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

Jorien Peters

Atze Jan van der Goot

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For quality of life

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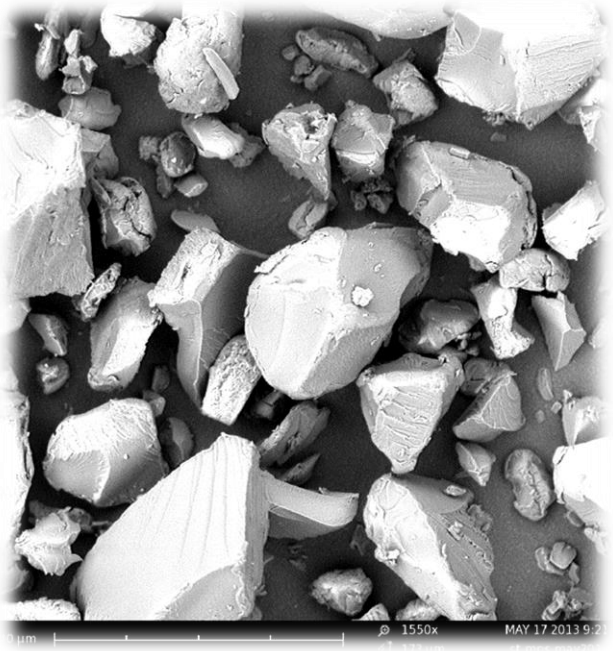
innovating with micro and nanotechnology

Overview presentation

- The need for low-caloric products
- The creation of superabsorbing particles
- Changing swellability MPs
- Conclusions



An increase in health awareness asks for the production of low-caloric foods

Percentage of people with a BMI ≥ 30*

- Increase in people with overweight
- Increase in people that are health conscious

→ production of low caloric products

*WHO, 2014

Highly swellable protein structures are thought to make a difference

Change in composition

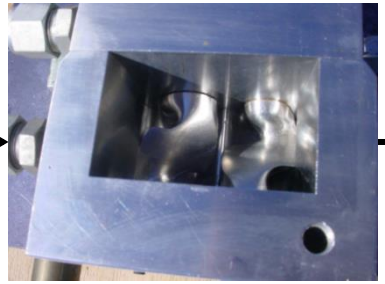
Problem: the addition of water can lead to softer products and/or syneresis

<u>Solution</u>

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

Swellable whey microparticles can be created by heat-induced gelation

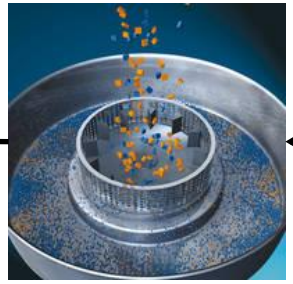
40% w/w WPI suspension
pH 6.8



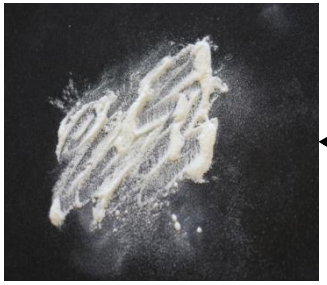
Heating while mixing
90 °C – 50 min

Wet gel
granules

Oven drying, 50 °C;
2 days



Ultracentrifugal mill,
sieve 80 µm



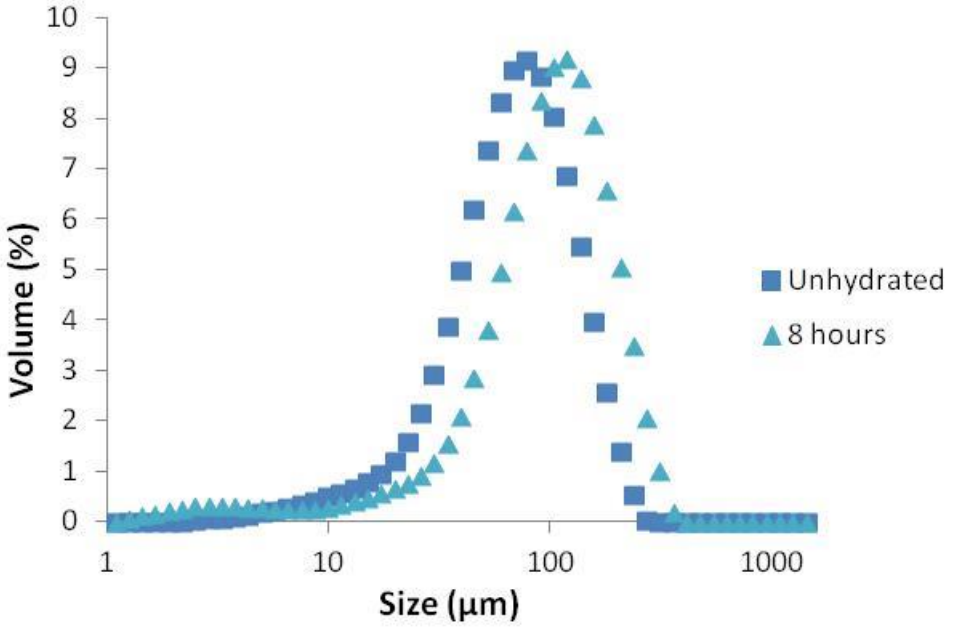
WPI microparticles

Properties of native WPI and WPI MPs

	Native WPI	**WPI microparticles**
Denaturation	Contains undenatured proteins*	Complete*
Size	~ 8 nm**	~ 70 µm
Protein concentration	~ 96% w/w***	~ 93% w/w*
Protein density	1.1 g/cm^3***	1.3 g/cm^3*

