacto-oligosaccharides are naturally occurring in milk and yogurt and function as prebiotics, that is, they are undigestible ingredients that stimulate the growth/activity of beneficial bacteria in the colon.

Galacto-oligosaccharides are produced when enzymes alter lactose. The type of GOS produced depends on factors such as enzyme source and amount, initial lactose concentration, whether the enzyme is free or immobilized, reaction conditions and composition of the starting material.

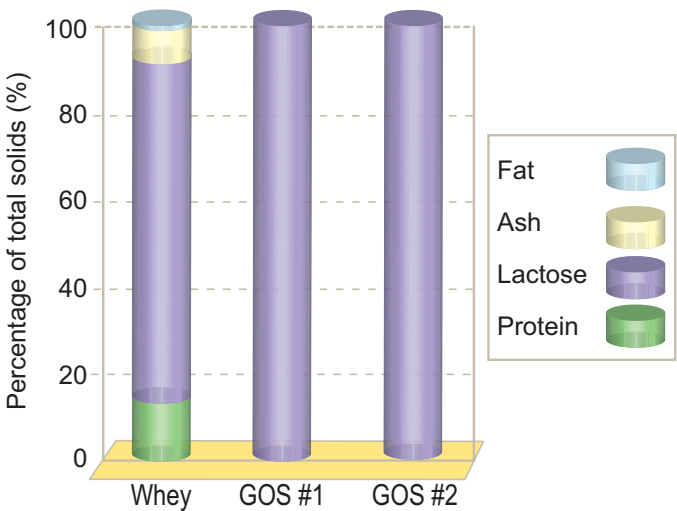
Commercial products differ in the purity of the GOS and the exact configuration of the compounds. Galacto-oligosaccharides are available in both liquid and dry forms. Liquid products typically contain about 50% w/v of GOS and powders 60 - 70%.

Regulations

None, product not defined
 FDA GRAS

ADPI Industry Standard

Galacto-oligosaccharide (GOS) composition



General composition of galacto-oligosaccharides (GOS)

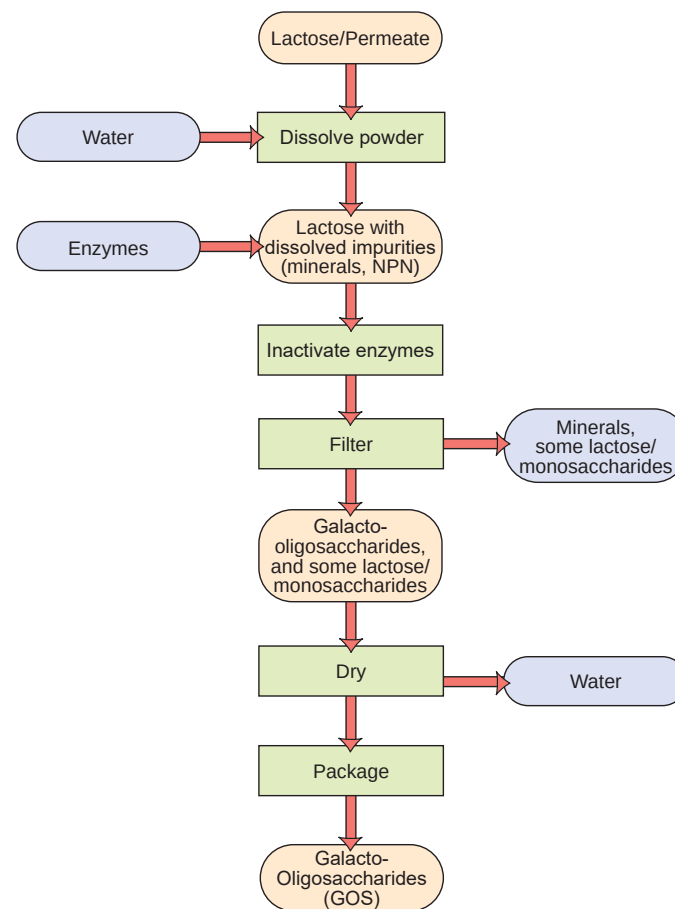
Component	GOS #1	GOS #2
	----- % -----	
Milkfat	< 0.1	< 0.1
Protein	na	na
Lactose and simple sugars	43	27
Galacto-oligosaccharides	54	70
Ash	< 0.1	< 0.1
Moisture	3	3

General composition of galacto-oligosaccharides (GOS)

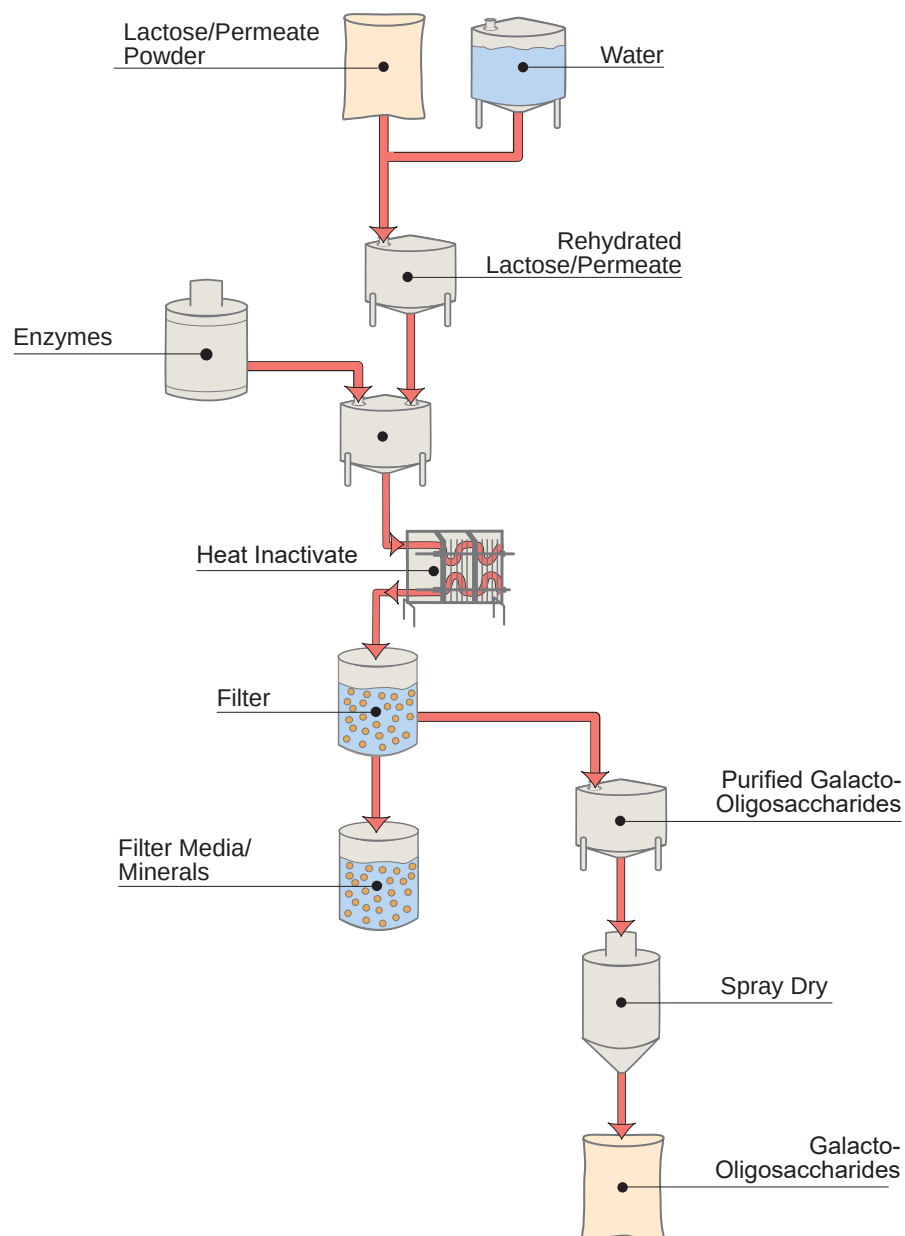
Component	Minimum/ maximum	GOS
		----- % -----
GOS*	minimum	28.5
Protein	maximum	0.7
Lactose	maximum	30
Sulfated ash	maximum	0.5
Moisture	maximum	4.5

