Processed cheese analogues technology

Technological and health role of whey proteins

Dr hab. Bartosz Sołowiej, Assoc. Prof.

University of Life Sciences in Lublin, Poland
Faculty of Food Sciences and Biotechnology

Processed cheese analogues

A little bit of history

- The production of **processed cheese** started in Europe, and could date to the **mid-1890s**.
- Commercial developments were made in Germany for the export of short shelf-life soft cheese, e.g. ***Camembert, Brie*** and ***Limburger***, which was achieved by **heating the cheeses in metal cans**.

A little bit of history

- Commercial production of processed cheese started in Europe and the USA between **1910 and 1920**. The production techniques were based on ***Cheddar*** and other cheese varieties, and used citrates or phosphates as the **emulsifying salts**.
- These early attempts to produce good-quality processed cheese were of limited success, but the process became widespread by the **1930s*.**

* other dairy and non-dairy ingredients could be added to the blend before processing (governed by statutory regulation within each country of manufacture).

A little bit of history

- **Cheese analogues** have gained importance in different areas in **1950s**. Firstly, largely because of a tremendous increase in **the consumption of pizza pie** and the fact that **cheese is among the costliest components** of a pizza pie, attention has focused on the development of cheese substitutes.
- In addition, the manufacture of an imitation cheese allows manufacturers greater scope in **manipulating constituents toward nutritional, textural, and economic ends**.

Processed cheese vs Processed cheese analogues

- **Processed cheese** is traditionally obtained by **mixing natural cheeses** with melting salts and water under the influence of heat and agitation.
- **Processed cheese analogues** are produced with **partial or whole replacement** of natural cheeses by milk or other proteins / milk fat by vegetable oil.

Need for cheese analogues

- **Fast foods and ready-made** conventional meals have become extremely popular wherein **cheese** is used as **one of the preferential ingredient**.
- **Natural cheese costs more than substitutes**. **The low cost of analogues is due to:**
  - low costs of vegetable oils compared with butter fat,
  - the low cost of casein,
  - relatively low cost of manufacturing equipment compared to that required for natural cheese,
  - the absence of a maturation period for these types of products.

Need for cheese analogues

- Cheese substitutes offer diverse functionality range (e.g. flowability, melt resistance, shreddability, etc.), which is made possible by **tailor-made formulations** and they exhibit **high functional stability during storage**.
- Substitute products can be designed to meet **special dietary needs** through changes in formulation (e.g. lactose-free, low calorie, low in saturated fat and cholesterol and even vitamin and mineral-enriched).

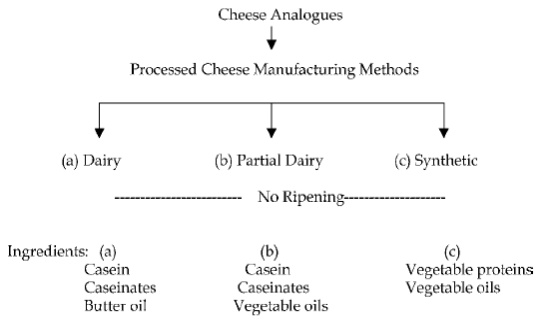


Fig. 1. Classification of cheese analogues.

Source: Chevan R.S., Jana A.: Cheese substitutes: An alternative to natural cheese. Int. J. Food Science, Technology & Nutrition, Vol. 2 (2007), No. 2, 25-39

Table. 1 Ingredients used in the manufacture of cheese analogues.

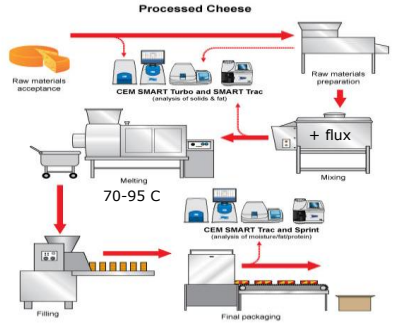
Ingredient	Main function/effect	Examples
Fat	Gives desired composition, texture and meltability characteristics, butter oil imparts dairy flavour	Butter, anhydrous milk fat, native or partly hydrogenated soybean oil, corn oil, palm kernel oil, etc.
Milk proteins	Gives desired composition, semi-hard texture with good shredability, flow and stretch characteristics	Casein, caseinates, whey proteins
Vegetable proteins	Gives desired composition and cost reduction.	Soyabean protein, peanut protein, wheat gluten
Starches	Substitution for casein and cost reduction	Native and modified forms of maize, rice potato starches.
Stabilizers		
i. Emulsifying salts.	Assist in the formation of physico-chemical stable product; modifies textural and functional properties	Sodium phosphate and sodium citrate.
ii. Hydrocolloids carrageenan.	Enhance product stability; modifies textural and functional properties	Guar gum, xanthan gum, carrageenan.
Acidifying agents	Assist control of pH in final product.	Organic acids e.g. lactic, acetic, citric, phosphoric.
Flavours and flavour enhancers	Imparts flavour; accentuates flavour.	EMC*, starter distillates, wood smoke extracts, spices, sodium chloride, yeast extract.
Colours	Impart desired colour	Annatto, paprika, artificial colours
Preservatives	Retards mould growth; prolongs shelf-life	Nisin, K-sorbate, Ca- or Na-propionate.
Mineralized vitamin preparations	Improved nutritive valve	Magnesium oxide, zinc oxide, iron, vitamin A palmitate, riboflavin, thiamine, folic acid.