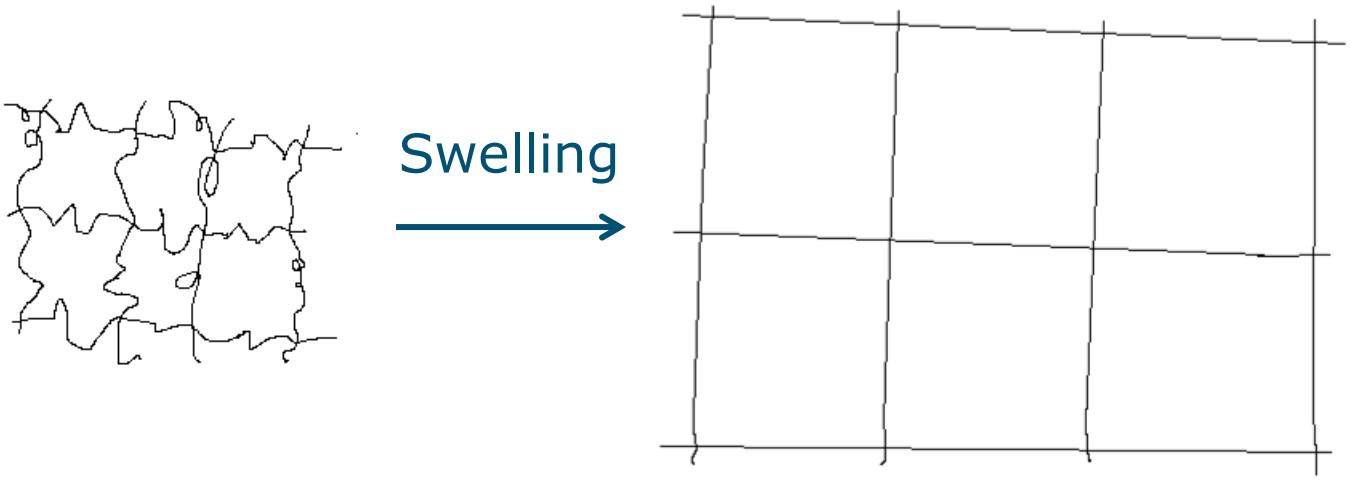
* Purwanti *et al.*, 2013
** Ju and Kilara, 1998
*** Purwanti *et al.*, 2012

Whey microparticles can swell



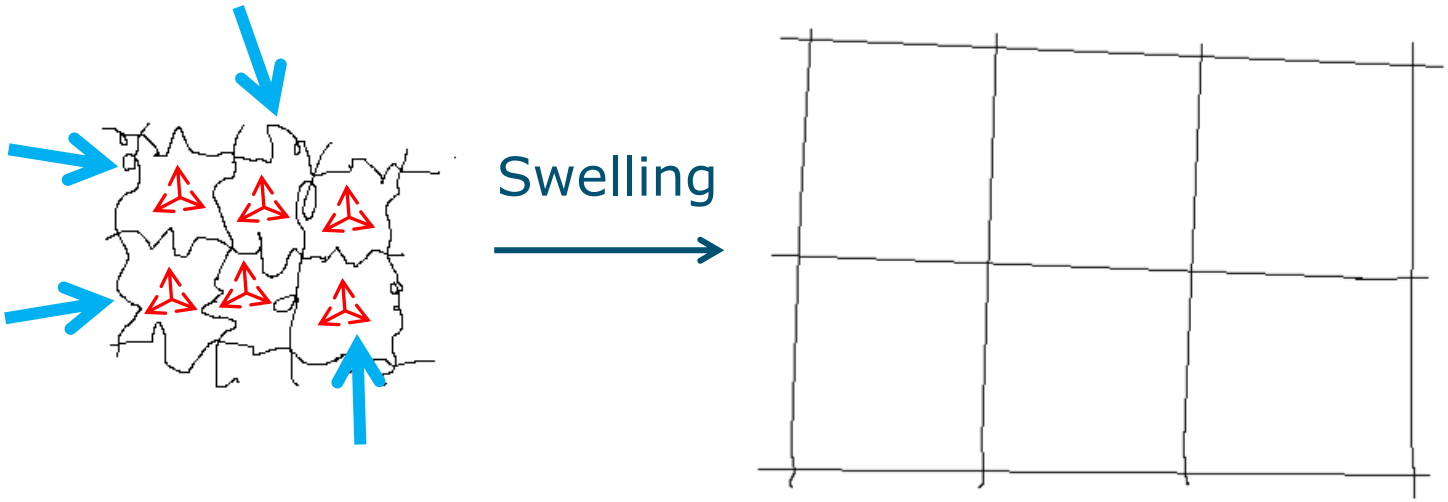
- Whey microparticles can swell in water

How to increase swellability?