* GOS composition in solids content

General Process for the Manufacture of Galacto-Oligosaccharides (GOS)



Manufacture of Galacto-Oligosaccharides (GOS)



Typical composition and characteristics

GOS #1*

♦ Typical composition		♦ Characteristics
Protein (db)	na%	Color: white
Moisture	3%	Flavor: sweet
Lactose and simple sugars (db)	45%	pH na
GOS (db)	55%	♦ Storage
Fat	<0.1%	<36 C, <65% rh
Ash	<0.1%	24 months

GOS #2*

♦ Typical composition		♦ Characteristics
Protein (db)	na%	Color: white
Moisture	3%	Flavor: sweet
Lactose and simple sugars (db)	30%	pH na
GOS (db)	70%	♦ Storage
Fat	na%	na
Ash	<0.1%	

* Exact composition depends on manufacturer

Lactose

Lactose can be produced from either whey or permeate although permeate is the more common starting material. Whey or permeate is concentrated until the solubility of lactose is exceeded and lactose crystals form. The crystals then are washed to remove impurities and dried.

Lactose is a disaccharide, that is, a carbohydrate made up of two sugar molecules. The monosaccharides or sugar molecules that comprise lactose are glucose and galactose. The chemical name for lactose is 4-O- β -galactopyranosyl-D-glucopyranose.

Lactose crystals

Although lactose can exist in a number of different forms, when dried it typically is present as:

- ♦ Alpha-lactose monohydrate crystals
(α -lactose monohydrate crystals)
- ♦ Beta-lactose crystals
(β -lactose crystals)
- ♦ Amorphous (glass) mixture of uncrystallized alpha (α) and beta (β) lactose

Alpha-lactose monohydrate crystals – formed when lactose crystallizes at temperatures $<93.5^{\circ}\text{C}$ (200°F). The α -lactose monohydrate form has one molecule of water as part of its structure. The molecule of water is bound to the lactose crystal and is also known as the water of crystallization. Alpha-lactose crystals often appear as prisms or tomahawk shapes. The crystals are very hard and can have a “sandy” or even glass-like mouthfeel.

Beta-lactose crystals – formed when lactose crystallizes at temperatures $>93.5^{\circ}\text{C}$ (200°F). The β form does not have water associated with its structure.

Amorphous (glass) – formed when a lactose solution is dried rapidly such as by spray drying or freeze drying. The amorphous form is very hygroscopic and will readily absorb water to form α -lactose monohydrate crystals. Lumps can develop in the product if enough crystals form. The amorphous form is typical in products such as nonfat dry milk.

Several other forms of lactose can be produced under special conditions.

Stable anhydrous α -lactose – produced at temperatures between 100 and 190°C (212 and 374°F) with a water vapor pressure of 6 to 80 cm mercury. Typically crystallized α -lactose monohydrate is sprayed onto a drum dryer to produce stable anhydrous α -lactose. Stable anhydrous α -lactose is relatively nonhygroscopic.

Hygroscopic (unstable) anhydrous α -lactose – is produced by heating α -hydrate lactose at temperatures above 100°C (212°F) under vacuum. Hygroscopic (unstable) anhydrous α -lactose is stable in dry air but will readily absorb moisture under typical atmospheric conditions.

Lactose and water

Lactose as a commercial product typically is in the form of α -lactose monohydrate. Beta-lactose was produced many years ago but is not typically available commercially except in the form of anhydrous lactose. Mixtures of α -lactose and β -lactose also are available.

Moisture specifications reflect the fact that water can be present in two different forms in lactose.

Bound – water that is part of the crystal structure of α -lactose.

Free – water that is not associated with the lactose crystal.

Total moisture – free and bound water.

The molecular weight of lactose is 342. The molecular weight of water is 18. Added together the molecular weight of α -lactose monohydrate crystal becomes 360. Therefore there is 5% moisture in an α -lactose monohydrate crystal due to bound water.

$$\begin{array}{rcl} \text{Lactose} + \text{water} & = & \alpha\text{-lactose monohydrate crystal} \\ 342 + 18 & = & 360 \\ 95\% + 5\% & = & 100\% \end{array}$$

The calculation for moisture in commercial lactose is based on the assumption that 100% of the lactose present is in the form of α -lactose monohydrate. In many cases this is a good assumption, however, in certain lactose products where significant amounts of β -lactose, stable anhydrous α -lactose or amorphous lactose may be present the assumption can lead to an underestimation of the free moisture content depending on the method of moisture analysis used. Free moisture content is important because it has a large affect on product shelf life.

Loss on drying refers to the free moisture content of lactose. The greater the loss on drying the more free moisture is present.

The Karl Fischer test for moisture indicates both bound and free moisture in lactose.

Free moisture must be less than 1% according to standards of identity. Because a free moisture of more than 1% would lead to quality issues, free moisture in crystalline lactose typically is less than 0.5%. The type of lactose affects the amount of free moisture typically present. Spray dried lactose would have a free moisture of not more than 1% while anhydrous lactose would have a free moisture of not more than 0.5%.

An example of moisture in lactose would be:

Bound	Free	Total
5%	0.3%	5.3%

Commercial lactose products

Industrial, fermentation lactose is not defined. The product essentially is lactose that does not meet the specifications for edible (food) or pharmaceutical lactose.

Edible (food) lactose is produced by evaporating, crystallizing, refining and then drying. The majority of lactose is dried on a flash dryer although spray and roller dryers also may be used. Only the lactose crystals are dried.

Although the product consists of primarily of α -lactose monohydrate some lactose will be in the amorphous form. The exact ratios of α -lactose monohydrate to amorphous lactose depend on the method of production; however, it is possible that 3 to 5% of the lactose is in the amorphous form. Typically more than 90% of the lactose is in the α -monohydrate form.

