Milk powder functionality & application issues

Ranjan Sharma

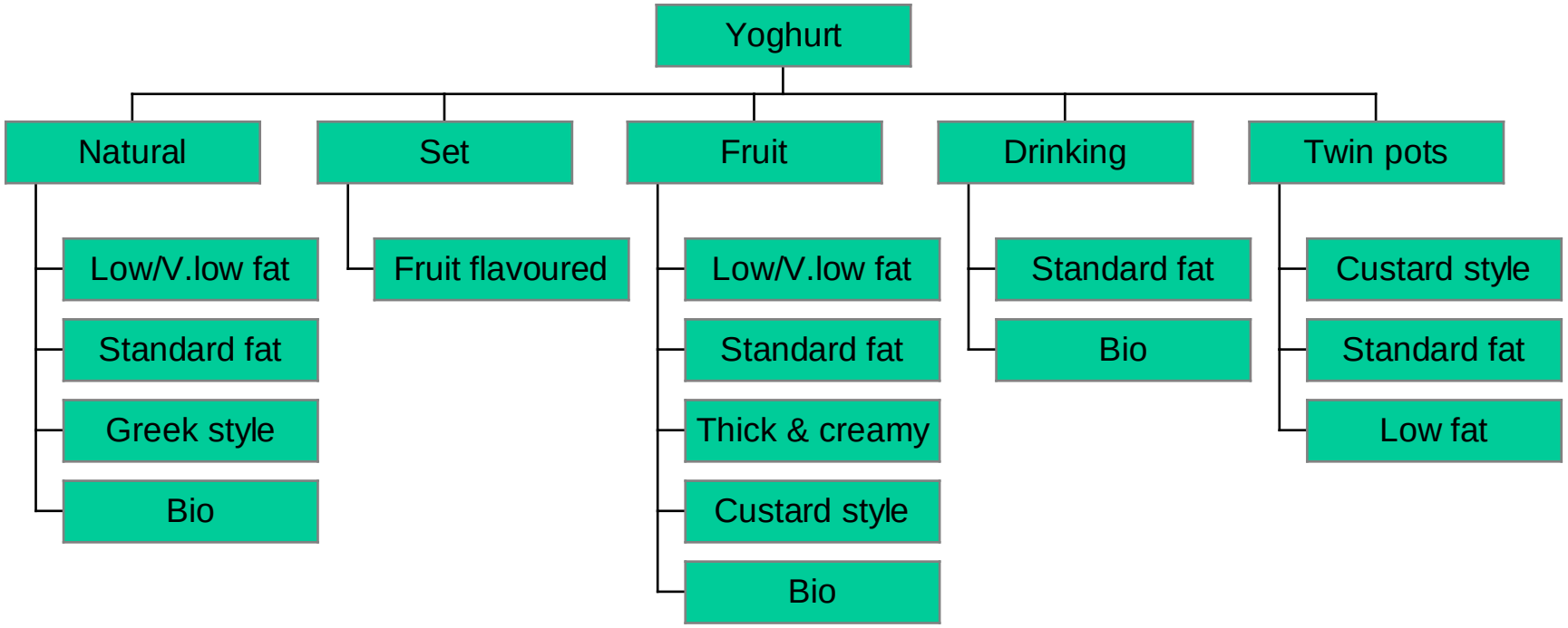
Defects in fermented milks

- White flecks in fermented milk products
  - Likely to be due to the poor heat stability of milk proteins, rendering the proteins to be unable to participate in the gel formation
  - Could happen during certain time of the season
- Dark sediments in yogurt
  - Likely to be due to poor quality milk powder, e.g. milk powder containing scorched particles