The Flory-Rehner equation describes swelling

Flory-Rehner equation



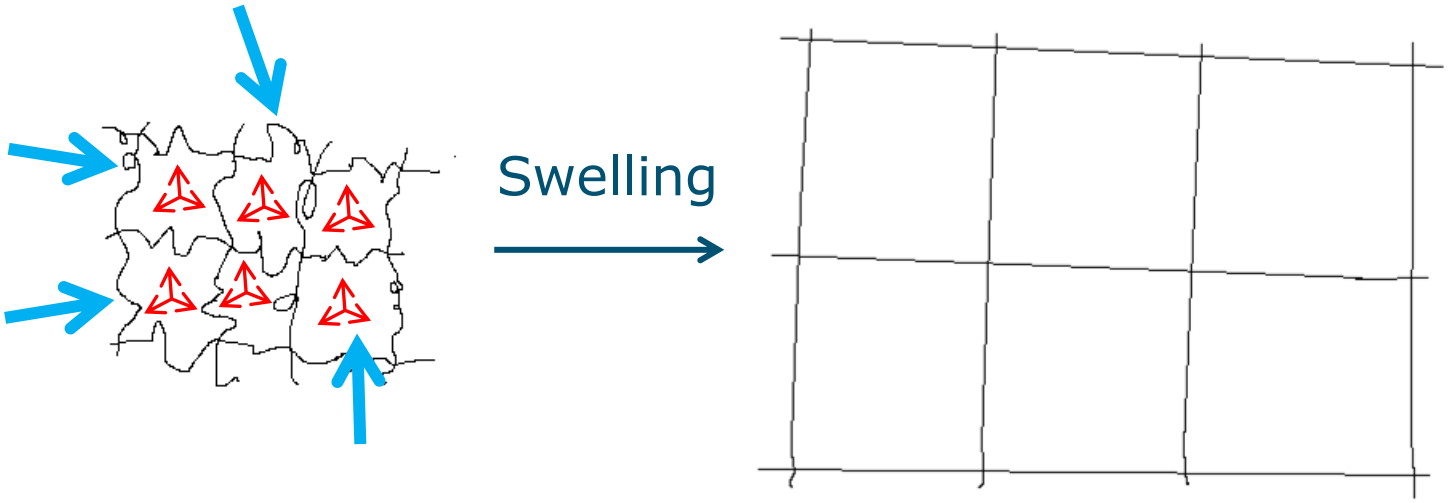
Swelling occurs when

- The protein and solvent want to mix
- The protein does not dissolve → network
- The network can expand

Networks swell until equilibrium is reached

Flory-Rehner equation

Mixing water/protein ↔ Expansion network

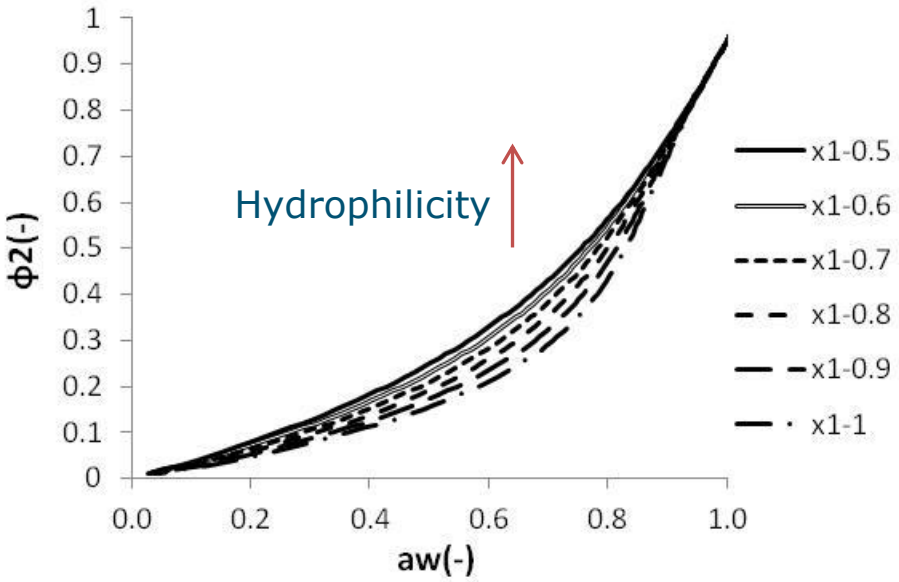


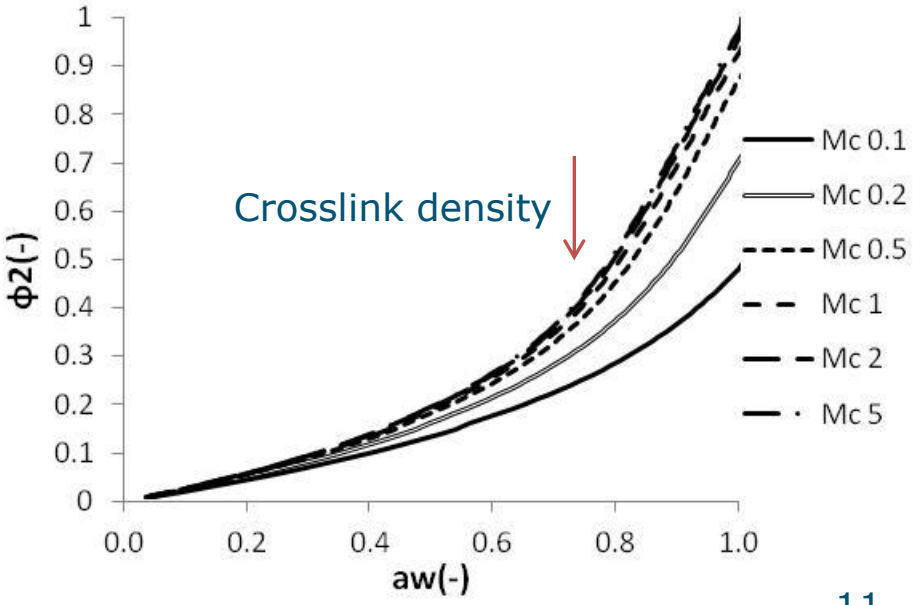
Changing the swellability of MPs by their hydrophilicity and/or crosslink density