Edible refined sprayed dried lactose is not defined but lies between edible and pharmaceutical lactose in composition and functionality. The product is produced by evaporating, crystallizing, refining, reevaporating, recrystallizing and then spray drying. The lactose crystals and the mother liquor (the liquid from which the lactose crystallizes) are sprayed dried together. Edible refined lactose is a mixture of α -lactose monohydrate and amorphous lactose.

Pharmaceutical lactose is produced by redissolving, refining and then filtering edible lactose crystals. The lactose then is evaporated, recrystallized and dried. There are three forms of pharmaceutical lactose: spray dried; crystalline; and anhydrous. The anhydrous type is drum (roller) dried and is primarily β -lactose.

Lactose also may be known as milk sugar.

Regulations

- ♦ Industrial, fermentation
None, product not defined
- ♦ Edible (Food)
21 CFR 168.122
Food Chemical Codex (FCC)
- ♦ Edible refined
None, product not defined
- ♦ Pharmaceutical
National Formulary (NF)

Lactose Definitions

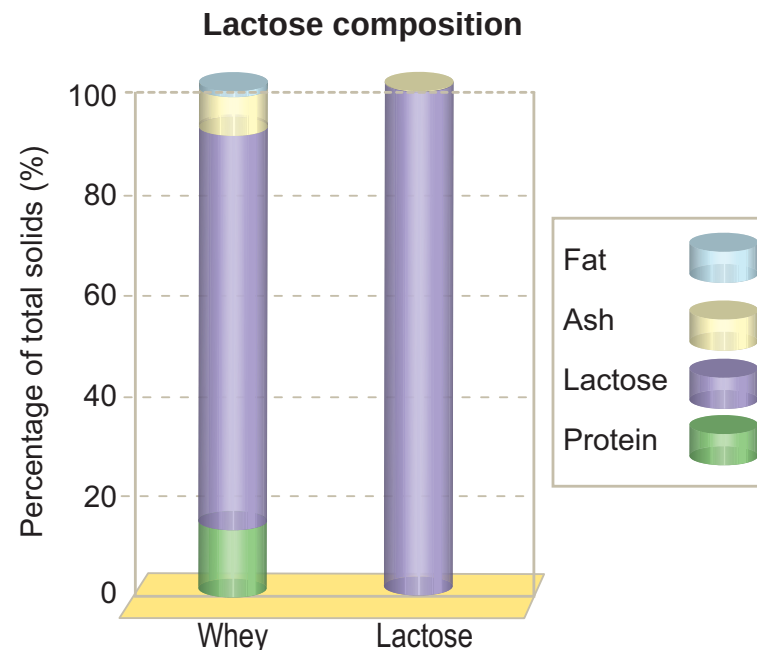
Lactose (CFR) – the carbohydrate normally obtained from whey. It may be anhydrous or contain one molecule of water of crystallization or be a mixture of both forms.

Lactose (FCC) – occurs as a white to creamy white, crystalline powder. It is normally obtained from whey. It may be anhydrous, contain one molecule of water of hydration, or contain a mixture of both forms if it has been prepared by a spray-drying process.

Anhydrous lactose (NF) – is primarily β -lactose or a mixture of α - and β -lactose.

Lactose monohydrate (NF) – is a natural disaccharide obtained from milk, which consists of one glucose and one galactose moiety. (Note – lactose monohydrate may be modified as to its physical characteristics. It may contain varying proportions of amorphous lactose.)

Lactose (Milk Sugar) (ADPI definition) - is a white to creamy white crystalline product, possessing a mildly sweet taste. It may be anhydrous, contain one molecule of water hydration, or be a mixture of both forms. It is manufactured from whey or permeate by evaporating, crystallizing, refining and then drying the lactose crystals. Lactose for human consumption complies with all provisions of the U.S. Federal Food, Drug, and Cosmetic Act.



General composition of lactose

Component	Industrial/ fermentation	Edible (food)	Edible refined	Pharmaceutical
	----- % -----			
Total protein	1.0	< 0.10	nil	nil
Lactose	98.0	99.0	99.5	99.85
Ash	0.45	0.20	0.20	0.03
Fat	0.20	< 0.10	nil	0.0
Moisture (free)	0.35	0.50	0.30	0.10

Specifications for US food grade lactose

Component	CFR		FCC	
	not less than	not greater than	not less than	not greater than
Lactose (db)	98.0%	-	98.0%	100.5%
Sulfated ash (db)	-	0.3%	-	-
Ash	-	-	-	0.3%
Total moisture	-	6.0%	-	-
Monohydrate	-	-	4.5%	5.5%
Spray dried	-	-	4.5%	5.5%
Anhydrous	-	-	-	1.0%
pH (10% solution)	4.5	7.5	4.5	7.5

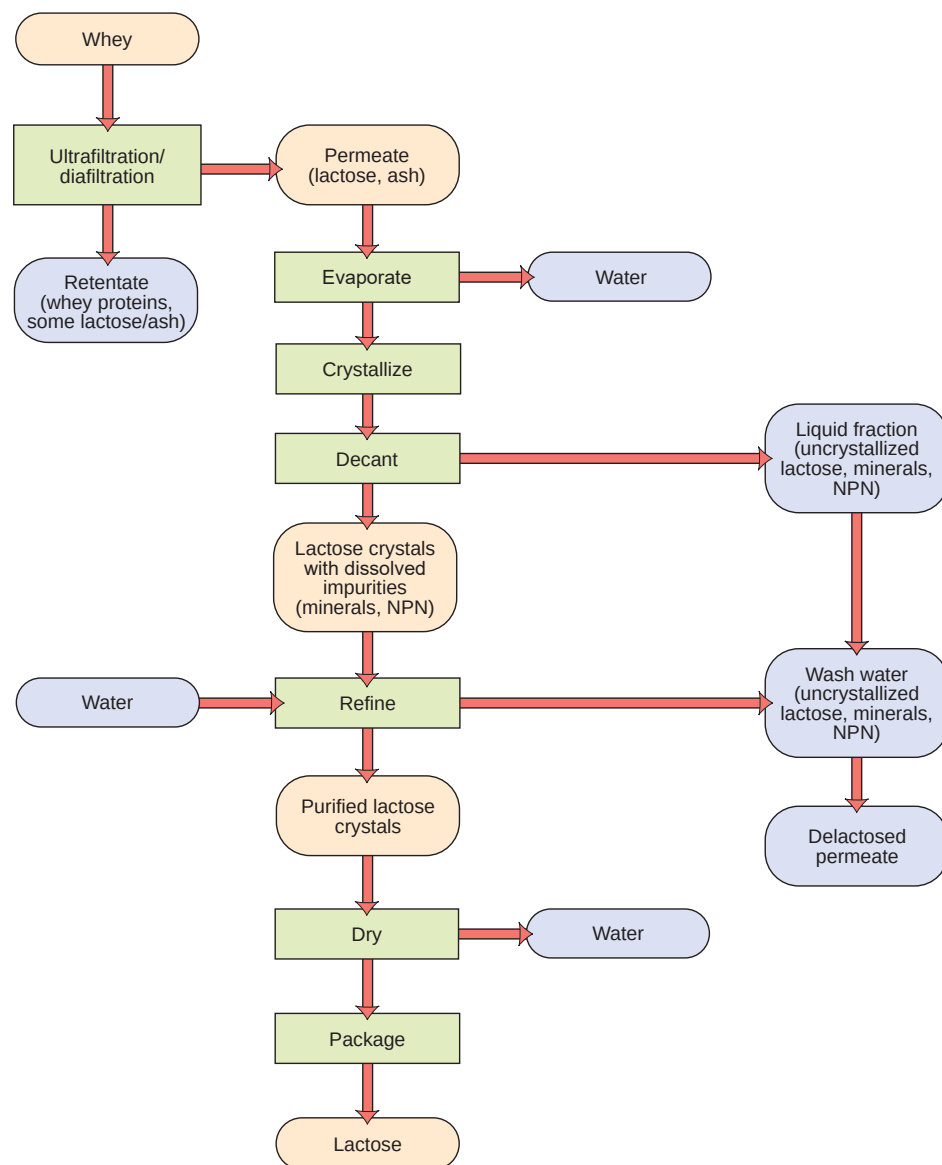
General ADPI industry standards for lactose