EMC = Enzyme modified cheese

Source: Chevan R.S., Jana A.: Cheese substitutes: An alternative to natural cheese. Int. J. Food Science, Technology & Nutrition, Vol. 2 (2007), No. 2, 25-39

Source: Chevan R.S., Jana A.: Cheese substitutes: An alternative to natural cheese. Int. J. Food Science, Technology & Nutrition, Vol. 2 (2007), No. 2, 25-39

Processed cheese and analogues technology



Processed cheese analogues production – laboratory scale

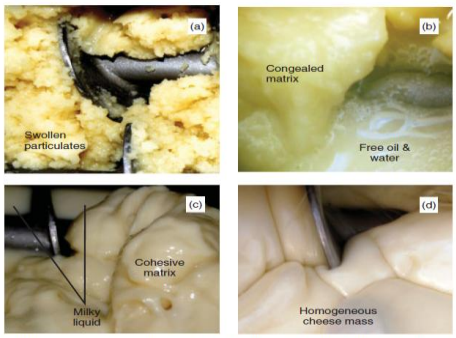
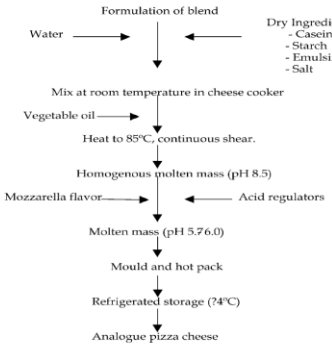


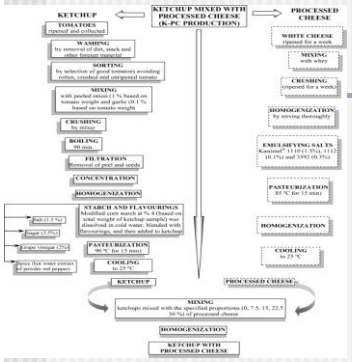
Plate 9.1 Illustrations of the four main stages of matrix development during the manufacture of analogue cheese.

Source: Tamime A. Processed cheese and analogues: An overview, 2011.



Production of pizza cheese analogue

Source: Chevan R.S., Jana A.: Cheese substitutes: An alternative to natural cheese. Int. J. Food Science, Technology & Nutrition, Vol. 2 (2007), No. 2, 25-39



Production of ketchup-processed cheese analogue

Source: Yilmaz M.T. et al.: Steady and dynamic oscillatory shear rheological properties of ketchup -processed cheese mixtures: Effect of temperature and concentration. J Food Eng. 2011, 103, 197-210.

Advantages

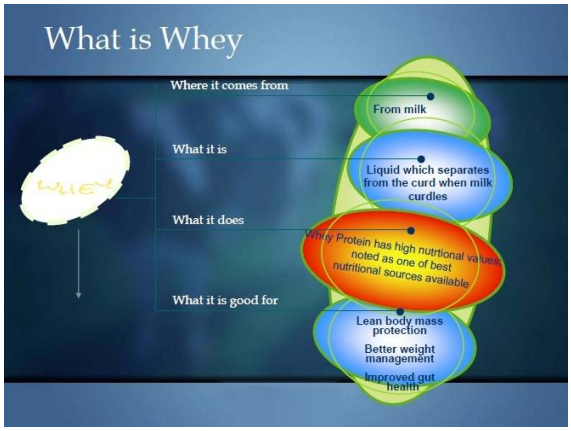
Processed cheese and **cheese analogues** have technical advantages over unprocessed cheese:

- extended **shelf-life**, **resistance to separation** when cooked, and the **ability to reuse scraps, trimmings and run off** from other cheesemaking processes.