Flory-Rehner equation

Mixing water/protein ↔ Expansion network

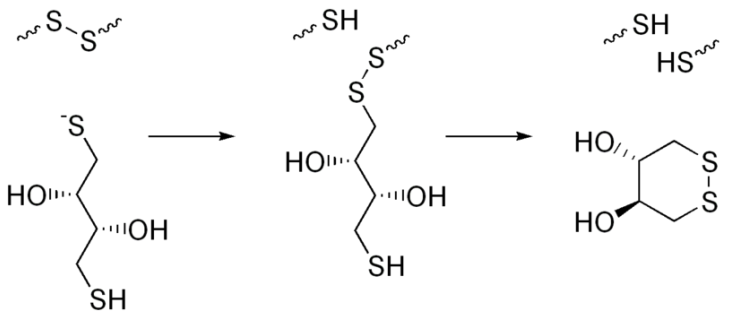
Hydrophilicity protein (χ) | Crosslink density (M_c)



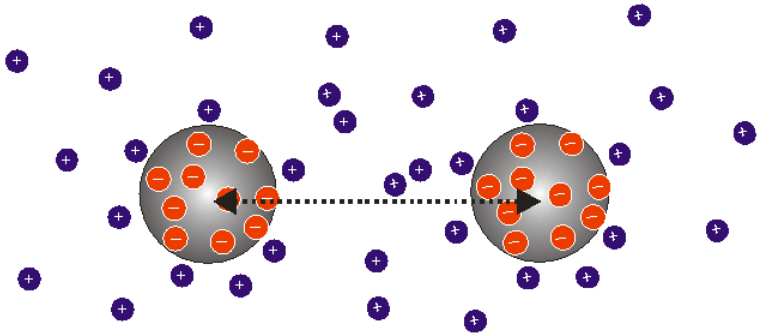


Changing the crosslink density of MPs with DTT and changing the pH

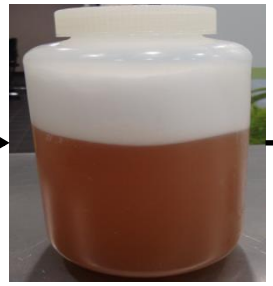
- Dithiothreitol (DTT)
  - Reducing agent
  - Breaks disulphide bonds



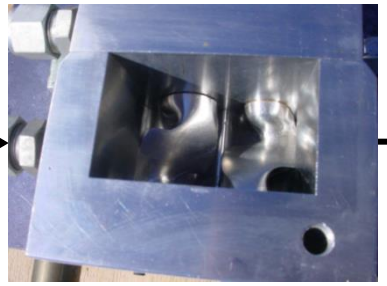
- Decreasing pH to value closer to IEP
  - Reduction amount of charges → Proteins can come closer to eachother



Making of MPs with DTT



40% w/w WPI suspension
pH 6.8



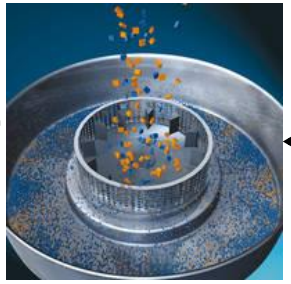
Heating while mixing
90 °C – 50 min

Wet gel
granules

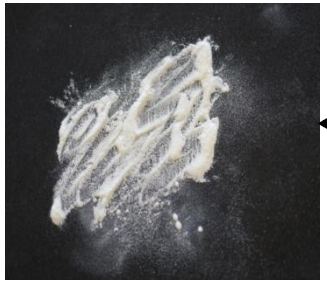
Addition after

Mixing
25g
particle
s in
50mL
solution

Oven drying, 50 °C;
2 days



Ultracentrifugal mill,
sieve 80 µm

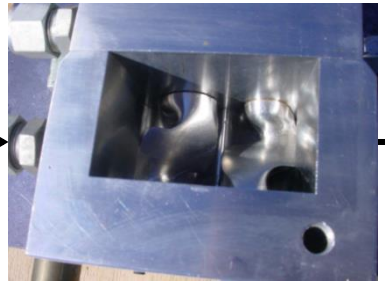


WPI microparticles

Making of MPs at pH 5.8

Addition before

40% w/w WPI suspension
pH 5.8



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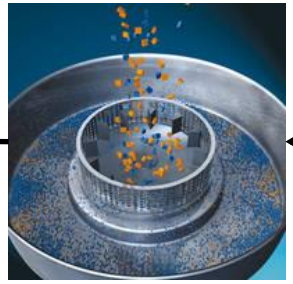