Component	Industrial/ fermentation	Edible (food)	Edible refined
	----- % -----		
Total protein (maximum)	1.0	0.20	0.15
Lactose (minimum)	98.0	99.0	99.5
Ash (maximum)	0.45	0.30	0.20
Moisture (total) (maximum)	6.0	6.0	6.0

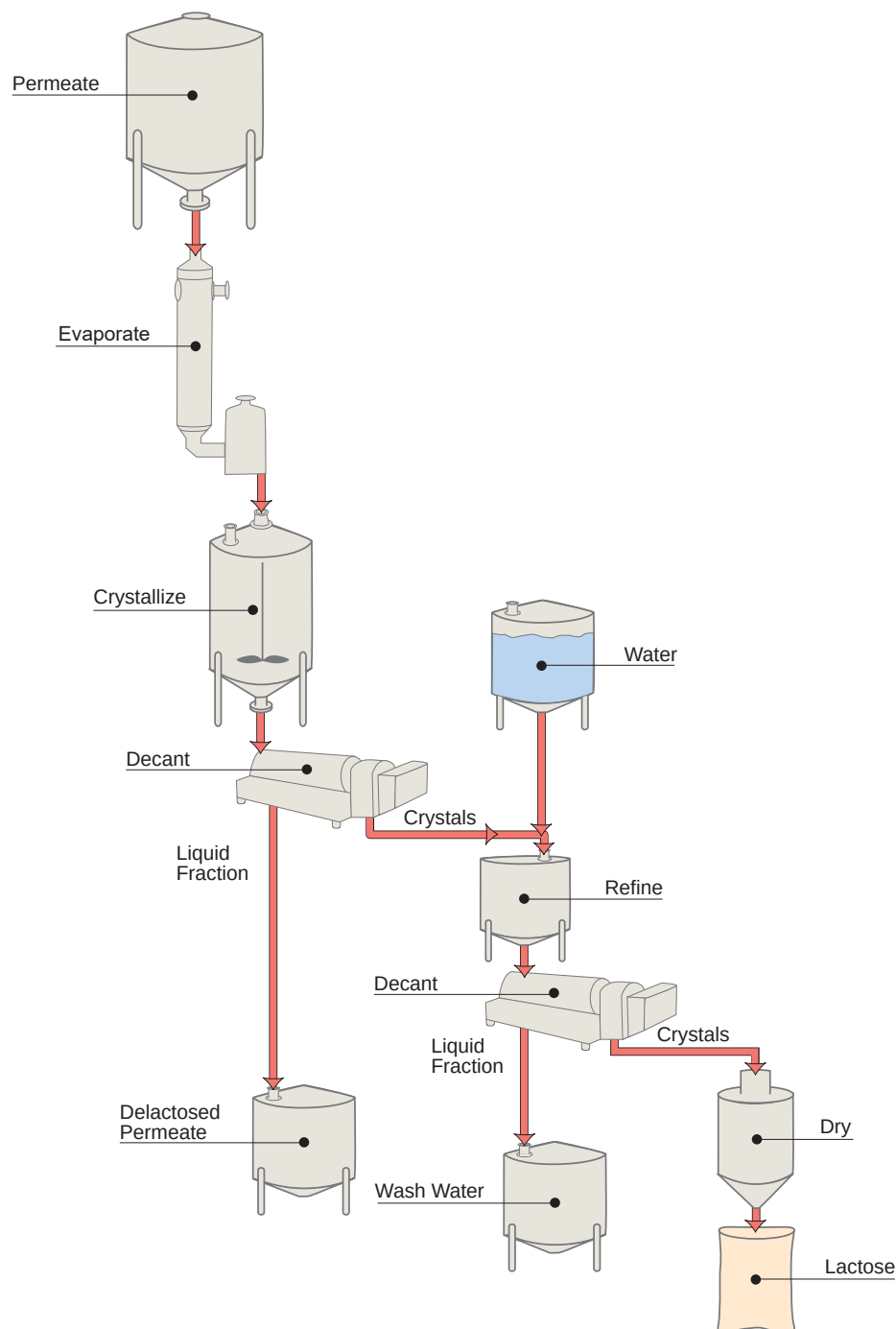
Common mesh sizes for edible lactose

Mesh size	Sieve size	Minimum % passage through sieve
40 mesh	40	80
100 mesh	100	80
200 mesh	200	80