Selection of skim milk powder

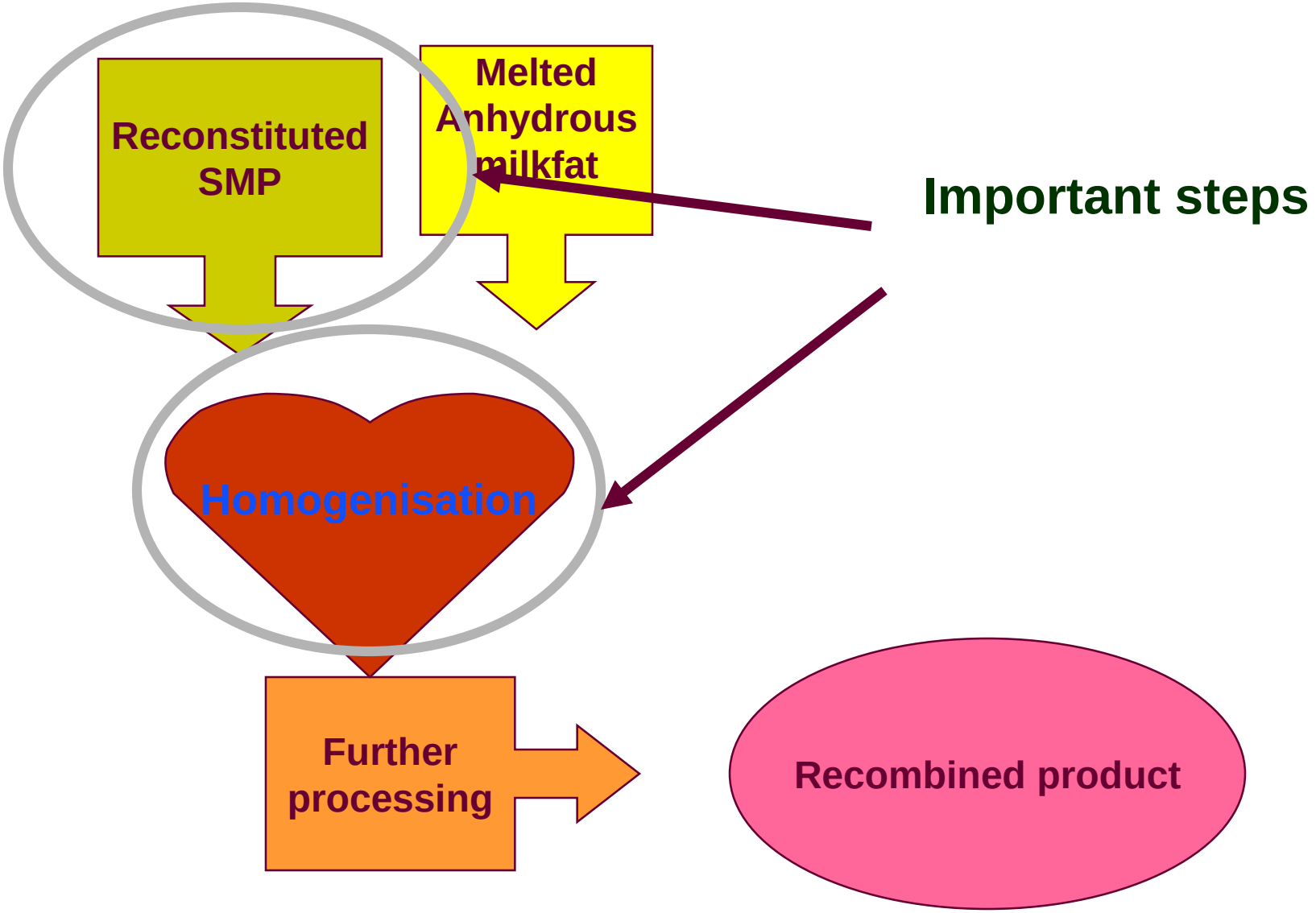
	Extra low heat	Low heat	Medium heat	Medium high heat	High heat
Heat treatment	<70°C/15s	70°C/15s	85-90°C/20-30s	96-124°c/30s	135°C/30s
WPNI, mg/g	-	>6.0	5.9-4.5	4.4-1.5	<1.5
Heat number	-	<80	80.1-83	83.1-88	>88
Recombined products					
Pasteurised milk		Antibiotic free			
UHT milk			Low CFU count: <500,000/ml		
Sterilised milk			Antibiotic free		
Sweetened condensed milk		Antibiotic free			
Evaporated milk					Antibiotic free
Fermented milks (yogurt)		Antibiotic free			
Hard Cheese	Antibiotic free, rennetability				
Semi-hard cheese					
White/Feta cheese					
Fresh cheese					
Ice cream		Antibiotic free			

