Structuring as a tool to control water binding of dairy-protein systems

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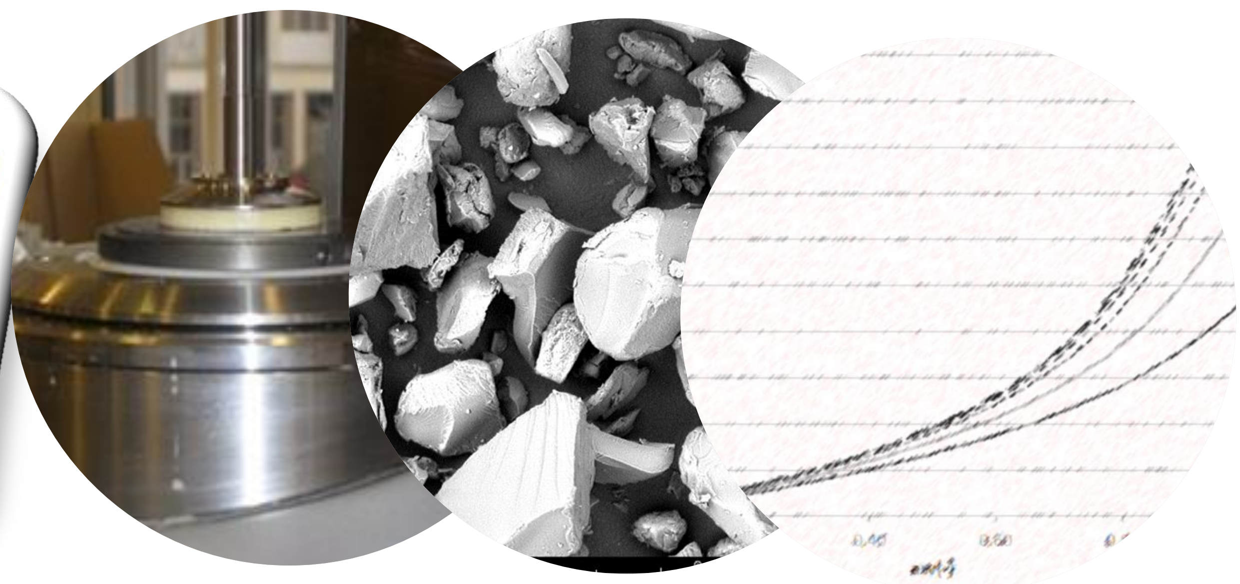
27 October 2014



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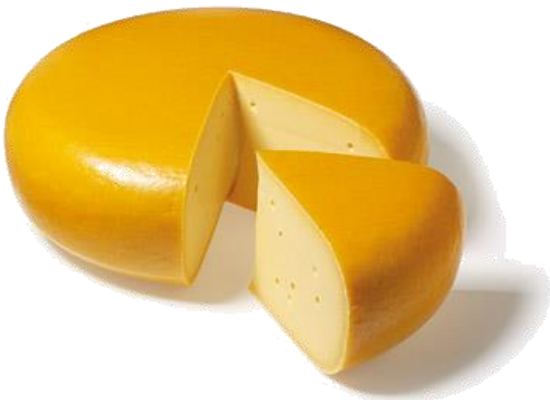
Towards increased water content in cheese



Change in composition →

Problem: the addition of water can lead to softer products and/or syneresis

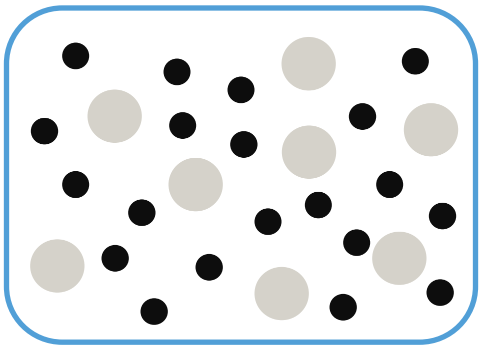
<u>Solution</u>

Creating protein structures which can absorb and tightly bind a relatively high amount of water