- Traditional cheesemaking produces **'scrap' pieces** that would not be acceptable for supermarket display
- Production of **processed cheese** or **analogue** from cheese scrap allows the cheesemaker to **use** otherwise unmarketable **scrap.**
- **Processing can turn** these scraps into **new presentable shapes** for repackaging and sale.

Disadvantages

- **Processed cheese** also normally lacks the range of textures available in unprocessed cheeses
- processed cheeses are normally **very smooth and medium-firm.**



Whey products used in processed cheese analogues

- sweet whey,
- demineralized whey,
- reduced-lactose whey,
- whey protein concentrates,
- whey protein isolates.

Take the „right” whey

- The use of **whey product(s)** typically results in superior flavour, body and texture; improved sheeting, slicing, shredding, spreading and in some cases meltability.
- Another advantage of whey products is the potential of improving **nutritional attributes in a cost effective fashion.**

Some of physicochemical measurements of processed cheese analogues

Technological role of whey proteins

Viscosimetry

Brookfield DV II+ viscometer (Stoughton, MA, USA)

- with a Helipath Stand (F)
- spindle velocity e.g. 0.5 rpm/min.

processed cheese and analogues viscosity

Dynamic oscillatory rheometry

Rheometer RS 300 (ThermoHaake, Karlsruhe, Germany)

- parallel plate
- frequency of 0.1 Hz
- temp. 20 – 80 ºC
- loss moduli (G')
- storage moduli (G")
- tan (δ)

- **Viscoelastic properties**

Texture measurements

Texture Analyser TA – XT2i (Stable Micro Systems, Surrey, England)

Texture profile analysis (TPA): hardness, cohesiveness, fracturability, adhesiveness, springiness, gumminess, chewiness.

- testing set (e.g. 15, 30 mm diameter)

Puncture test:

- testing set (e.g. 10 mm diameter)

Relaxation time:

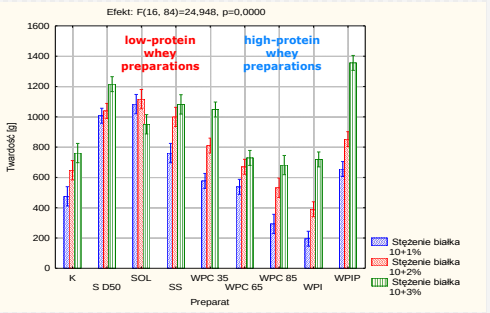
- Testing set (e.g. 35 mm diameter)

Schreiber test

(modified Schreiber test – Mleko & Foegeding, 2001)

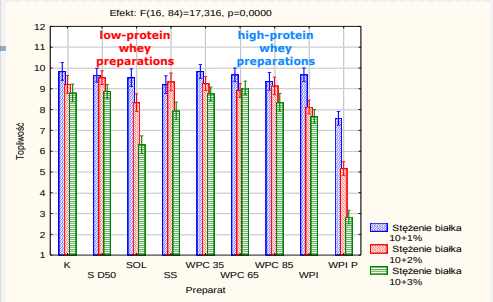
Meltability of processed cheese and analogues

The effect of different whey protein concentration on processed cheese analogues hardness [G] - TPA



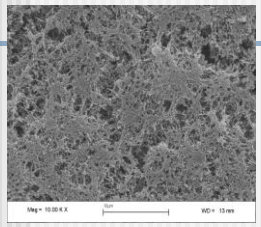
Source: Solowiej B. Obtaining and physicochemical properties of processed cheese analogues with whey preparations - Ph.D. thesis

Meltability of processed cheese analogues (Modified Schreiber test – Mleko & Foegeding, 2001)

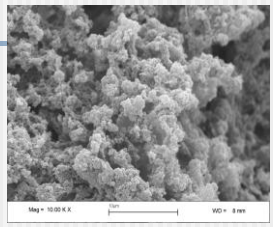


Source: Solowiej B. Obtaining and physicochemical properties of processed cheese analogues with whey preparations - Ph.D. thesis

Microstructure of processed cheese analogues



SEM processed cheese analogues with addition of 1% low-protein whey concentrate (WPC 35)



SEM processed cheese analogues with addition of 3% low-protein whey concentrate (WPC 35)

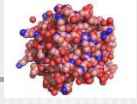
Source: Solowiej B., Mleko S., Gustaw W., Udeh K.O.: Effect of whey protein concentrates on texture, meltability and microstructure of acid casein processed cheese analogues. Milchwissenschaft, 2010, 65 (2), 169-173.

