Dry fractionation for sustainable production of functional legume ingredients

(overlapping text: pea ingredients)

Pascalle Pelgrom, Remko Boom, Maarten Schutyser

Wageningen University – Laboratory of Food Process Engineering

Maarten.Schutyser@wur.nl

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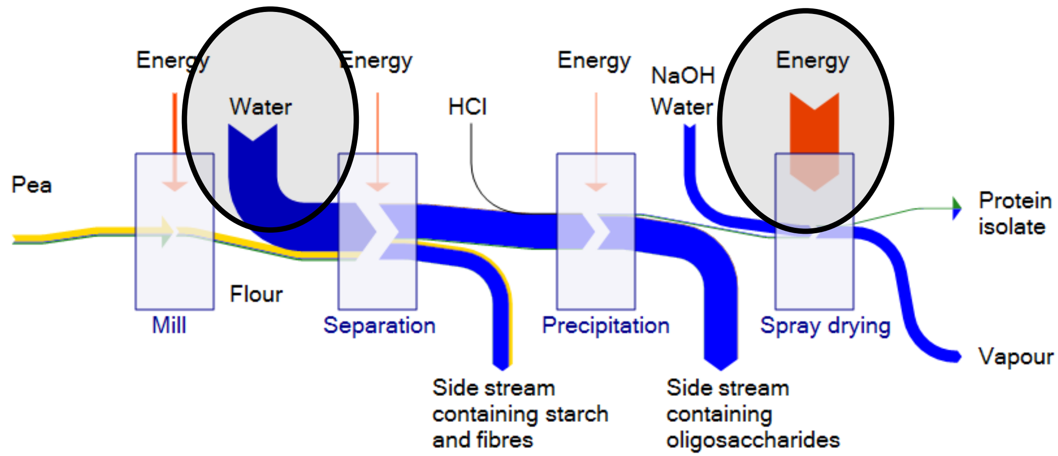
Sustainability of protein