Fermented products: yoghurt example

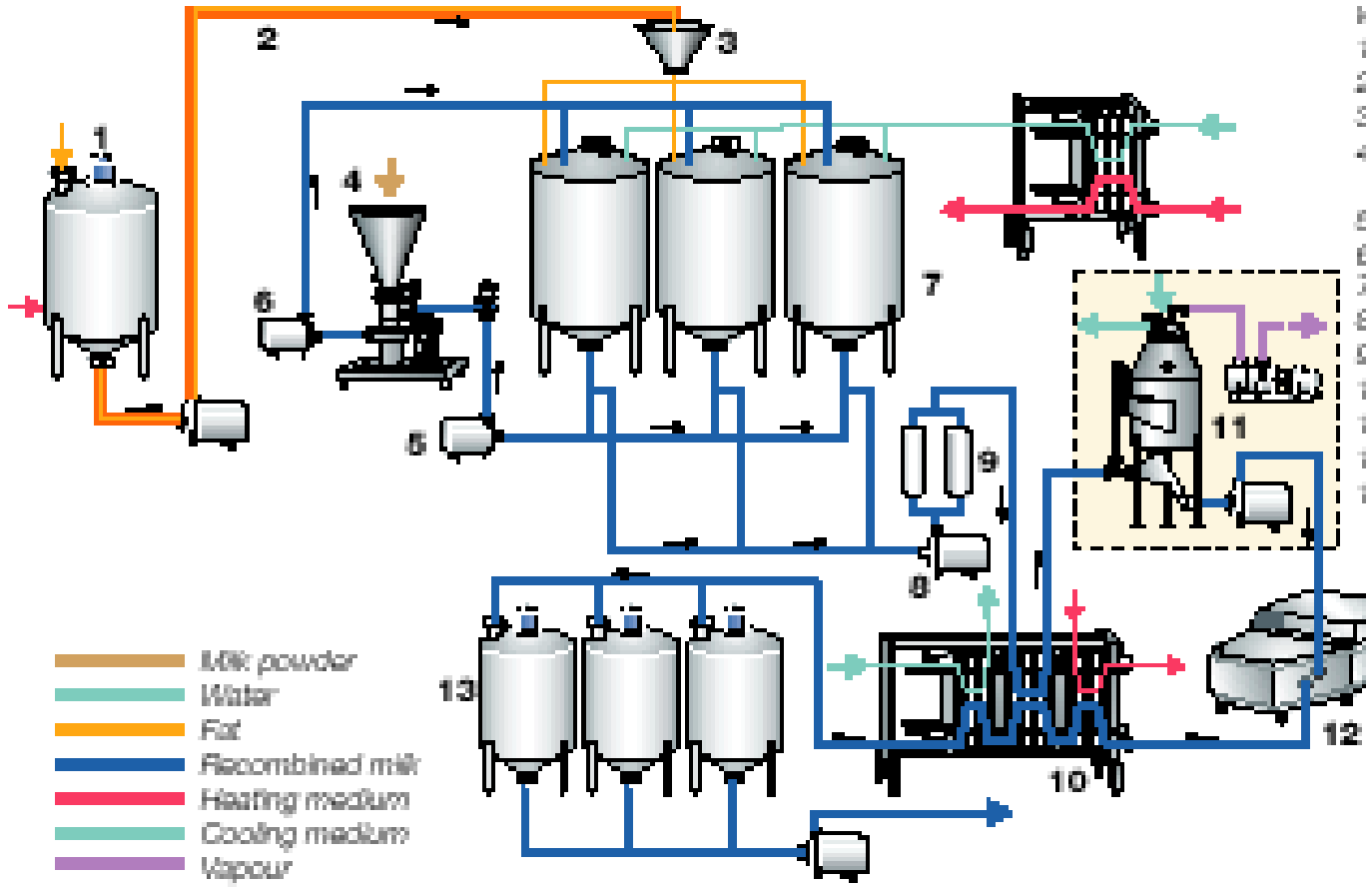


Dairygold

Basic application process – reconstitution and recombining

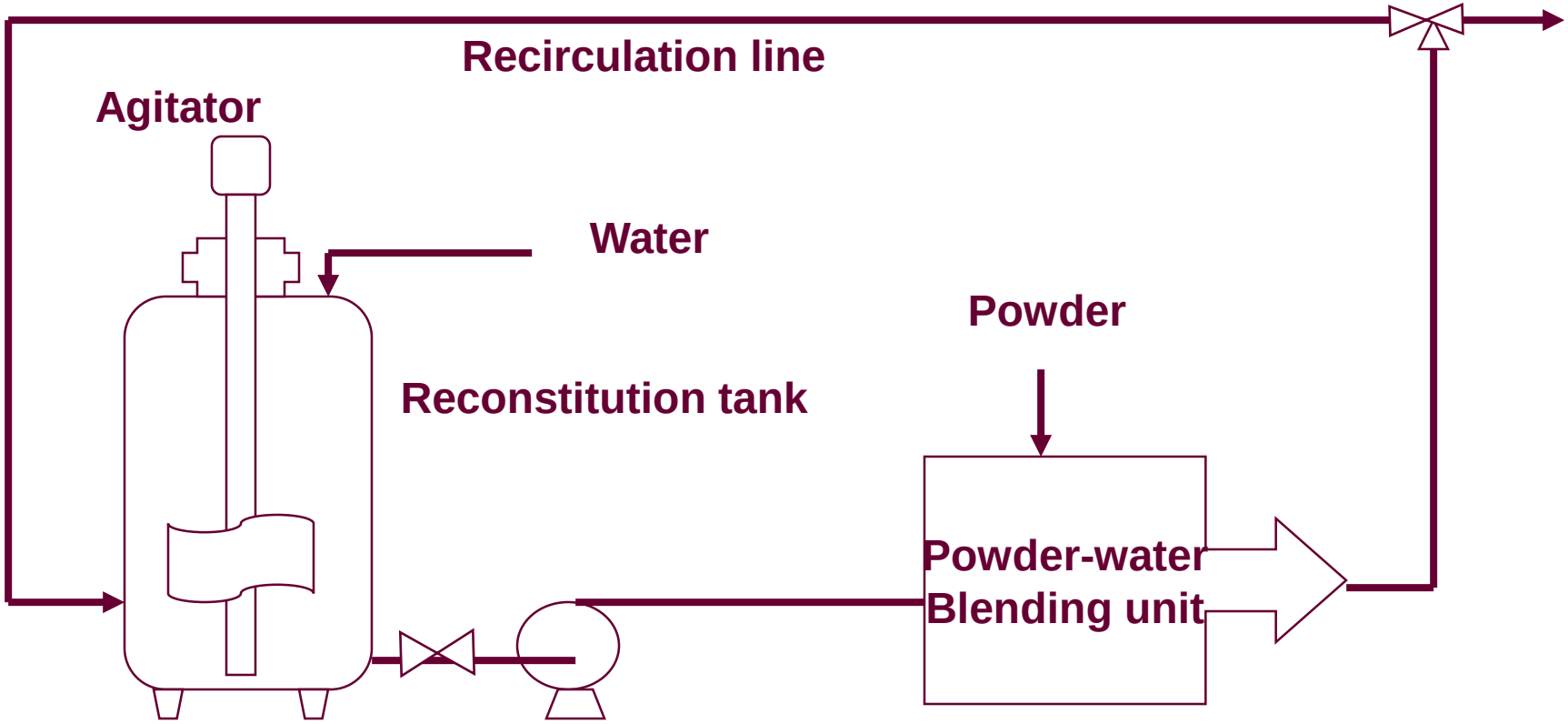


Equipment for recombining