General Process for the Manufacture of Food Grade Lactose



Manufacture of Edible Lactose



Typical composition and characteristics

Edible (food) lactose

♦ Typical composition

Protein*	0.2%
Moisture	
total	4.6%
free	0.5%
Lactose**	99.0%
Fat	na
Ash	0.3%

♦ Characteristics

Color: white to slight yellow
 Flavor: clean, slight sweet
 pH: 4.5 to 7.0

♦ Storage

<25 C, <75% rh
 24 months

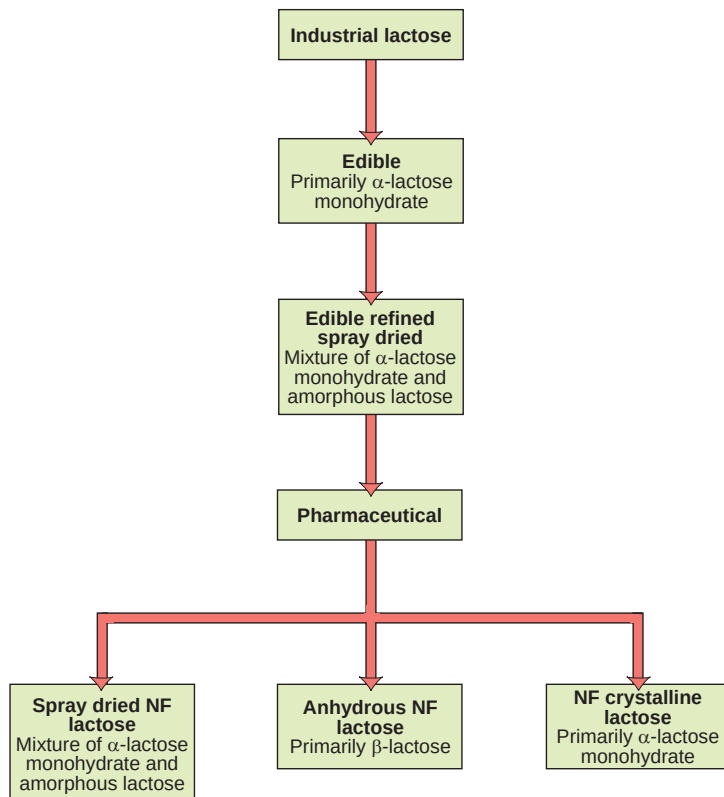
* Non protein nitrogen included in this value. May or may not contain true protein.

** Monohydrate

Product Labeling

Product may be identified on the label as "Lactose" or "Milk Sugar"

Progression of Lactose Types



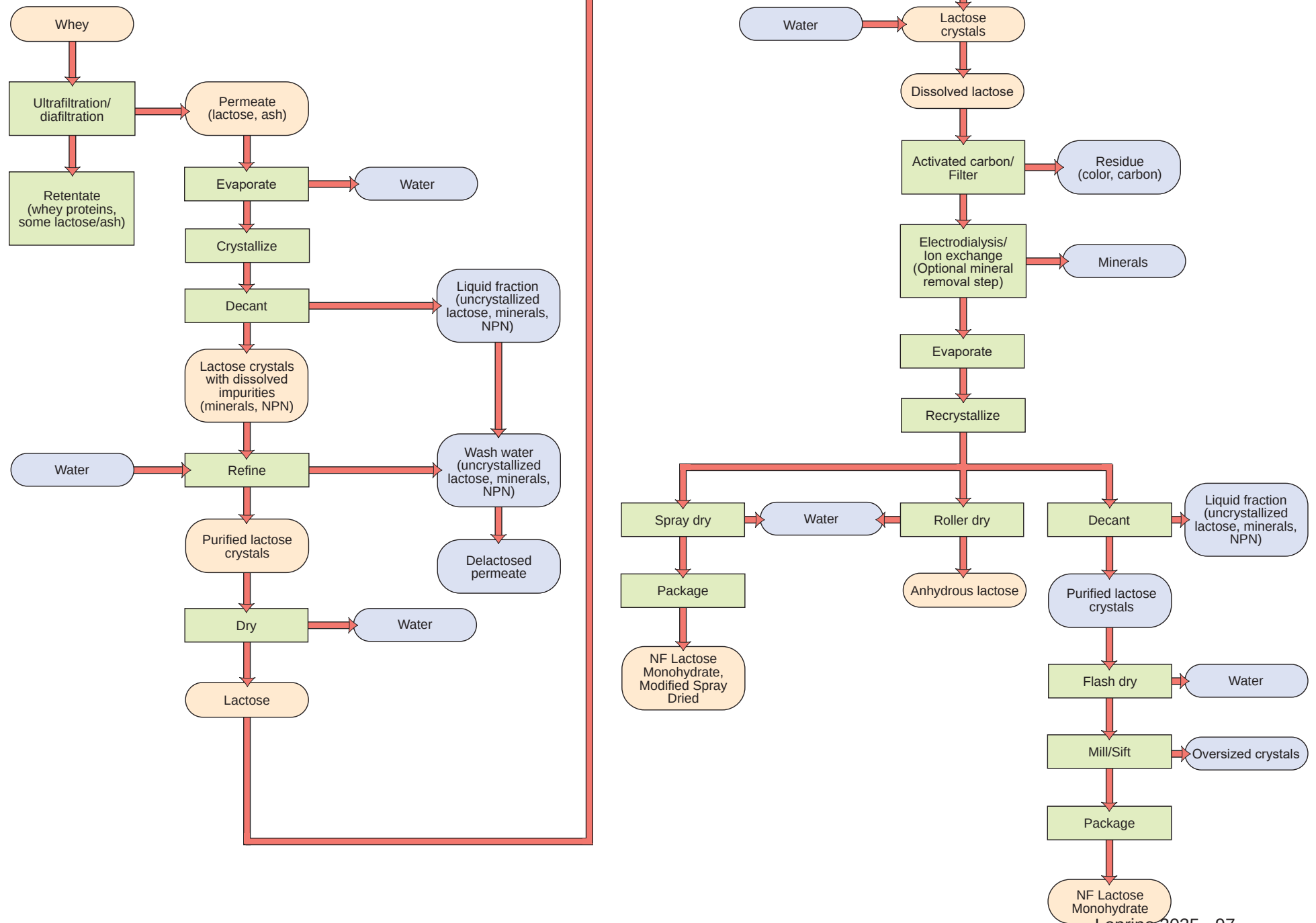
Specifications for US pharmaceutical lactose*

Component	Monohydrate		Anhydrous	
	not less than	not greater than	not less than	not greater than
Protein and light absorbing impurities	-		-	
210 nm		0.25 au	-	0.25 au
300 nm		0.07 au		0.07 au
Ash	-	0.1%	-	0.1%
Total moisture	4.5%	5.5%	-	1.0%
Free moisture	-	0.5%**	-	0.5%
Acidity (0.1N NaOH)	-	0.4 ml	-	0.4 ml