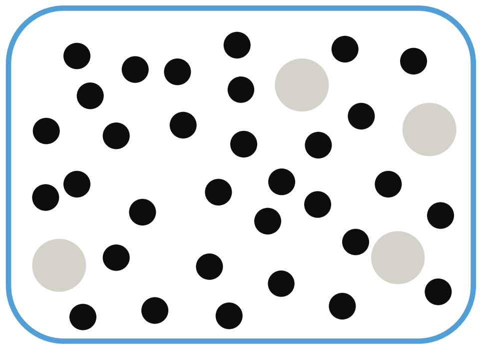
Hypothesis

- Change internal structure of the product

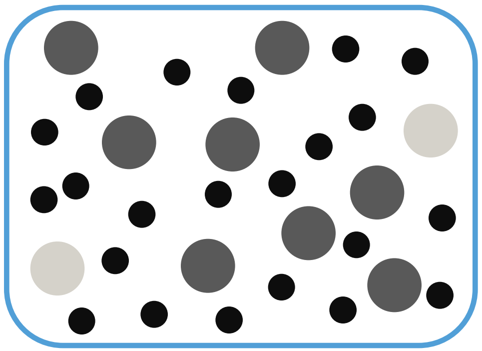
Regular cheese



Reduced-fat cheese



Modified internal structure of reduced-fat cheese

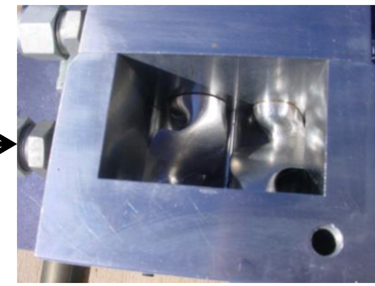


Interesting to have a look at protein particles

Swellable whey microparticles can be created by heat-induced gelation

40% w/w WPI suspension
pH 6.8

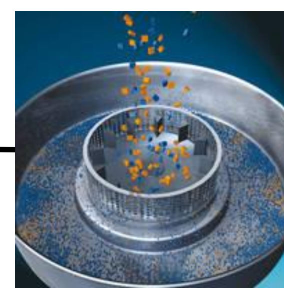
Centrifugation
10 min 1000 rpm



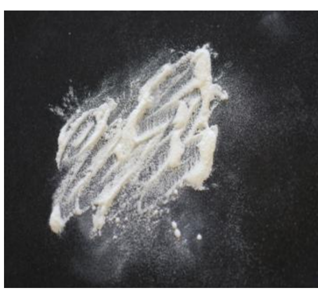
Heating while mixing
90 °C – 50 min

Wet gel
granules

Oven drying, 50 °C;