TetraPak Dairy Handbook

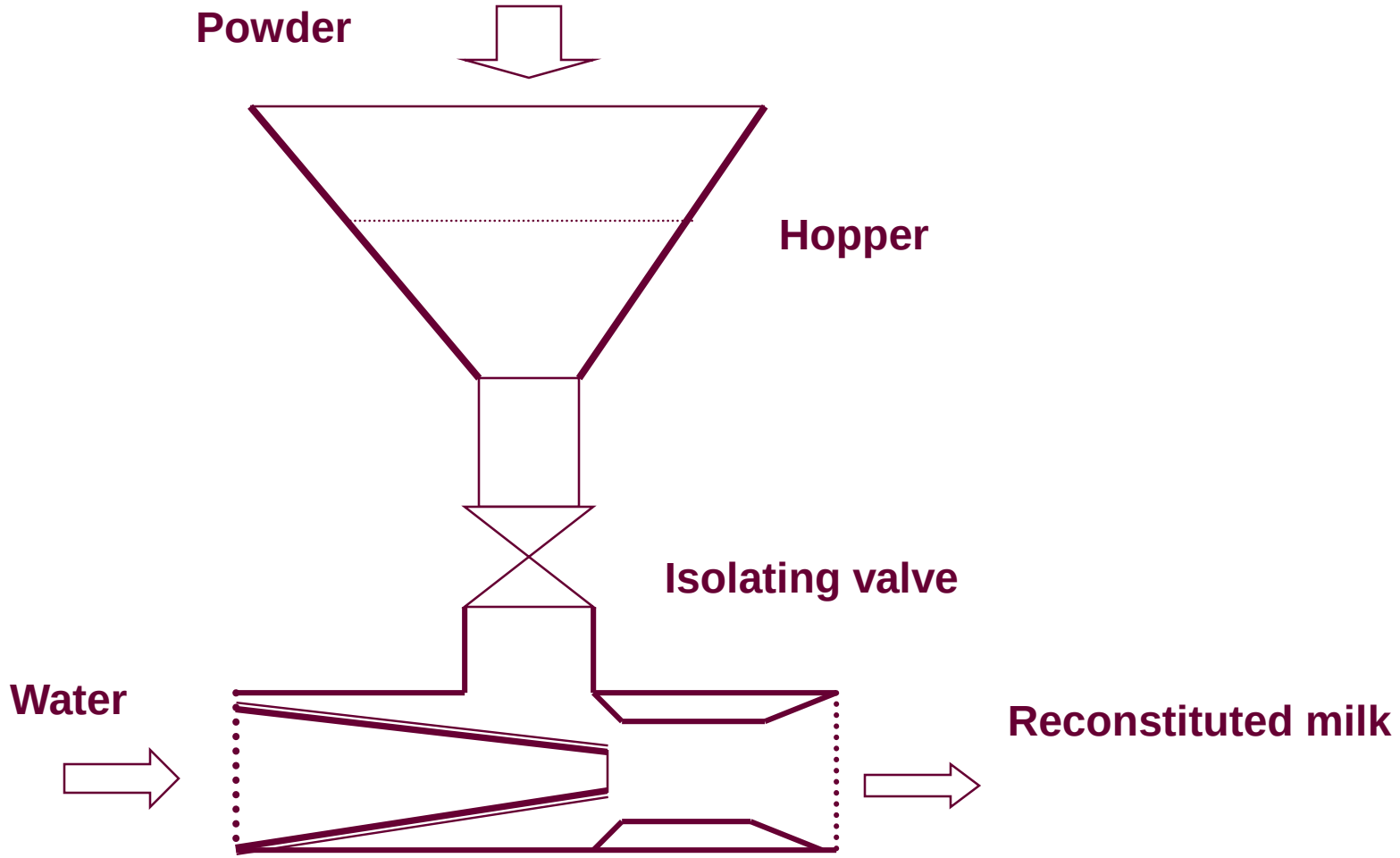
Setup for reconstitution of SMP



Types of powder-water blending systems

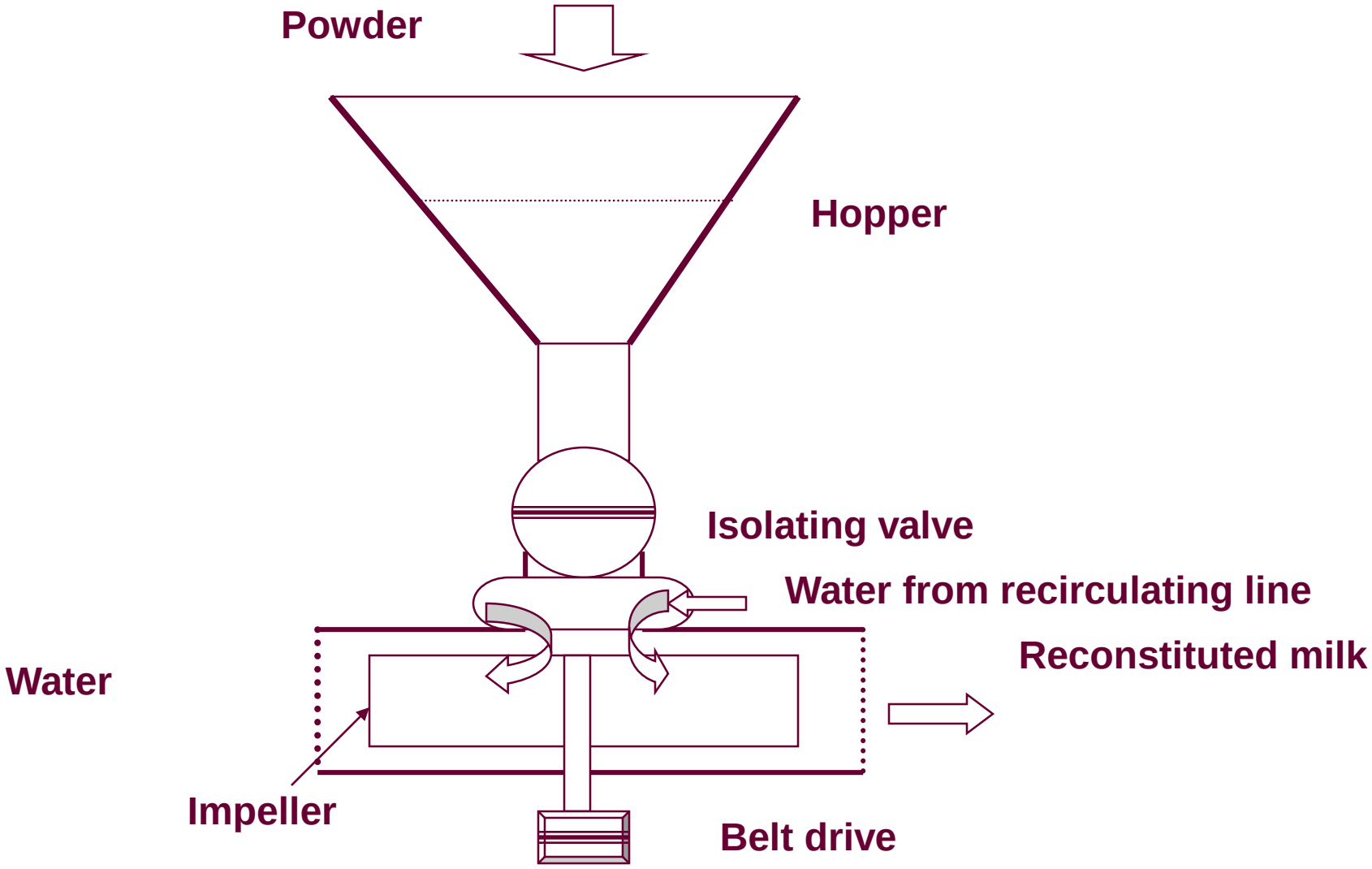
- Venturi blender
- Tri-blender
- Centrifugal blender