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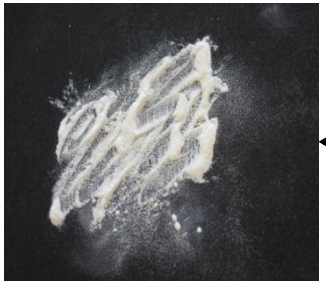
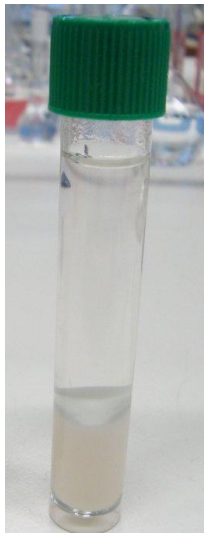
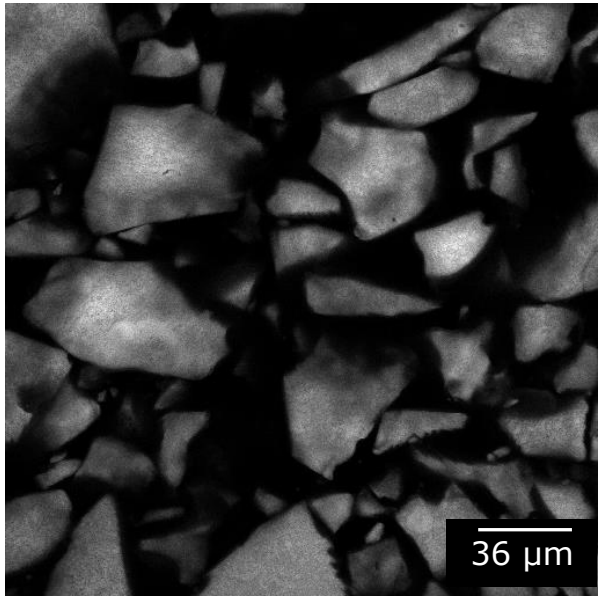


WPI microparticles

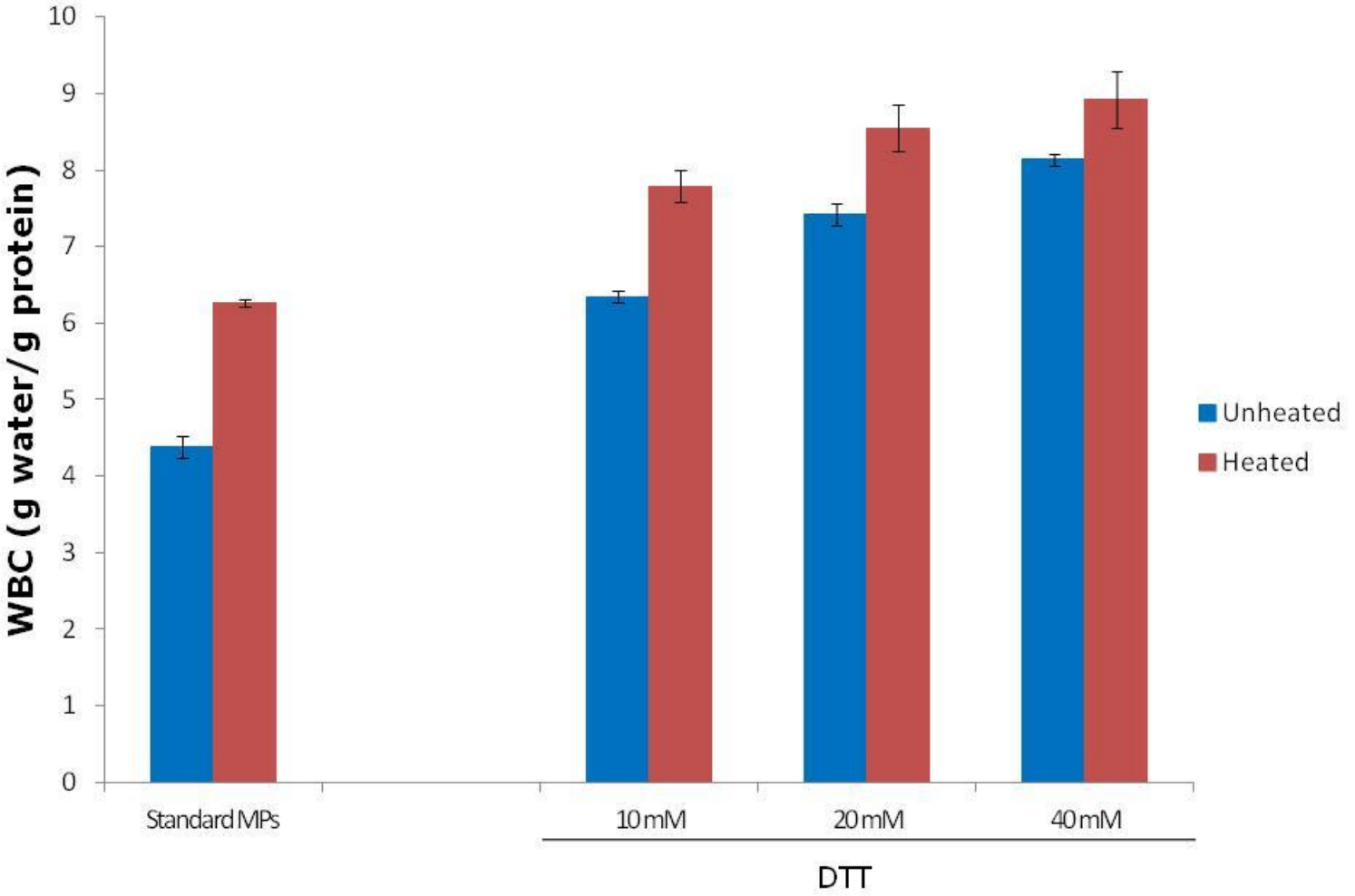
Measuring the WBC

- Mixing a 10% dispersion of MPs + MQ-water
- (Heating for 30 min. at 90°C)
- Centrifuging at 3000 rpm for 20 min (25°C)
- Dry pellet for 24 h at 105°C