2 days

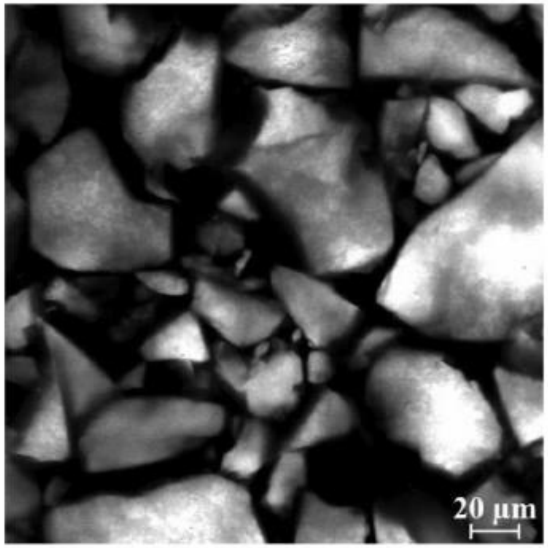


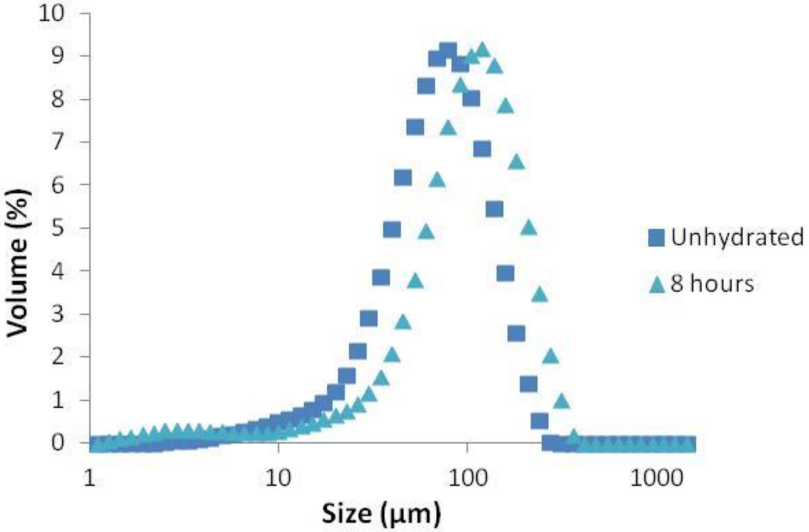
Ultracentrifugal mill,
sieve 80 µm

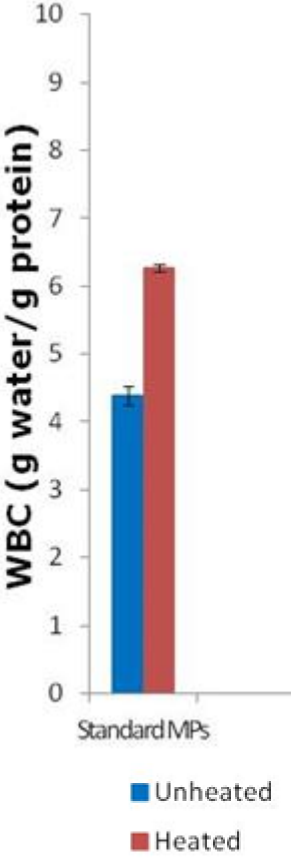


WPI microparticles

Whey microparticles can swell



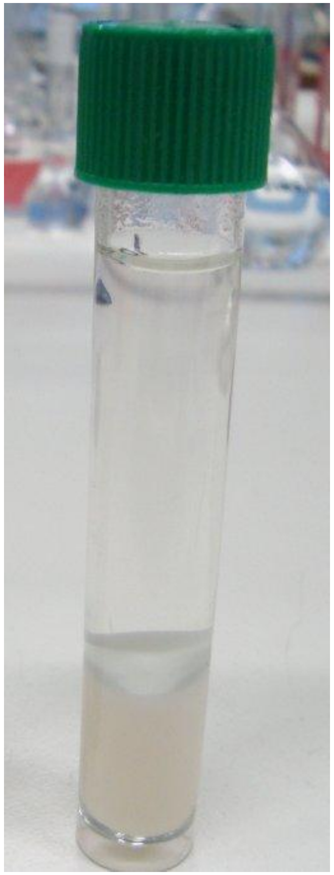




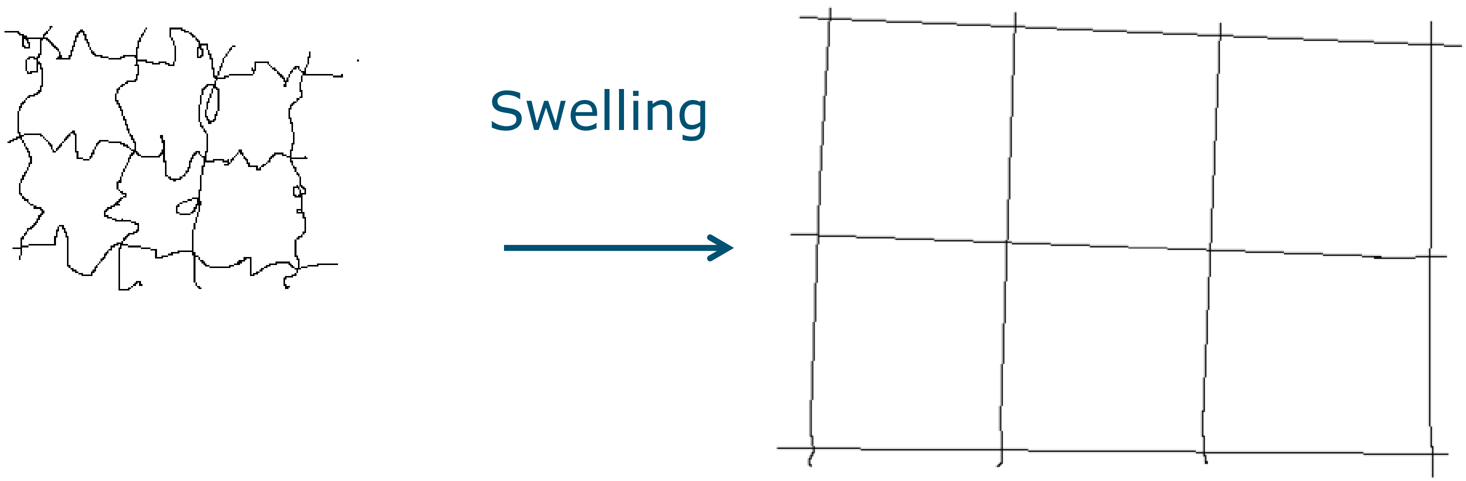
- Whey microparticles can swell in water

WHC methods
centrifugation method – excess of water

- Excess of water
  - Make a dispersion
  - Mix the solution
  - Centrifuge the solution
  - Remove the supernatant and determine the weight of the formed pellet



How to increase swellability?