Venturi blender

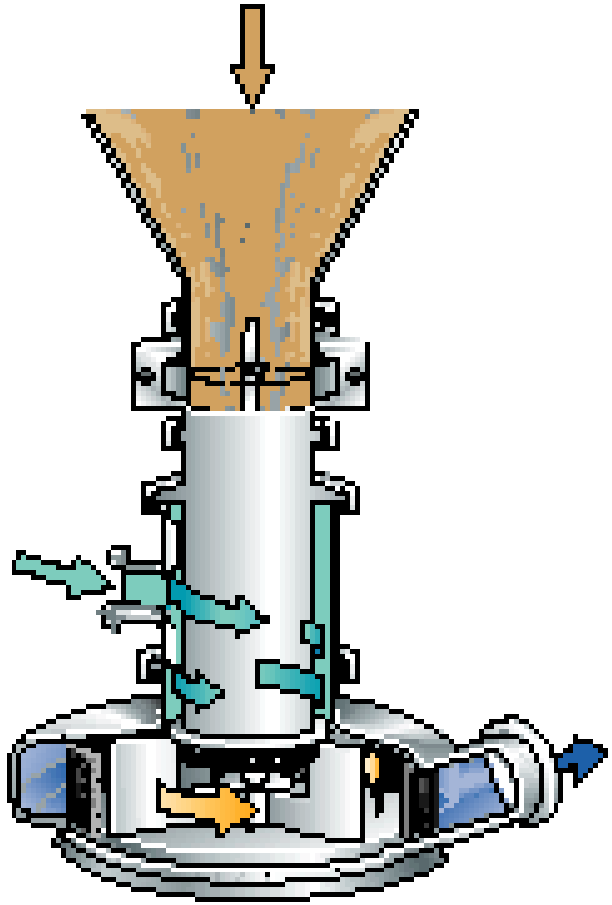


Tri-blender

Centrifugal blender



High-speed blender for reconstitution of milk powder



Dairy Processing Handbook, Tetra Pak

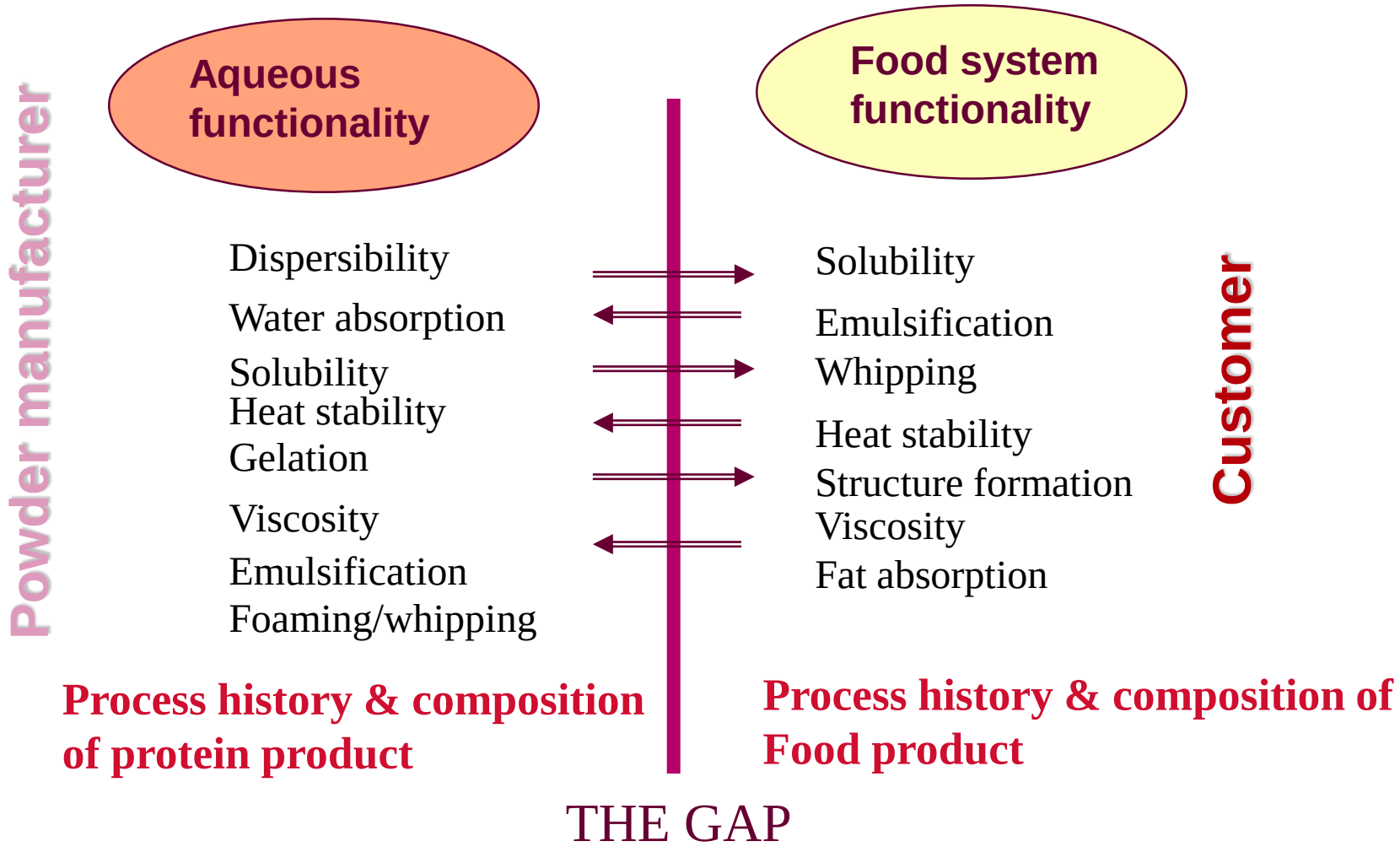
Water quality for recombining

Substances or characteristics	upper limit level
Colour	Pt-Co scale-5 units
Odour and taste	neutral
Turbidity	turbidity units - 5 units
Total solids	500 mg/1
pH (acceptable variation band)	7.0–8.5
Anionic detergents	0.2 mg/1
Mineral oil	0.01 mg/1
Phenol compounds	0.001 mg/1
Total hardness (in $CaCO_3$)	100 mg/1
Calcium (Ca)	75 mg/1
Magnesium (Mg)	30 to 150 (1) mg/1
Copper (Cu)	0.05 mg/1
Iron (Fe)	0.1
Manganese (Mn)	0.05 mg/1
Zinc (Zn)	5 mg/1
Chlorides (Cl)	100 mg/1
Sulphates (SO_4)	100 mg/1
Nitrates (NO_3)	45 mg/1

Source: FAO

Properties of WMP and SMP

"Aqueous" & "Food System" Functionality



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Dairy Handbook

Temperature and time for reconstitution (dissolving) milk powder

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- Temperature – keep above melting point of milk fat, e.g. 40-45°C
- Time – minimum of 30 min needed for complete hydration of protein

Maintain adequate agitation and recirculation during reconstitution

Tests for heat stability of milk powder

- HCT-pH
- Viscosity-pH
- Empirical tests

How to solve the problem of variations in heat stability during application

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- Difficult to control the variation during application
- Could try out the following
  - Manipulation of processing steps, such as low-temp mixing, avoiding direct contact with calcium salts, etc
  - Addition to ingredients that improve heat stability, such as carbohydrates