Health role of whey proteins

The Sub-Fractions of Whey Protein

- Beta-lactoglobulin,
- Alpha-lactalbumin,
- Immunoglobulins (Ig),
- Bovine Serum Albumin (BSA),
- Glycomacropeptide (GMP),
- Lactoferrin,
- Lactoperoxidase,
- Lysozyme.

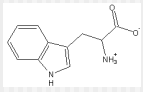
Beta-lactoglobulin



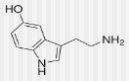
- Beta-lactoglobulin is the most abundant whey protein component, making up approximately **50-75 %** of the whey protein.
- It binds **fat-soluble vitamins** making them more available to the body.
- It is rich in muscle sparing energy supplying branched chain **aminoacids (BCAAs).**

Alpha-lactalbumin

- Alpha-lactalbumin is the second most abundant whey protein component, making up approximately **12-24 %** of the whey protein.
- It is primary protein found in **human breast milk.**



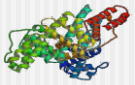
- Being high in tryptophan, an essential amino acid, potential benefits include **sleep regulation and mood improvement under stress.**
- Alpha-lactalbumin is the only whey protein component **capable of binding calcium.**



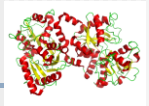
- Lactalbumin may also help **raise serotonin** in defciency states and **lower cortisol** when in excess.

Immunoglobulins and Bovine Serum Albumin

- Immunoglobulins (mostly IgG, with IgA and IgM), and Bovine Serum Albumin (BSA), make up approximately **5-15 %** of the whey protein.



Lactoferrin



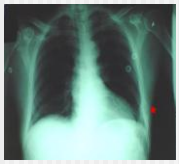
- Lactoferrin, a glycoprotein, makes up approximately **0.2 -1 %** of the whey protein.
- Lactoferrin **inhibits the growth of bacteria** (*E. coli and L. Monocytogenes)* and fungi due to its ability to bind iron.

* Iron is a nutrient usually required for bacterial growth.

- Lactoferrin also **promotes the growth** of beneficial bacteria such as *L. Bifidus*, helping infants establish good microbial conditions in their intestines.

- It is also an **antioxidant** that naturally occurs in many body secretions such as tears, blood, breast milk, saliva and mucus.

- Lactoferrin has:
  - **antiviral**,
  - **anti-tumor**,
  - **anti-inflammatory activity**
- Lactoferrin is also a **cysteine rich sub-fraction.**



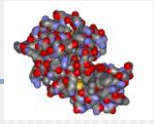
- Lactoferrin shows considerable inhibitory action against **HIV**
- Recent clinical trials have demonstrated that intake of **cysteine-rich whey protein** formulas benefits patients with HIV/AIDS.

- Also, intake of a cysteine-rich whey protein supplement for eight weeks **increased** weight gain, **reduced** the occurrence of gastrointestinal side effects, and **improved** tolerance to highly active anti-retroviral therapy (HAART) in HIV patients.

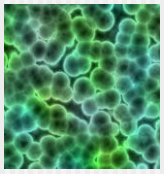
Lactoperoxidase

- Lactoperoxidase makes up approximately **0.5 %** of the whey protein.
- Like lactoferrin, it **inhibits the growth** of iron dependent bacteria.

Lysozyme



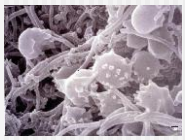
- Lysozyme makes up less than **0.1 %** of the whey protein.
- Lysozyme contains **immunity enhancing properties.**



- Lysozymes **contain enzymes** that can attach to and **digest bacteria cell walls**, thus destroying them.

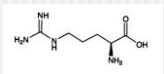
Glycomacropeptide

- Glycomacropeptide (GMP) helps **control appetite** and **inhibit the formation** of dental plaque and dental cavities.
- Levels may range from **1 % to 18 %**, depending on how the whey is processed.

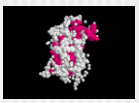


Physical Performance

- Whey proteins are **easily digestible** high quality proteins with a relatively high proportion of **branched chain amino acids (BCAA)** such as leucine.
- These amino acids provide an **energy source** during endurance exercise, which allows athletes to train **more intensively** for longer periods of time.



- The abundance of **leucine** in whey plays a role in the **synthesis of muscle protein.**
- Also, whey proteins are rich in the amino acids, **arginine and lysine**, which may increase the release of **growth hormone**, a **stimulator of muscle growth.**



Conclusion

- Recognition of **whey** as a source of diverse biologically active compounds with unique physiological and functional attributes provides opportunities for the food industry to **develop functional foods**, or foods that have **potential health benefits** beyond their nutrient content.
- Also, the **technologial role** of whey proteins is invaluable.

Thank you for your attention