# Samspillet mellem proces og produktegenskaber: Mælkeproteiner som ingrediens i fødevarer

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# Agenda

- Introduction
- Types of milk protein ingredients for fermented milk products
- Micro- and nanoparticulated whey protein
- Interaction with other components
  - Exopolysaccharides (EPS) made by lactic acid bacteria
  - Gellan gum
- Conclusion and perspectives

# Introduction: Why?

- ✓ Water binding (decrease syneresis)
- ✓ Structure formation (better texture)
- ✓ Fat replacement (creaminess perception)
- ✓ Health and nutrition (increased satiety etc)
- ✓ Avoidance of acid whey (Greek style yoghurt)

- ✓ Clean label (adding dairy back into dairy)
- ✓ No off-flavour
- ✓ Excellent functionality (e.g. compared to many vegetable proteins)
- ✓ Versatile (composition/processing)

# Use of milk protein ingredients in fermented dairy products

- Whey protein concentrates and isolates (WPC, WPI)
  - Used extensively in the industry
- Casein and caseinates
  - Used extensively in the industry
- Mixtures of the above
  - Used extensively in the industry
- Milk protein concentrates (MPC/MPI) and coprecipitates
  - Some use of MPC
- Micro- and nano-particulated whey protein (MWP, NWP)
  - MWP used, NWP coming into the market
- Micellar casein isolates
  - Could possibly be used

# Micro- and nanoparticulated whey protein

Microparticulated whey protein (MWP) can be defined as (or delimited to):

*'Microparticulated whey protein are ingredients able to be produced commercially from milk or whey with enhanced functionality compared to non-particulated whey protein due to process-induced aggregation of protein and particle sizes ranging mainly from 1 to10 µm'.*

Nanoparticulated whey protein:

*' As above – but with particle sizes below 1 µm and mainly ranging from 100-500 nm'*

*Richard Ipsen 2017 Microparticulated whey proteins for improving dairy product texture, International Dairy Journal, 67, 73-79*

# Manufacture of micro- and nanoparticulated wheyprotein

The process of manufacturing consists of:

1. Concentrating the whey

2. Simultaneous heating (70-120°C) and shearing (~ 1200 $min^{-1}$)

   *Note: Shearing not always performed in commercial productions*

   *Note: Changes in pH/mineral content*

3. Spray drying (optional)

# Why use micro- or nanoparticulated whey protein?

- Dairy ingredients
- MWP has been shown to be useful as a fat replacer in a number of dairy products:
  - **Yoghurt and other fermented products**
  - Semi-hard cheese
  - Ice cream
- MWP affects texture in low fat dairy products in a manner that ensures a creaminess almost comparable with full fat products.

Note: MWP(NWP have added functionality compared to WPC/WPI

# MWP and hydration

*Hydration matters:*

MWP provides more immobilized water ($M_{21}$) compared to WPC
Surface characteristics of MWP are important:

- Hydration of small whey microparticles (<1 μm, C) for 60 min prior to heat treatment was sufficient for effective interaction with other proteins and resulted in high gel strength and enhanced water holding capacity
- Large microparticles (D) inhibited the gelation process and resulted in increased gelation times and weak, low viscosity yoghurt gels

*Isabel Celigueta Torres, Gülsüm Mutaf, Flemming Hoffmann Larsen and Richard Ipsen 2016  Effect of hydration of microparticulated whey protein ingredients on their gelling behaviour in a non-fat milk system,  Journal of Food Engineering, 184, 31-37*
*http://dx.doi.org/10.1016/ j.jfoodeng.2016.03.018*

# The role of disulphide bonds

*NEM: N-ethylmaleimide, a thiol blocking agent*
*Milk model systems (no fat, chemically acidified)*

NWP: Increased particle size and higher firmness
Efficient thiol/disulphide interactions
Non-covalent interactions (e.g. hydrophobic) with the other proteins present in milk

MWP: Weak protein network.
Not efficiently integrated as part of the gel network in the model systems.