  - Choose mild pre-heating conditions

Quality requirements for milk powder for fermented milk products

- Low-to-high-heat
- Good solubility (solubility index 1.25 mL max)
- No scorched particles (Disc B or better)
- Clean, fresh flavour and odour
- Light cream to white colour
- Water binding
- Viscosity

Influence of milk powder and WPC manufacturing process on application of yogurt

- The extent of preheating and whey protein denaturation are the key parameters during powder manufacture that can influence properties in yogurt

Can WMP and SMP be used together….

- Both SMP and WMP can be used separately or in combination with each other
- The selection of either or both would depend on the desired composition

Requirements during processing

- Water quality
- Milk powder quality
- Equipment for recombining
- Heat-treatment
- Starter
- Incubation temperature
- Post fermentation handling

Heat treatment to yogurt milk

- Pasteurisation – 75°C for 20 s
- High temperature heating – 85°C fro 30 min or 95°C for 10 min

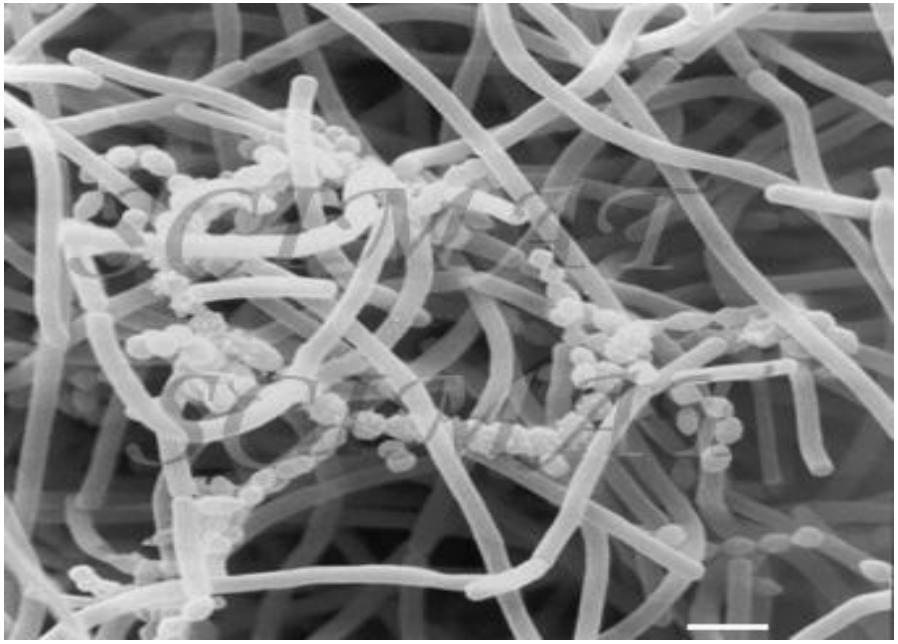
Purposes

- Food safety
- Competition-free environment for yoghurt culture
- May need to comply with country-specific regulations
- Helps in water binding and structure build-up

Yoghurt cultures

- Standard yoghurt cultures
  - Combination of *Streptococcus thermophilus* and *Lactobacillus bulgaricus*
- Additional cultures
  - *Leuconostoc* spp for extra flavour
  - *S. cremoris* and *S. lactis* (in some countries, such as India)
- Probiotic cultures
  - Several, some proprietary
  - *Lactobacillus acidophilus*
  - *Lactobacillus casei*
  - *Lactobacillus reuteri*
  - *Bifidobacterium bifidum*