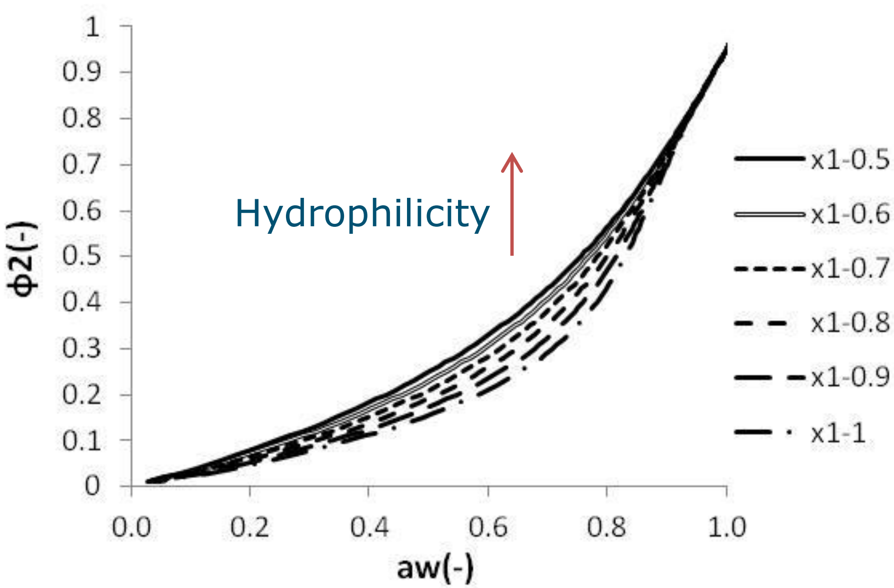
$$\ln a_w = \ln(1-\varphi_1) + \varphi_1 + \chi {\varphi_1}^2 + \frac{E v_w}{RT}\left[{\varphi_1}^{1/3}{\varphi_0}^{2/3} - \frac{\varphi_1}{2}\right]$$

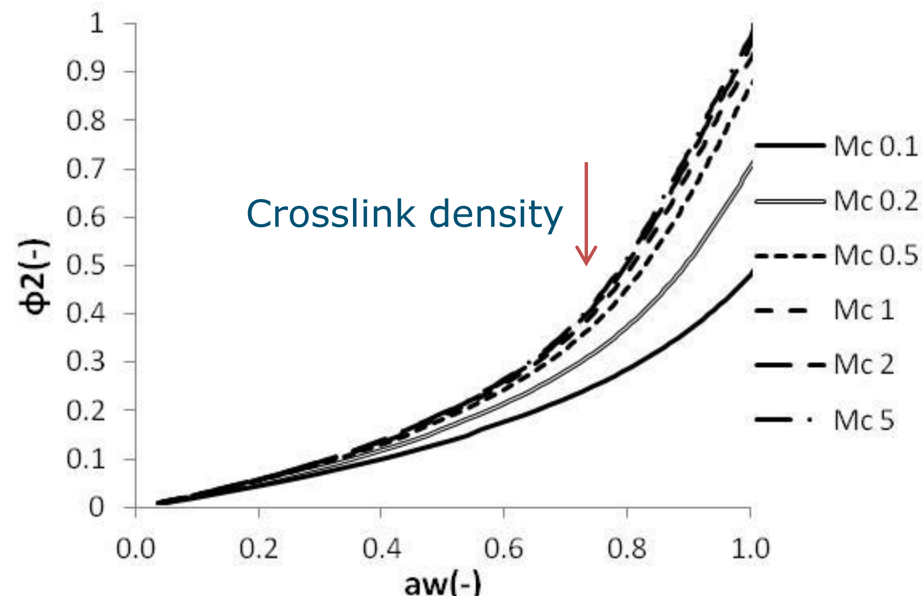
Changing the swellability of MPs by their hydrophilicity and/or crosslink density

Flory-Rehner equation

Mixing water/protein ↔ Expansion network

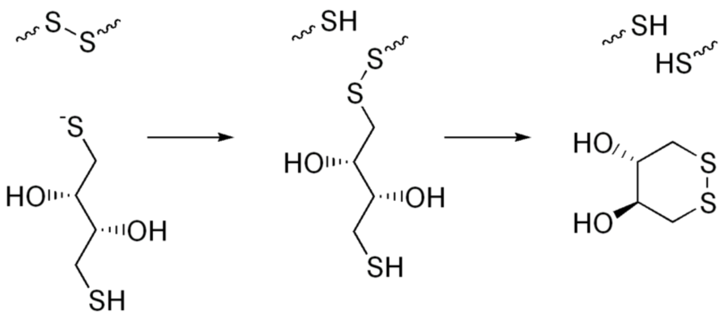
Hydrophilicity protein (χ) | Crosslink density (M_c)