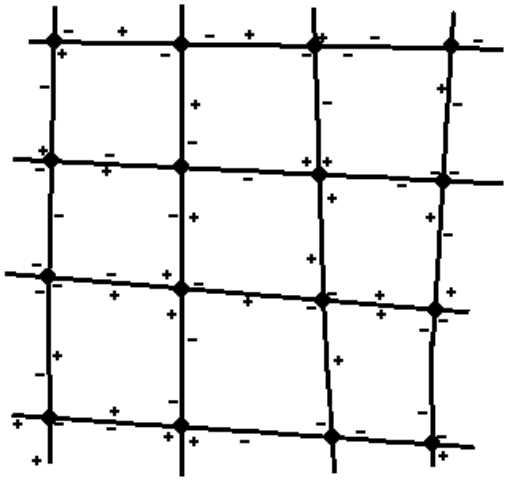
Decreasing the crosslink density with DTT



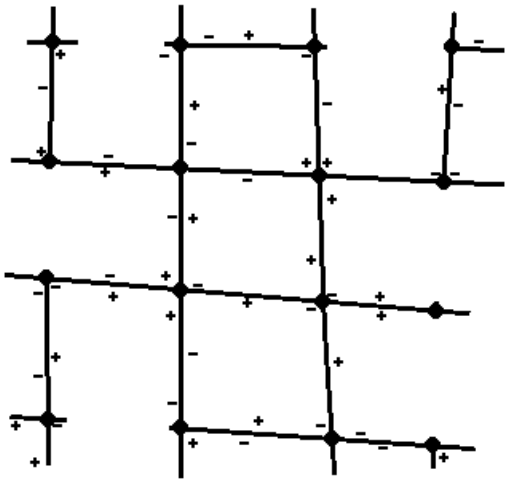
↑ concentration DTT → ↑ WHC

Possible reactions MPs with DTT

Standard MPs

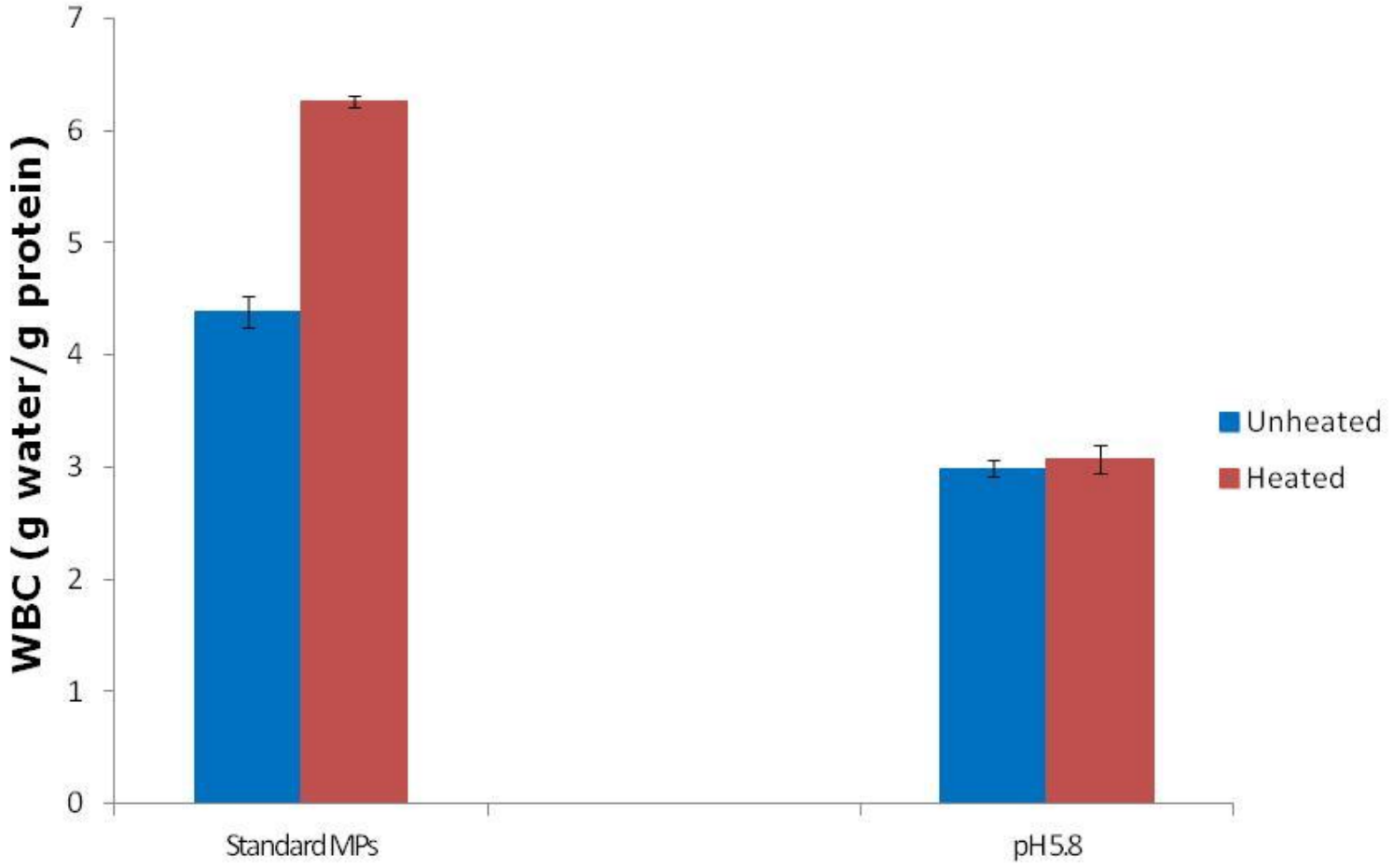


MPs + DTT



Reduced crosslink density → decreased elasticity → increased swellability

Increasing the crosslink density by changing the pH to 5.8



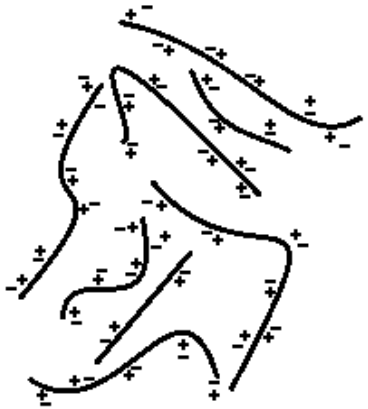
MPs made at pH 5.8 → ↓ WBC