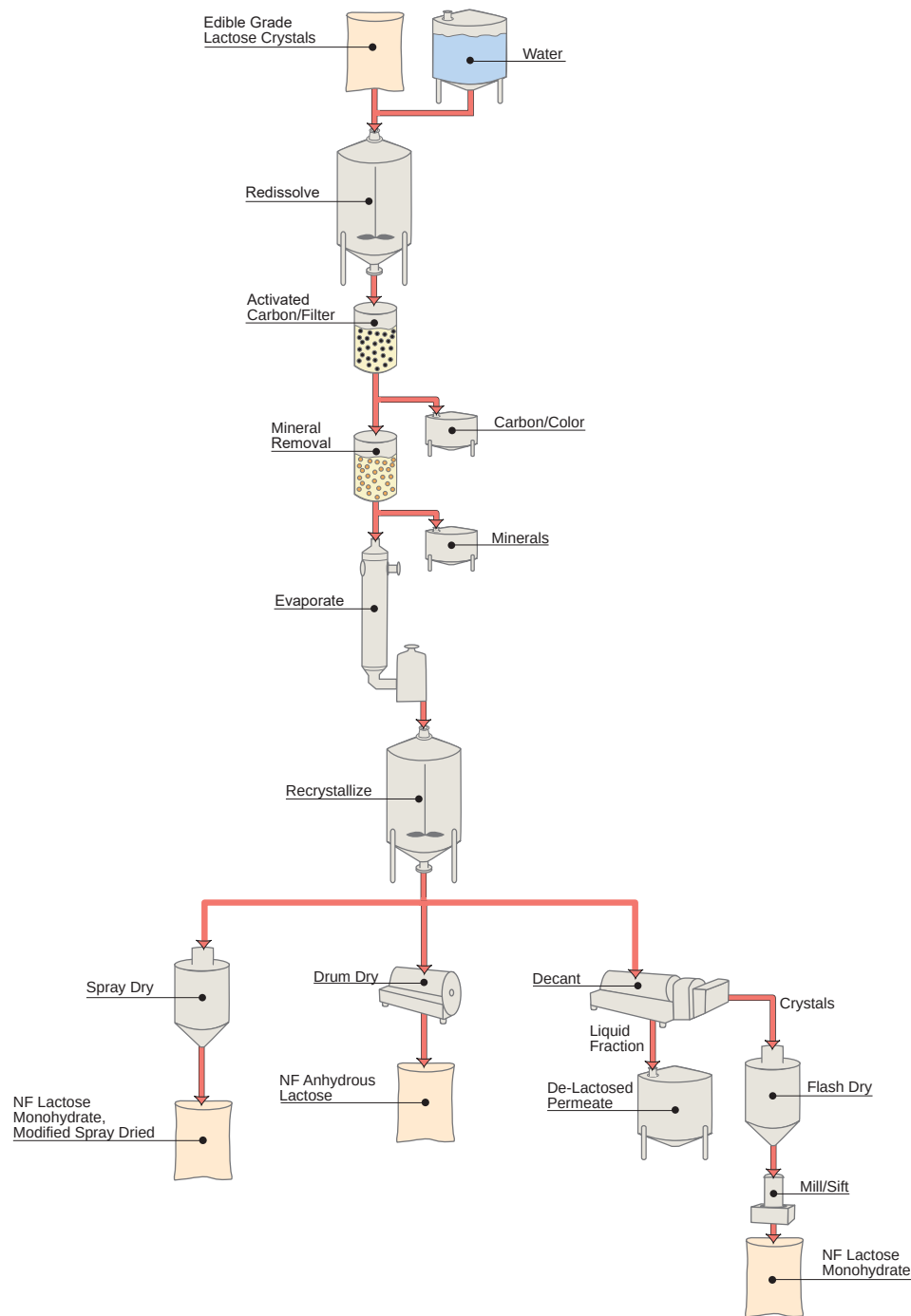
* National Formulary

** Modified monohydrate not greater than 1.0%
(Spray dried monohydrate)

General Process for the Manufacture of Pharmaceutical Grade Lactose



Manufacture of Pharmaceutical Lactose



Typical composition and characteristics

Refined edible lactose (spray dried)

Typical composition		Characteristics	
Protein*	nil	Color:	white
Moisture		Flavor:	clean, slight sweet
total	5.0%	pH	4.5 - 7.0
free	0.3%	Storage	
Lactose**	99.5%	<25 C, <75% rh	24 months
Fat	nil		
Ash	0.2%		

* Non protein nitrogen included in this value. May or may not contain true protein.

** May be combination of α -monohydrate and amorphous

Pharmaceutical lactose (monohydrate)

Typical composition		Characteristics	
Protein and light absorbing impurities		Color:	white
220 nm	0.03au	Flavor:	bland, slight sweet
300 nm	0.01au	Storage	
Moisture		<25 C, <75% rh	36 months
total	5.0%		
free	0.3%		
Lactose	99.9%		
Fat	nil		
Ash	0.02%		

Dairy Minerals

Dairy minerals may be produced from either whey or permeate. There are several methods for producing dairy minerals; however, generally the whey or permeate is concentrated such that calcium phosphate precipitates. The precipitated calcium phosphate then is removed from the liquid and washed to remove impurities such as lactose and nonprotein nitrogen. The resulting product typically has at least 20% calcium along with other minerals found in milk or whey.

The ratio of calcium to phosphorous or phosphate in dairy minerals is considered important by many end users. Typically a ratio similar to the ratio of calcium to phosphorous in milk is desired. Care must be taken when considering the ratio as some manufacturers express the ratio as calcium (Ca)/phosphorous (P) while other use calcium (Ca)/phosphate (PO_4). A typical ratio for calcium to phosphorous would be 1.8. A ratio of 0.6 would be typical for calcium to phosphate.

Calcium in whey typically is present in the form of calcium phosphate. Other minerals also are present and depending on their concentration they are divided into major and minor elements.

Major elements – calcium (Ca), sodium (Na), potassium (K), magnesium (Mg), chloride (Cl) and phosphorous (P)

Minor elements – zinc (Zn), copper (Cu), iron (Fe) and others

The terms minerals, salts and ash often are used interchangeably; however, they are not equivalent terms.

Minerals – generally refers to elements other than carbon (C), hydrogen (H), oxygen (O) and nitrogen (N) that are found in dairy products.

Minerals typical in dairy products include calcium (Ca), magnesium (Mg), phosphorous (P), iron (Fe), potassium (K), sodium (Na) and zinc (Zn).

Milk salts – includes both inorganic and organic substances. Organic acids with a negative charge and amino acids with positive charges are included in this group. Mineral salts have a molecular weight of 300 or less.

Positively charged components (cations) include calcium (Ca), potassium (K), sodium (Na), magnesium (Mg) and amines.

Negatively charged components (anions) include phosphate (PO_4), sulfate (SO_4), carbonate (CO_3), chloride (Cl^-), carboxylic acid and citrate.

Ash – is the residue that remains when milk/whey is heated to very high temperatures in a muffle oven. Organic acids are lost during ashing. Some minerals such as sulfur and phosphorous also may be lost. Other minerals may be converted to oxides, sulfates, phosphates, silicates and chlorides. In general, ash overestimates the concentration of minerals present since oxygen often is combined with minerals in the remaining ash.

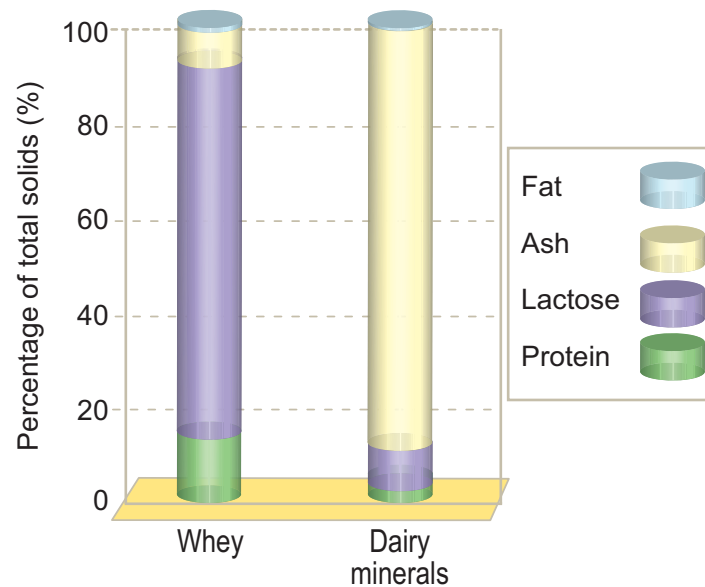
Dairy minerals also may be referred to as whey mineral concentrate, milk mineral concentrate or milk calcium.