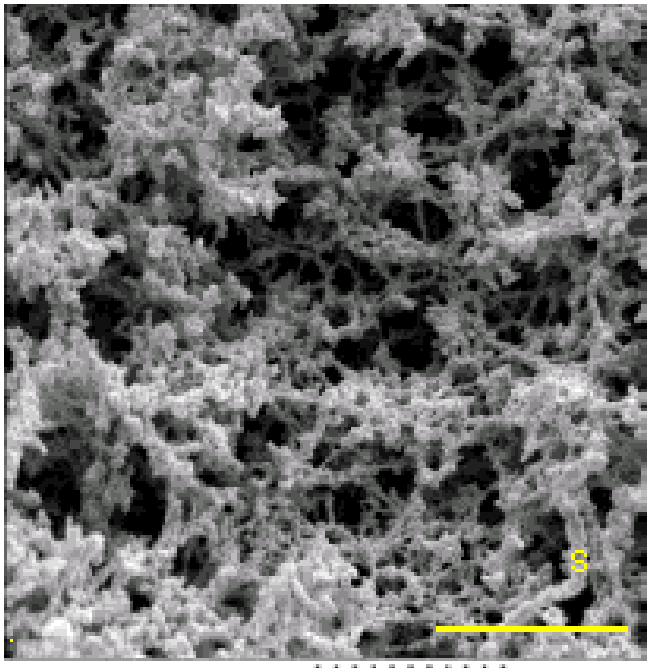
What do the cultures look like?



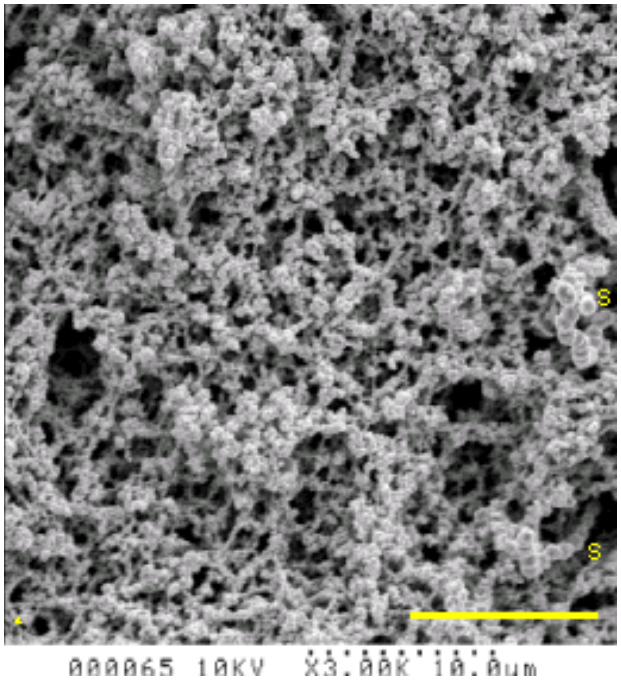
Bar = 2 um

- *S.thermophilus* (beads)
- *L.bulgaricus* (rods)

Whey protein concentrate (WPC) in yoghurt



All skim milk solids,
12% TS, 4.2% protein



60% Skim milk solids

+ 40% WPC40

(Puvanenthiran, Williams & Augustin, 1999)

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  - Could happened during certain time of the season
- Dark sediments in yogurt
  - Likely to be due to poor quality milk powder, e.g. milk powder containing scorched particles

UHT milk: requirements for milk powder

- Good heat stability (medium to medium-high-heat powder)
- Good solubility (solubility index <1.25 ml)
- No scorched particle (disc B or better)
- Clean and fresh flavour
- Light cream to white colour
- Good emulsifying properties

WMP and SMP in acid conditions

- For yogurt-type products
  - Good quality, low-to-medium heat powders
- Milk powders (WMP and SMP) are not suitable for clear-type acid beverages (WPC and WPI are better suited)

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Unpleasant flavour

- Manufacturers could have problems in processing milk powder during the late lactation period, however, manufacturers manipulate processing conditions to produce good consistent and quality milk powders

Functional milk drinks

- Milk drinks containing ingredients at levels higher than normally found and implied to have health/medical benefits
  - Vitamins
  - Minerals
  - Herbs
  - Probiotics and prebiotics
  - PUFA

Difficult to make direct health claims

Quick tests for differentiating low-heat, medium-heat and high-heat milk powders

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- Whey protein nitrogen index
- Heat number
- Solubility index
- Empirical test (Heat 12%TS milk in a pressure cooker for 15 min, note precipitation or gelation)