Possible reactions at pH 5.8

WPI dispersion

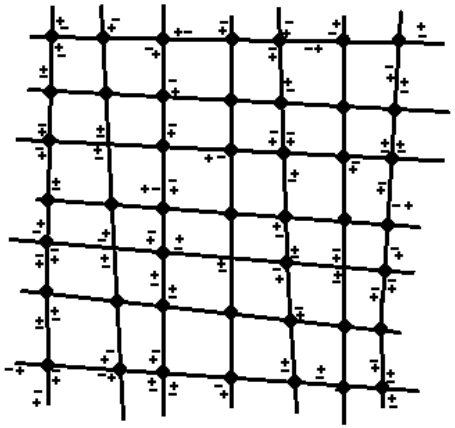
Whey protein chains are charged

WPI dispersion at pH 5.8



Charges proteins are screened

MPs formed at pH 5.8



Increased crosslink density in MP network

Increased crosslink density → increased elasticity → decreased swellability

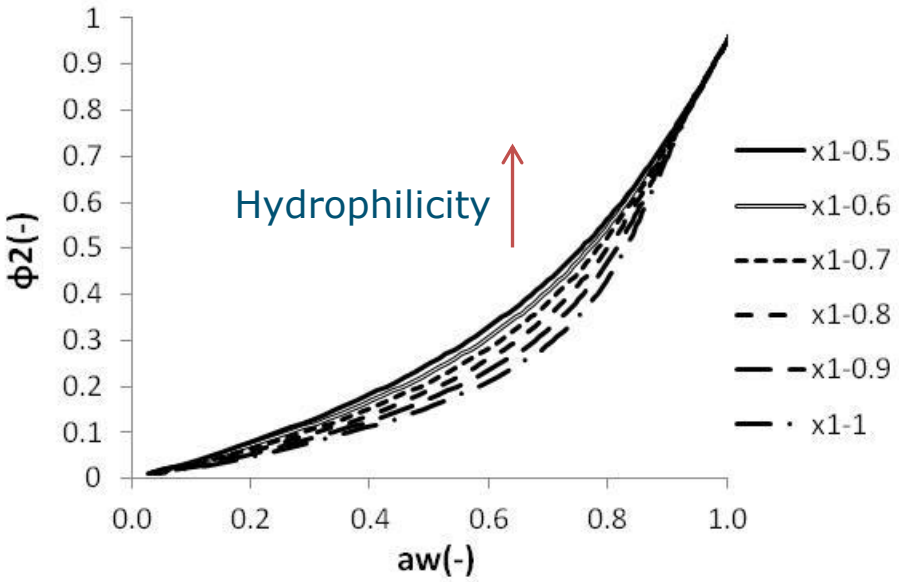
Changing the swellability of MPs by their hydrophilicity and/or crosslink density