Regulations

- ◆ GRAS Notice No. 52 (2001)

ADPI Industry Standard

Dairy minerals composition



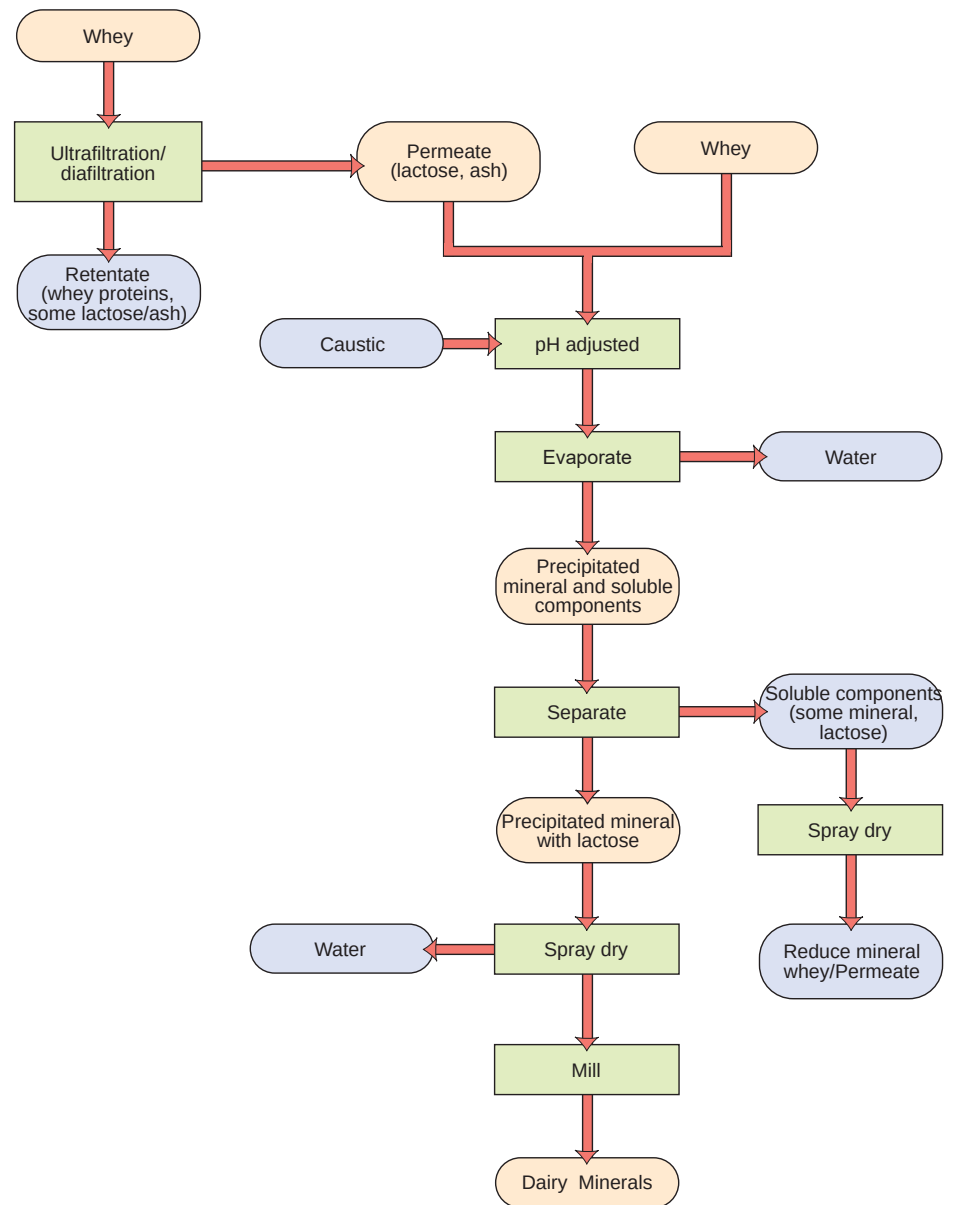
General composition of dairy minerals

Component	Dairy minerals
	----- % -----
Protein	5
Lactose	6
Ash	82
Fat	< 1
Moisture	6

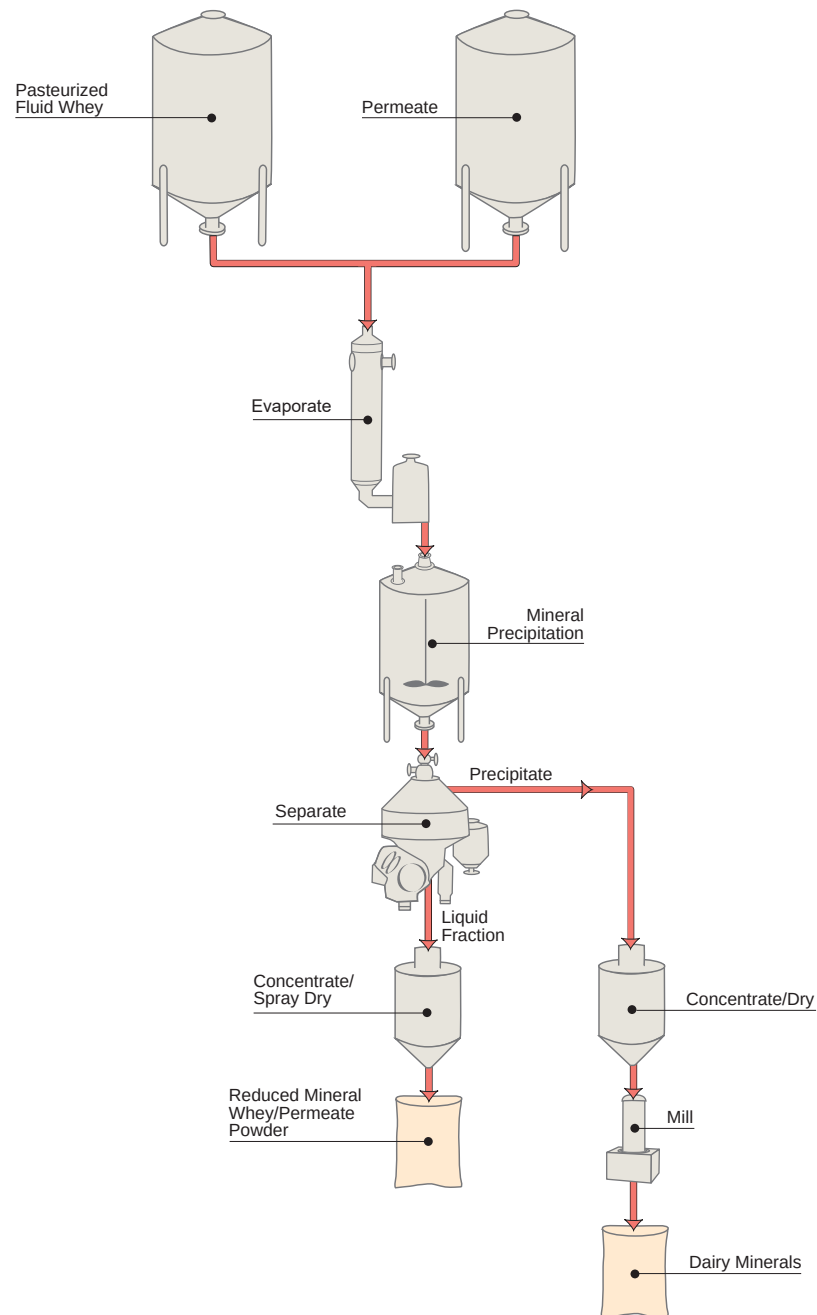
ADPI industry standard for dairy minerals