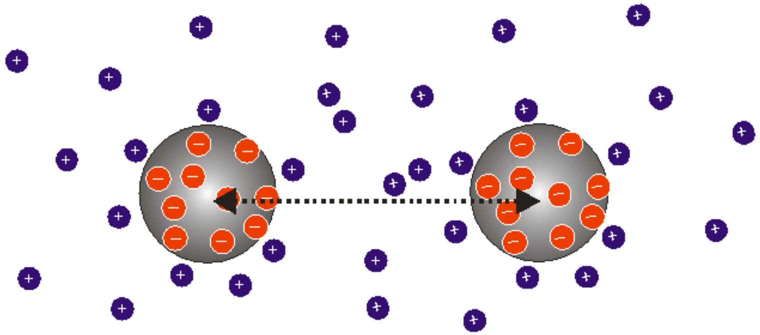




Decreasing the crosslink density with DTT

- Dithiothreitol (DTT)
  - Reducing agent
  - Breaks disulphide bonds

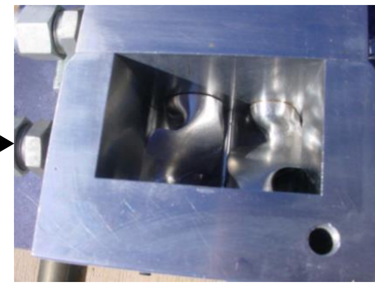




Making of MPs – standard + addition chemicals

40% w/w WPI suspension
pH 6.8

Centrifugation
10 min 1000 rpm



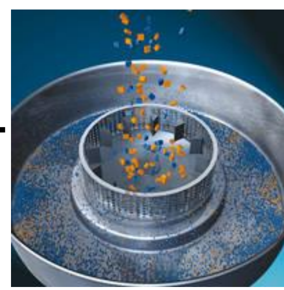
Heating while mixing
90 °C – 50 min

Wet gel
granules

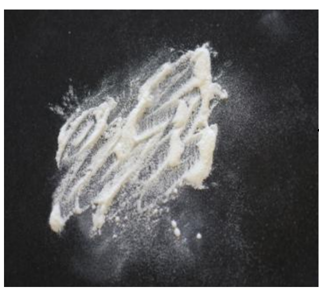
Addition after

Mixing 25g particles in 50mL solution

Oven drying, 50 °C;
2 days

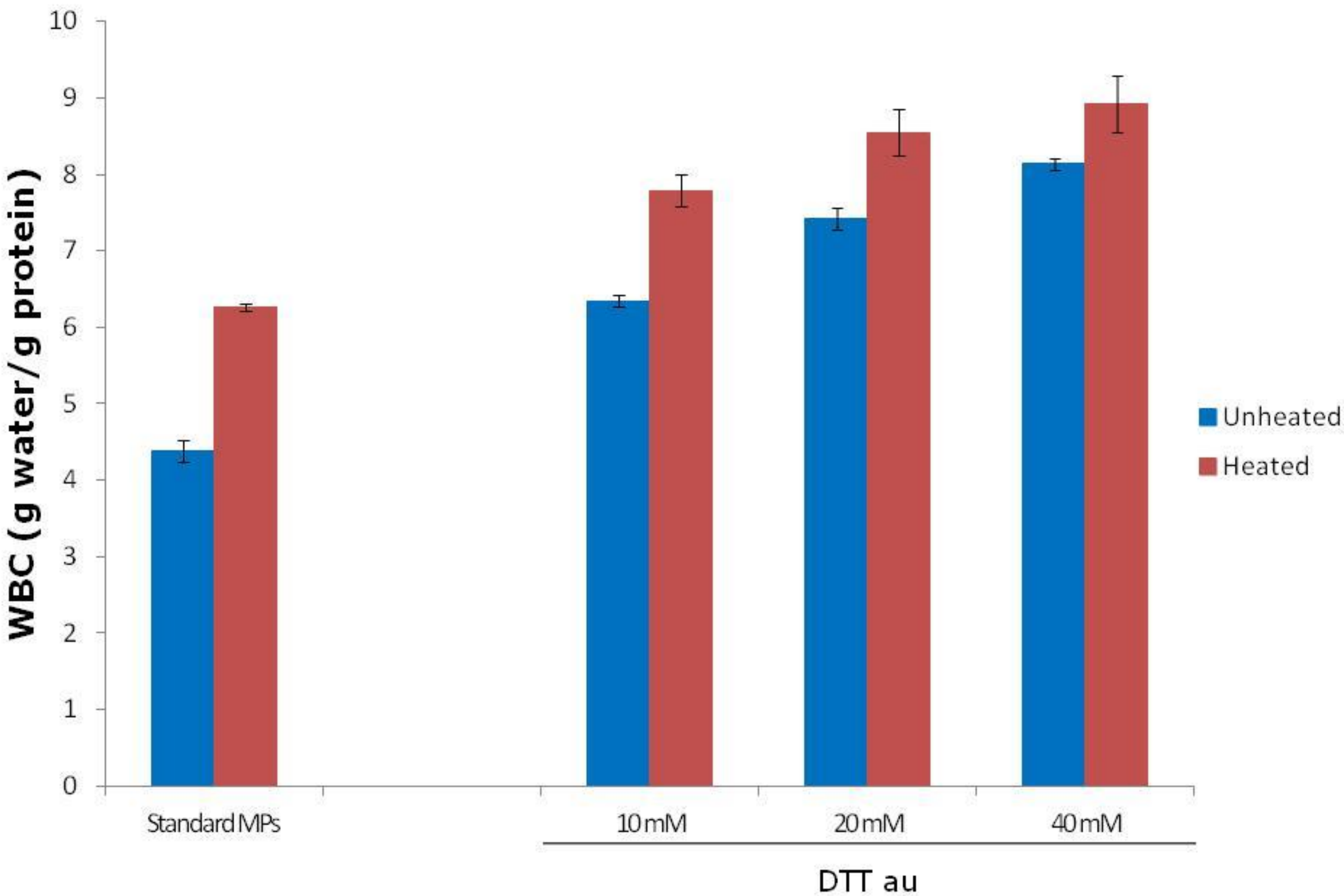


Ultracentrifugal mill,
sieve 80 µm