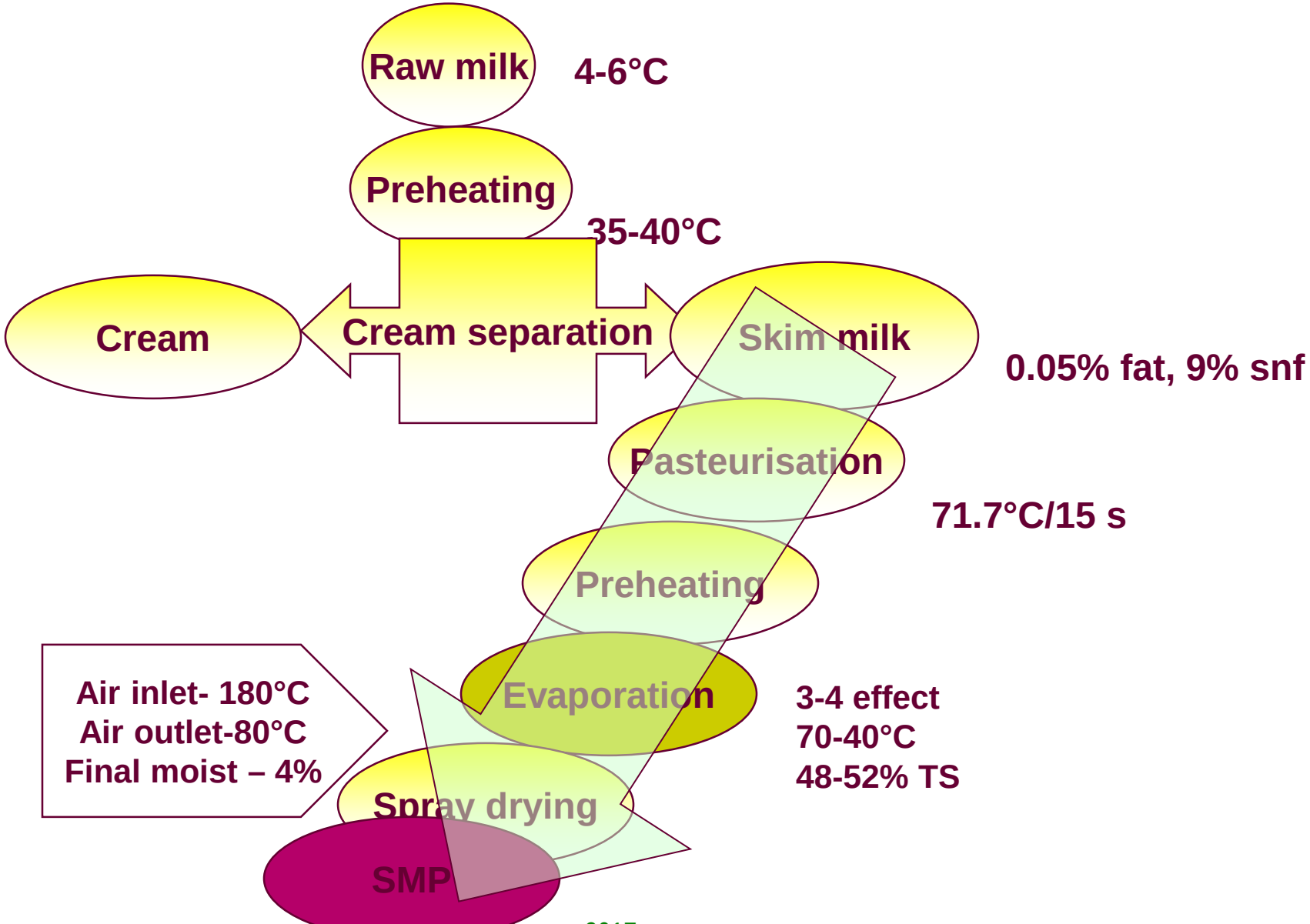
Advanced milk powders

The Approach

- Identify target functionality required
- Understand major factors affecting target functionality
- Alter composition and process variables
- Apply functional screening tests
- Test properties in final food product

Interactions between the dairy & other ingredients and processing affect the expression of ingredient functionality in the final food product

Manufacture of SMP



Buttermilk powder

- The aqueous material released during churning of cream to manufacture butter
- Buttermilk is a solution of residual fat, protein, lactose and mineral in water
- Rich source of natural fat globule membrane components, such as membrane protein, phospholipids, etc
- Drying of buttermilk follows essentially same procedure as skim milk powder (pasteurisation, concentration and drying)

BMP – typical composition

Moisture	3%
Protein	34%
Fat	6%
Carbohydrate	49%
Ash	8%

BMP – typical vitamins and minerals (mg/kg)

Sodium	517
Potassium	1592
Calcium	1184
Phosphorus	933
Magnesium	110
Zinc	4.02
Iron	0.30
Copper	0.111
Manganese	0.023
Selenium	0.020
Vitamin A	0.054
Thiamin	0.392
Riboflavin	1.579
Niacin	0.876
Vitamin B6	0.338
Folate	0.047
Vitamin B12	0.0038
Pantothenic Acid	3.170
Vitamin C	5.70
Vitamin E	0.40

BMP – functional properties

Browning	**Proteins in buttermilk powder can react with lactose and other reducing sugars to develop a brown colour when a product is heated.**
Emulsification	**Proteins in buttermilk powder have both polar and non-polar regions and are able to function as emulsifiers, stabilizing oil-water interfaces in emulsified products such as sauces and dressings.**
Foaming	**Milk proteins are also able to stabilize the air-water interface and promote foam formation and stability in products such as baked goods.**
Water binding	**Milk proteins can bind water and in doing so, increase the viscosity of products such as puddings**
Flavour	**Buttermilk powder can enhance the dairy flavour of products.**

BMP - applications

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Baked goods
To provide desirable flavour, help incorporate air into the product, aid in the development of browning as the product is baked and preserve freshness by binding water.

Ice cream
To function as a source of milk solids non-fat and supply compounds that aid in the initial stabilization of the oil-water interface in the mix (proteins, phospholipids) and the air-water interface as the mix is whipped and frozen (proteins).

Dry mixes such as pancake, waffle or biscuit mixes.

Puddings, sauces and certain beverages
To absorb water and increase the product viscosity.

Breading or batter
To provide desirable brownness upon heating.

Coating for snack foods
To have dairy flavours (e.g. sour cream and onion)

Chocolate
To provide flavour and possibly beneficial emulsifying ability

Processed cheese slices and spreads
To add viscosity and contribute to the structure of the product.

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Emulsification problems with UHT milk

- Poor quality milk powder (e.g. with free fat and off flavours)
- In adequate homogenisation during recombining
- Milk powders contains high amounts of aggregated proteins (due to very high heating temperatures during powder manufacture)
- Poor heat stability of milk powder

Addition of low molecular weight surfactants helps in improving emulsion stability

Alcohol test

- A measure of the stability of milk, not necessarily correlated to heat stability
- Milk high in calcium shows poor alcohol stability
- Stage of lactation of milk affects alcohol stability – early lactation – poor stability
  - mid lactation – good stability
  - Late lactation – range of stability
- Alcohol stability improves with increase in pH of milk

pH range for recombined milk

- Normal suitable range is pH 6.4 to 7.0
- Milk stability decreases considerably below pH 6.2
- High calcium milks more stable at higher pH values

Casein

- The fat and ash content in acid casein are influenced by
  - Fat content of skim milk – high fat milk results in casein with high fat
  - Quality of raw milk (e.g. high acidity)
  - Number of washings – more the number of washing, lower the ash content
  - Temperature of coagulation – optimum temperature results in less ash content