Component	Minimum/ maximum	Dairy minerals
		----- % -----
Minerals	minimum	70.0
Calcium	minimum	22.0
Protein	maximum	7.0
Fat	maximum	1.0
Lactose	maximum	11.0
Moisture	maximum	6.0

General Process for the Manufacture of Dairy Minerals



Manufacture of Dairy Minerals



Typical composition and characteristics

Dairy minerals

♦ Typical composition

Protein (db)*	4.5%
Moisture	6%
Lactose	6%
Fat	< 0.1%
Ash	83%
Calcium	23%
Phosphorous (as PO ₄)	40%
Ca:P	1.7

♦ Characteristics

Color: white to off white
 Flavor: clean, salty
 pH 6.5
 Partical size:
 coarse 95% < 100µm
 fine 95% < 10µm

♦ Storage

<25 C, <65% rh
 12 to 24 months

* Non protein nitrogen included in this value. May or may not contain true protein.

Abbreviations

ADPI	American Dairy Products Institute
CFR	Code of Federal Regulations
CFSAN	Center for Food Safety and Applied Nutrition
CMP	Casein macropeptide
db	Dry basis
DBM	Dry buttermilk
DBP	Dry buttermilk product
DF	Diafiltration
DWM	Dry whole milk
FAO	Food and Agriculture Organization of the United Nations
FCC	Food Chemical Codex
FDA	Food and Drug Administration
GMP	Glycomacropeptide
GOS	Galacto-oligosaccharides
GRAS	Generally recognized as safe
IFNCA	Islamic Food and Nutrition Council of America
Ig	Immunoglobulin
IGF	Insulin-like growth factors
INDM	Instant nonfat dry milk
MC	Micellar casein
MF	Microfiltration
MMP	Microfiltered milk protein
MPC	Milk protein concentrate
MPI	Milk protein isolate
mWPC	Milk whey protein concentrate
na	Not available
NDM	Nonfat dry milk
NF	National Formulary
NFDM	Nonfat dry milk
NPN	Nonprotein nitrogen
PMO	Pasteurized Milk Ordinance
rh	Relative humidity
SMP	Skim milk powder
spc	Standard plate count
TA	Titrateable acidity
UF	Ultrafiltration
USDA	US Department of Agriculture

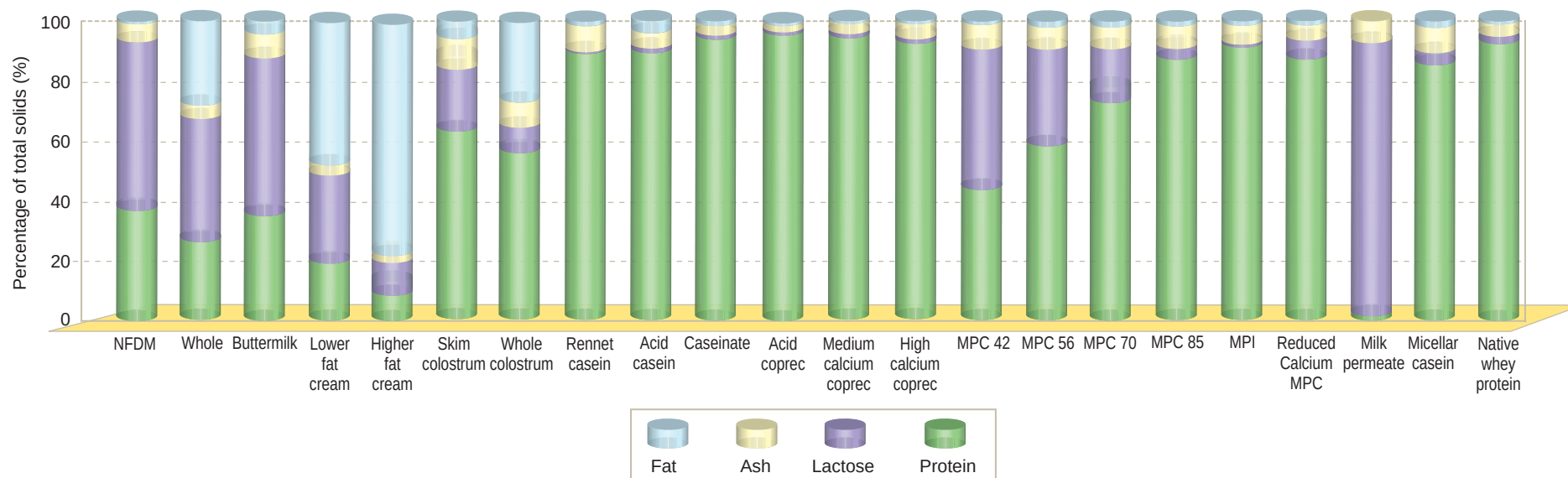
USPHS	United States Public Health Services
WHO	World Health Organization
WPC	Whey protein concentrate
WPI	Whey protein isolate
WPNI	Whey protein nitrogen index
WPPC	Whey protein phospholipid concentrate

Symbols

α	Alpha	C	Carbon
β	Beta	Ca	Calcium
K	Kappa	CaCl	Calcium chloride
μ	Micron	Cl	Chloride
>	Greater than	CO ₃	Carbonate
<	Less than	Cu	Copper
$\nlessgtr$	Not greater than	Fe	Iron
$\nlessgtr$	Not less than	H	Hydrogen
		HCl	Hydrochloric acid
		K	Potassium
		Mg	Magnesium
		N	Nitrogen
		Na	Sodium
		NaOH	Sodium hydroxide
		O	Oxygen
		P	Phosphorous
		PO ₄	Phosphate
		SO ₄	Sulfate
		Zn	Zinc

Summary Graphs

Composition of dairy ingredients made from milk



Composition of dairy ingredients made from whey