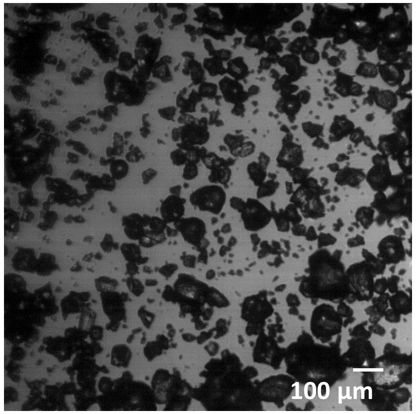
WPI microparticles

Decreasing the crosslink density with DTT

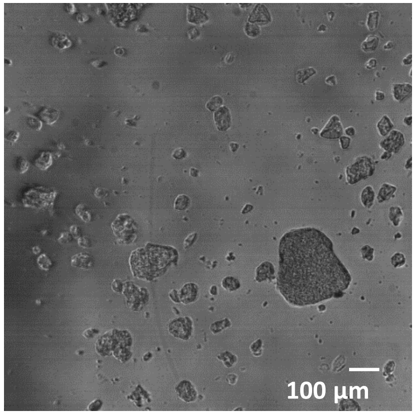


↑ concentration DTT → ↑ WHC ↑ stability

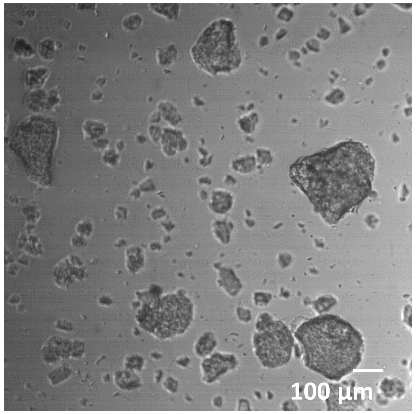
Microscopic images MPs with 67mM DTT



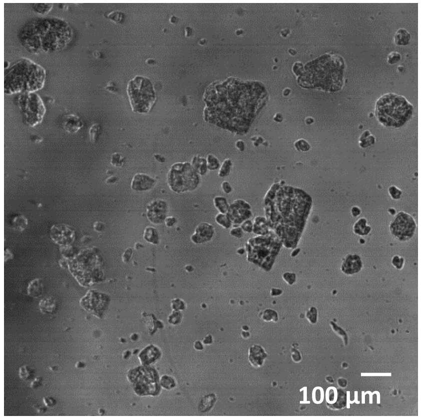
Unhydrated



24 hours hydration



48 hours hydration



72 hours hydration

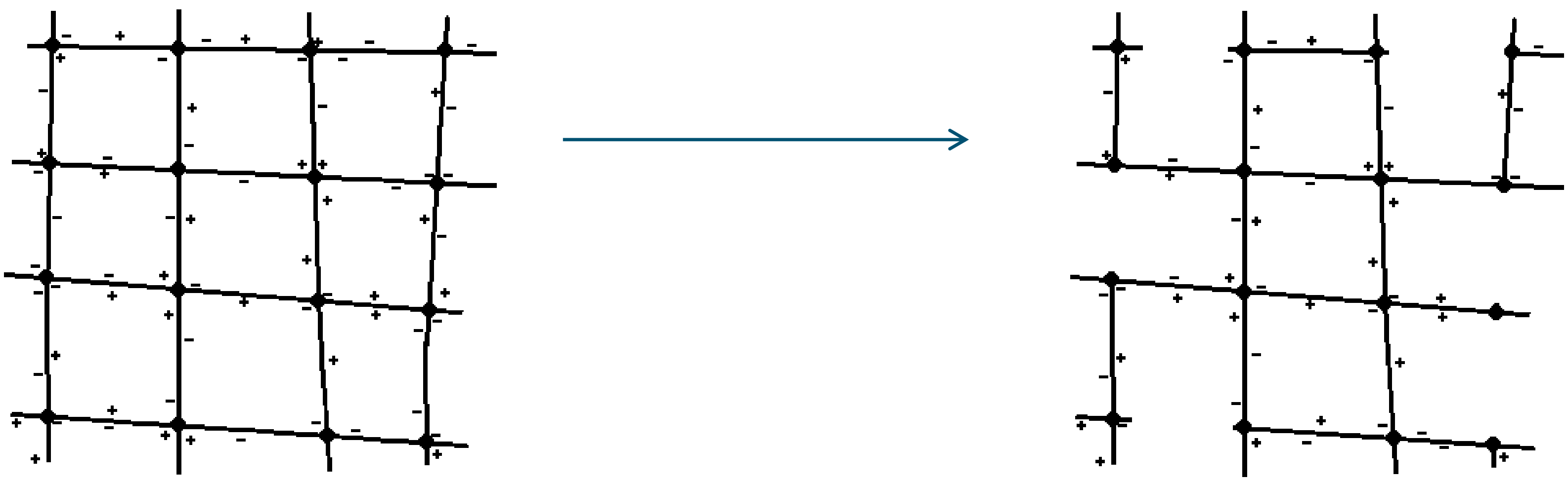
Conclusions

- After 24h of hydration the size of the particles increased
- No cracks were visible
- Particles looked smaller, more rounded and less dense than the standard MPs