*Guanchen Liu, Søren Bang Nielsen, Marianne Lund Lametsch, Jacob Holm Nielsen and Richard Ipsen 2016 Effects of disulfide bonds between added whey protein aggregates and other milk components on the rheological properties of acidified milk model systems, International Dairy Journal, 59, 1-9*
*http://dx.doi.org/10.1016/j.idairyj.2016.03.002*

# MWP vs NWP : Recent findings

Whey protein isolate (WPI), micellar casein and **MWP** in a milk model system:
Casein preferentially interacted with heat-denatured WPI, causing formation of casein-whey protein complexes during acidification. MWP can thus prevent formation of a dense protein network

Whey protein isolate (WPI), micellar casein and **NWP** in a milk model system:
NWP binds to casein micelles, hence heating causes increase in particle size when the casein/whey protein ratio is low (1:1)
Addition of NWP results in a strong protein network after acidification.
WPI aggregate during heating and acidification and form heat- induced nanoparticles that participate in the acidified network.

*Liu et al, 2016*

# Exopolysacharides (EPS)

Without EPS

With EPS

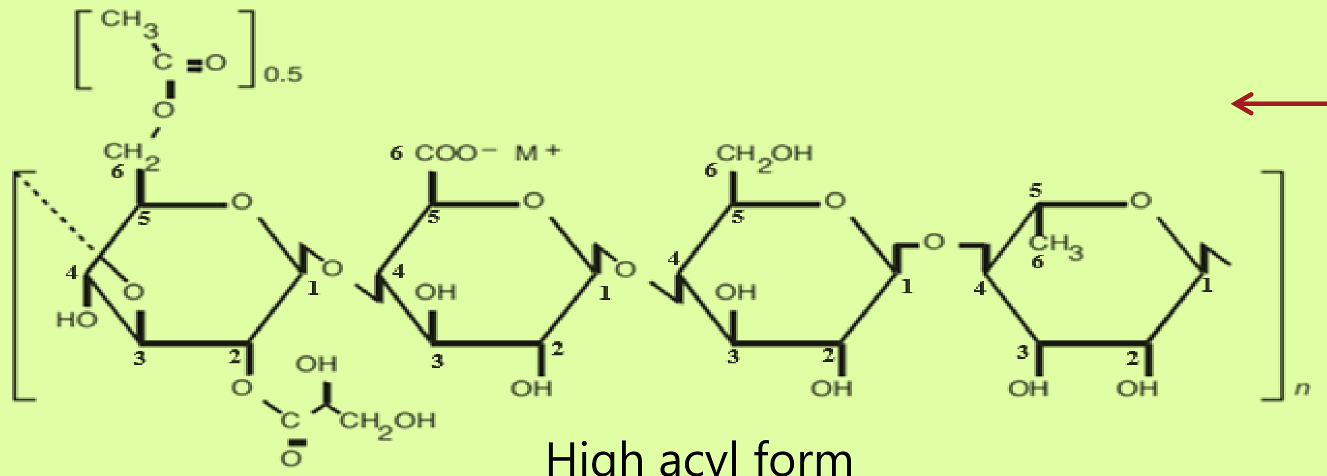
EPS: Exopolysaccharides

# Interactions between whey protein and EPS

Graininess depends on the interaction between type of added whey protein and the applied EPS producing culture

*Patrizia Buldo, Connie Benfeldt, Ditte Marie Folkenberg, Hanne Bak Jensen, Jose Manuel Amigo Rubio, Sander Sieuwerts, Katrine Thygesen, Frans van den Berg and Richard Ipsen 2016, The role of exopolysaccharide-producing cultures and whey protein ingredients in yoghurt, LWT - Food Science and Technology, 72, 189-198 http://dx.doi.org/10.1016/ j.lwt.2016.04.050*