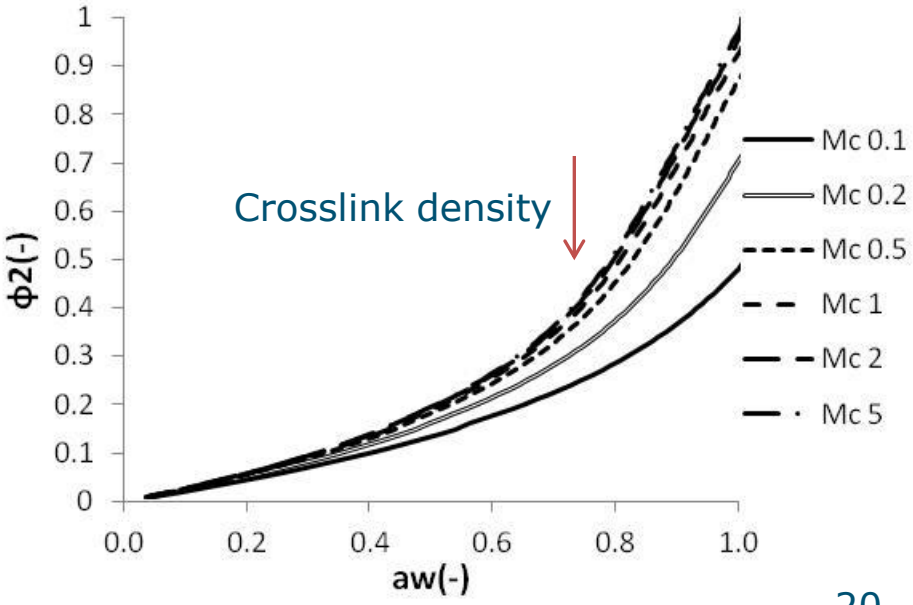
Flory-Rehner equation

Mixing water/protein ↔ Expansion network

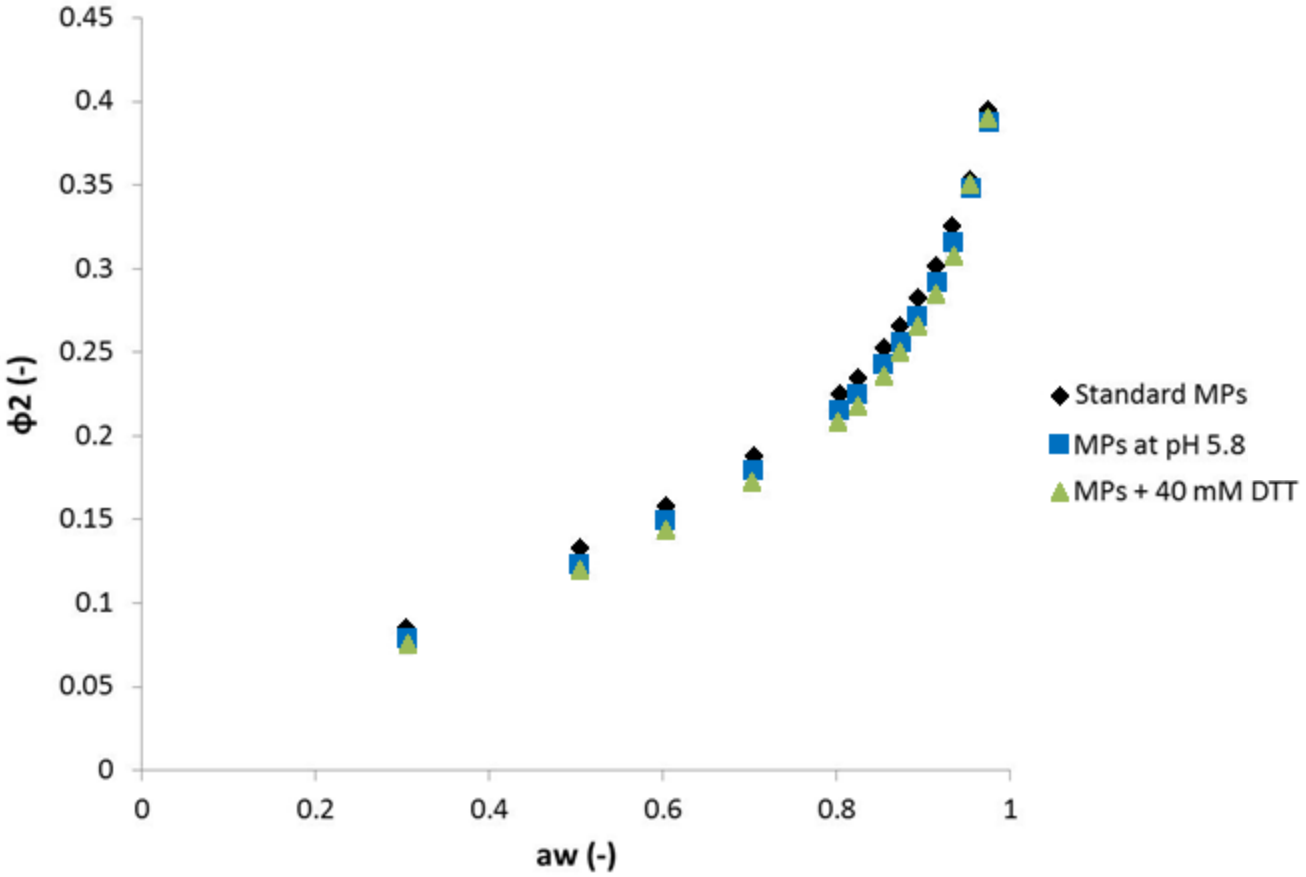
↓ ↓

Hydrophilicity protein (χ) Crosslink density (M_c)





Isotherms standard and modified MPs



- Isotherms are the same for standard and modified MPs

Conclusions

- MPs are structures that have a potential to be used in low-caloric cheese

- The crosslink density could be used to change the WBC of the MPs
  - DTT decreased the crosslink density and increased the WBC
  - Lowering the pH to values close to IEP increased the crosslink density and decreased the WBC

Thank you for your attention

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