Possible reactions MPs with DTT

Standard MPs

MPs + DTT au



- Reduced crosslink density → decreased elasticity → increased swellability

WHC methods
centrifugation method – excess of water

- Excess of water
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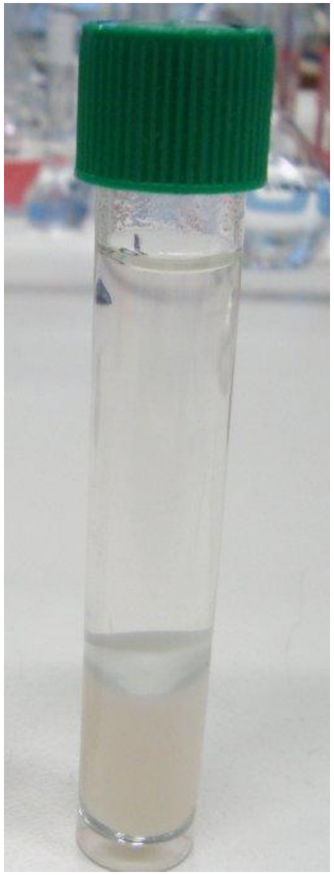
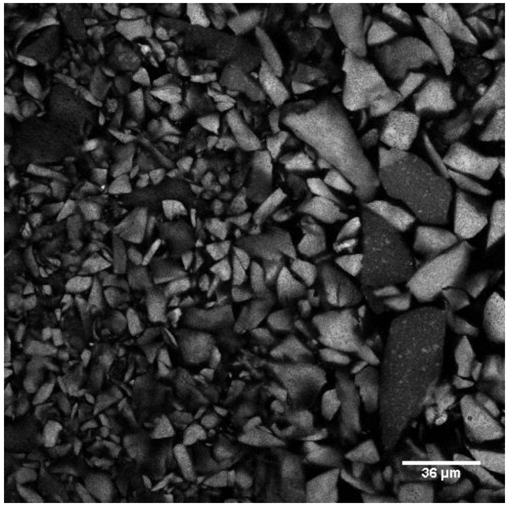
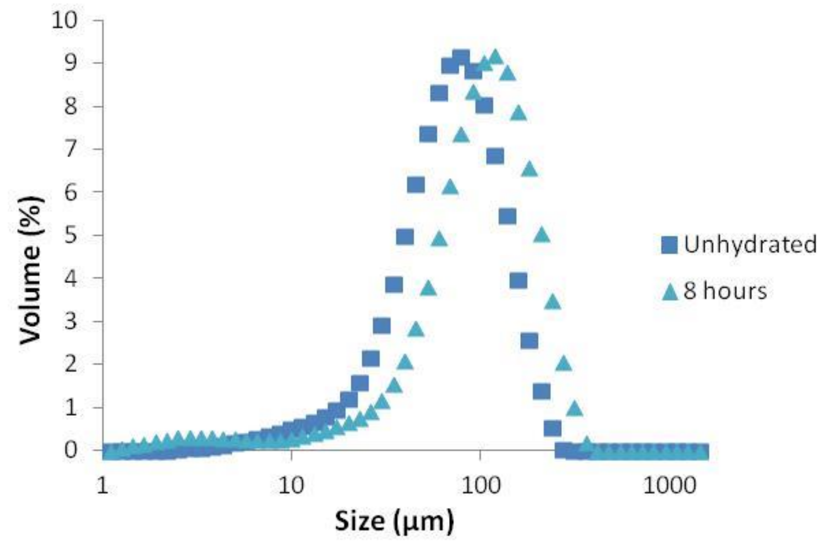
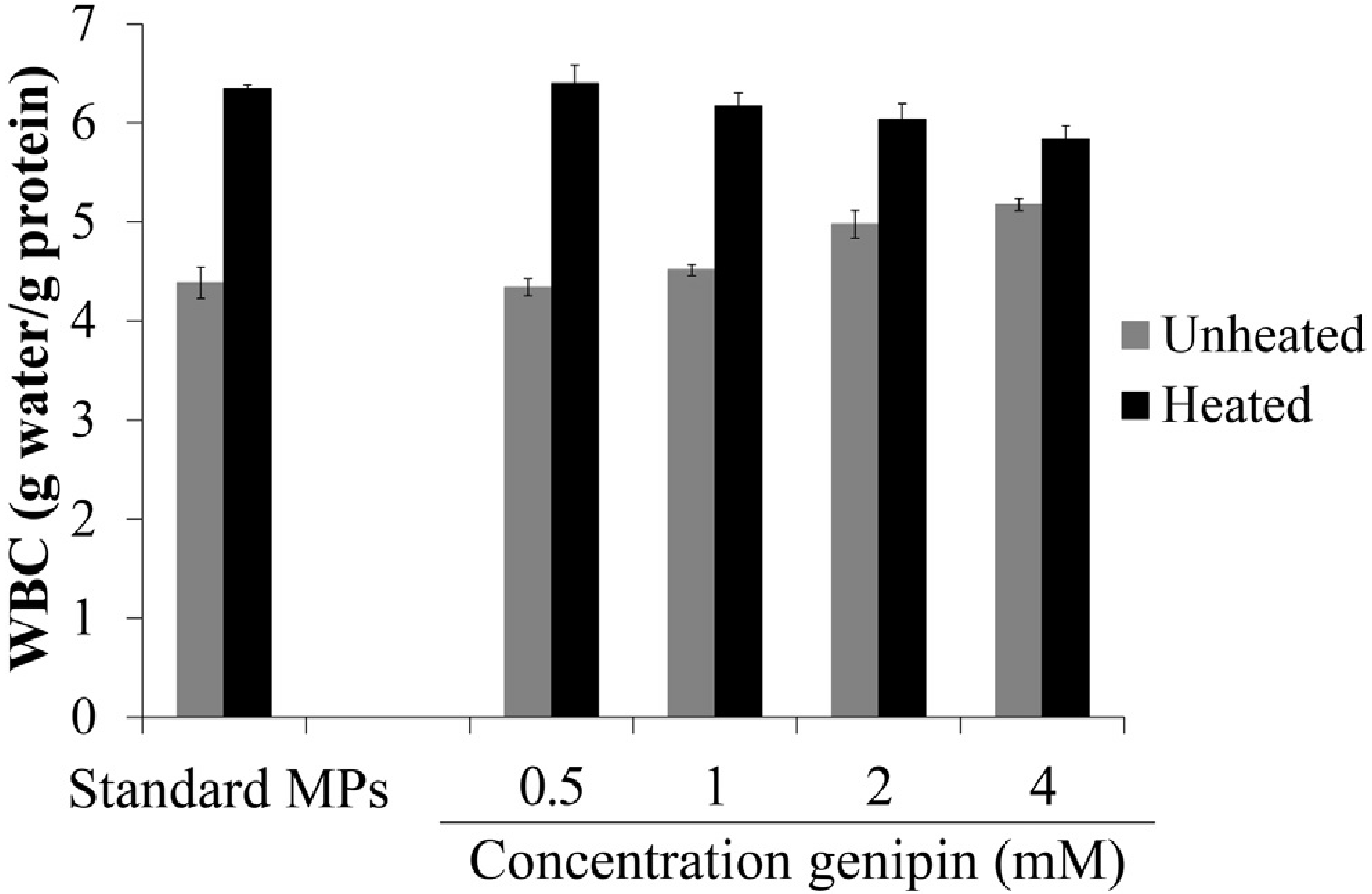



Swelling of particles



	Dry particle size	Hydrated particle size	Swelling (g water/g protein)	Water in and between particles
MP	88	113	0.9 (4.2)	1:3.4
MP + DTT	73	122	2.8 (8.3)	1:1.7

Genipin: adding crosslinks



Conclusions

- Altering the crosslink density (nanostructuring) is a route to control water binding properties of whey protein particles

- Effect is less clear (or opposite) than expected
    - Protein is oligomer and not a polymer
- Role of water between particles has to be explored further
- Behaviour of particles in a model system is next step

Thank you for your attention

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Thanks to

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Remko Boom (WU)

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