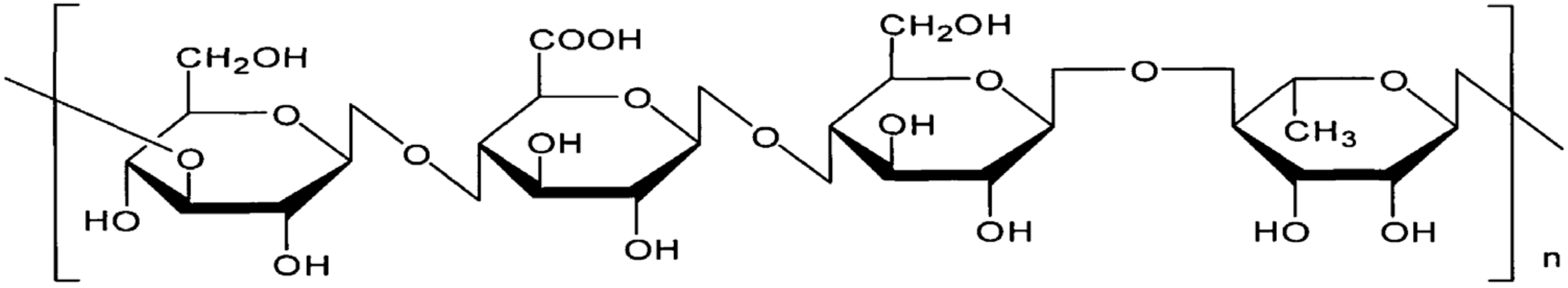
# Milk proteins and gellan gum in yoghurt



High acyl form

High acyl gellan gum (HAG): No additional processing

Low acyl gellan gum (LAG): A high proportion of the acetyl and glyceryl residues rmoved



Low Acyl form

Gellan gum is a water-soluble anionic polysaccharide produced by the bacterium *Sphingomonas elodea*

# Milk proteins and gellan gum in yoghurt

Gellan gum type determines interactions:

HAG: Open structure, larger protein aggregates (~ 40μm versus ~ 27μm) and better texture with inceased whey protein (casein:whey protein ratio 4:3)

LAG: Formation of a more continuous network, although with larger serum pores when only SMP was used. Better gel firmness and increased viscosity compared to HAG, but more syneresis

*Patrizia Buldo, Connie Benfeldt, Juan Pablo Carey, Ditte Marie Folkenberg, Hanne Bak Jensen, Sander Sieuwerts, Kalliopi Vlachvei, Richard Ipsen, 2016 Interactions between milk proteins and different gellan forms: their effect on microstructure and textural properties of acidified milk, Food Hydrocolloids, 60, 225-231* http://dx.doi.org/10.1016/j.foodhyd.2016.03.041

# Milk proteins and gellan gum in yoghurt

Syneresis significantly decreased when adding gellan in a system with unchanged ratio of casein to whey proteins, with HAG having a more pronounced effect. Increasing the ratio of whey proteins did not decrease syneresis

*Patrizia Buldo, Connie Benfeldt, Juan Pablo Carey, Ditte Marie Folkenberg, Hanne Bak Jensen, Sander Sieuwerts, Kalliopi Vlachvei, Richard Ipsen, 2016 Interactions between milk proteins and different gellan forms: their effect on microstructure and textural properties of acidified milk, Food Hydrocolloids, 60, 225-231 http://dx.doi.org/10.1016/j.foodhyd.2016.03.041*

# Milk proteins and gellan gum in yoghurt

Improved texture with LAG:
Formation of complexes between protein and gellan gum (electrostatic interactions)

HAG incompatibel with casein:
Micro-phase separation and weak texture, but increased water holding capacity and lower syneresis due to presence of HAG in the serum phase

Increasing the ratio of whey protein to casein:
Improved texture due to preferential binding between HAG and whey protein. Increased syneresis.

*Patrizia Buldo, Connie Benfeldt, Juan Pablo Carey, Ditte Marie Folkenberg, Hanne Bak Jensen, Sander Sieuwerts, Kalliopi Vlachvei, Richard Ipsen, 2016 Interactions between milk proteins and different gellan forms: their effect on microstructure and textural properties of acidified milk, Food Hydrocolloids, 60, 225-231* *http://dx.doi.org/10.1016/j.foodhyd.2016.03.041*

# Conclusion and perspectives

- Milk protein ingredients offers a wide range of clean label solutions for use in fermented milk products
- They  provide decreased syneresis, better texture, and can serve to replace fat
- Interactions with other milk components during processing into fermented milks should be more elucidated
- Interactions with other added ingredients is also determining for performance, especially in products with long shelf life