Animal protein

*4-11 g protein/MJ**

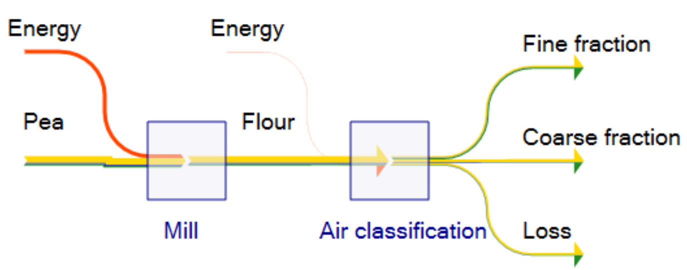
Wet fractionation

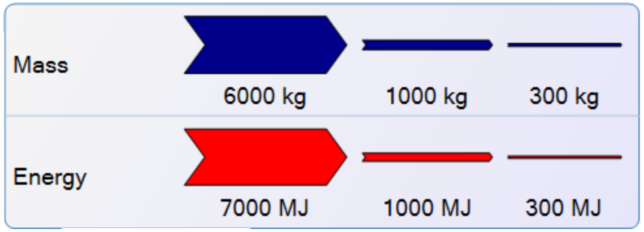
3.5 g protein/MJ



Dry fractionation

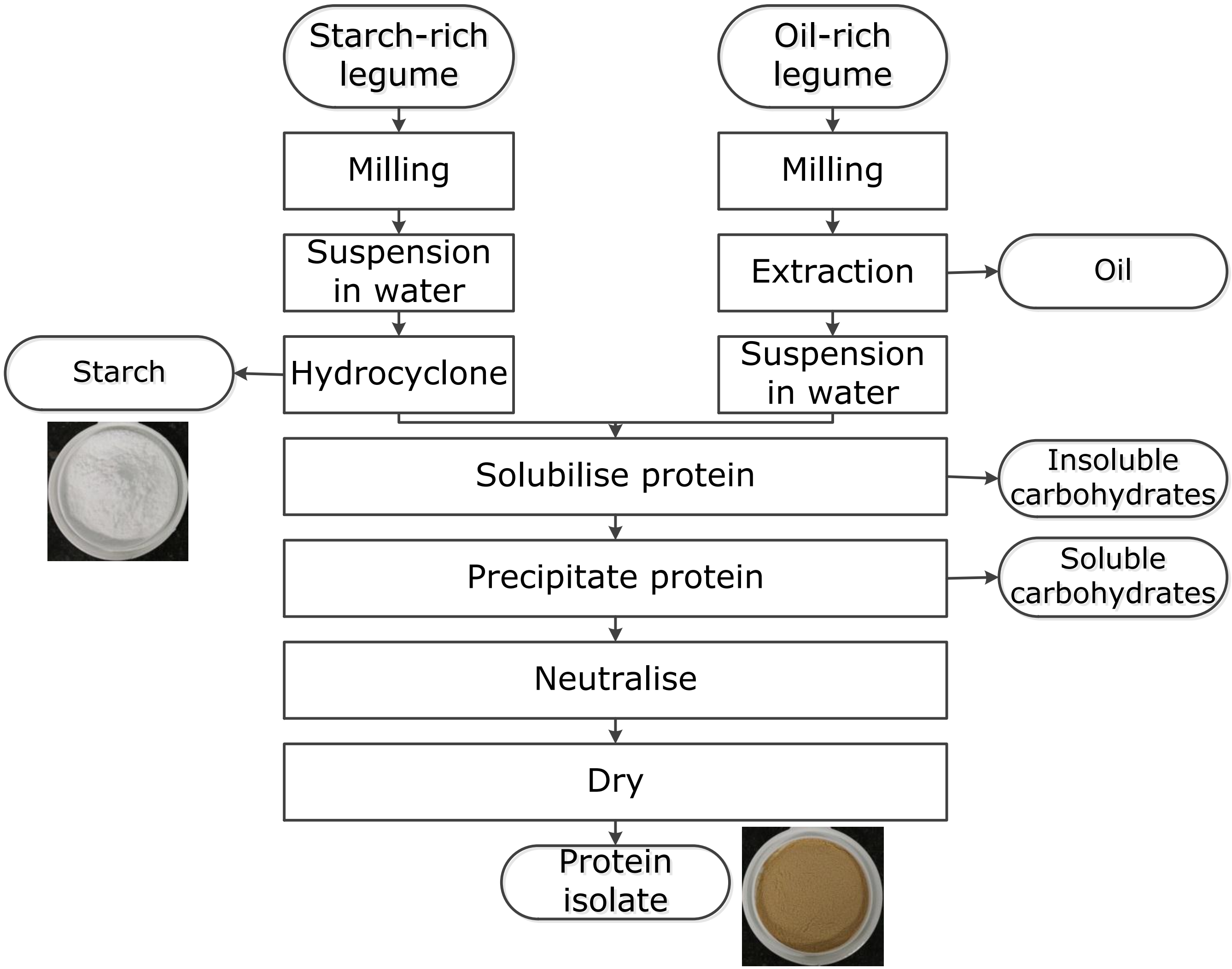
28.2 g protein/MJ





* *González, A. D., B. Frostell, et al. (2011). Food Policy 36(5): 562-570.*

Wet fractionation of legume protein



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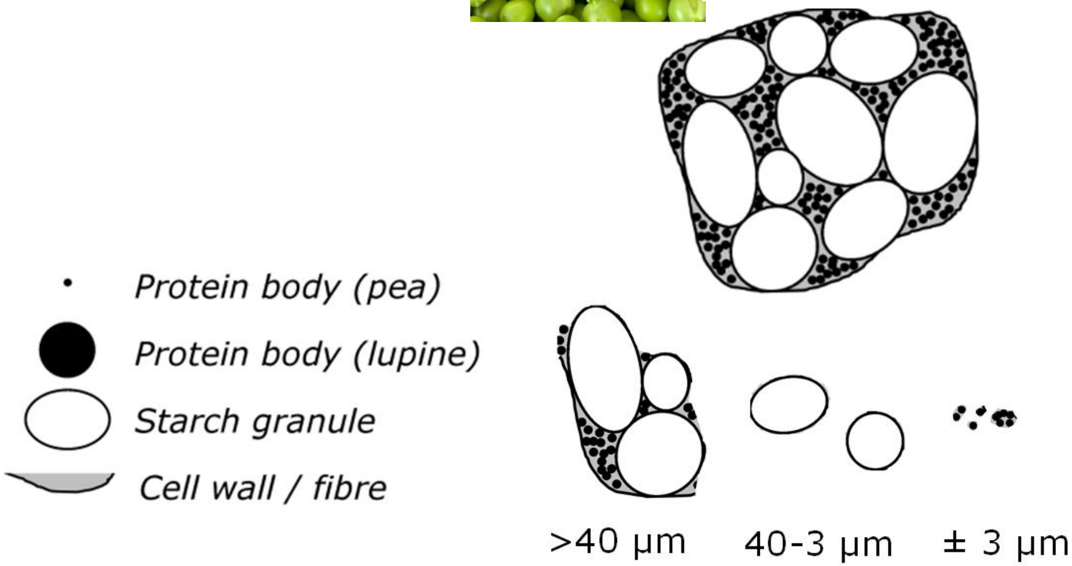
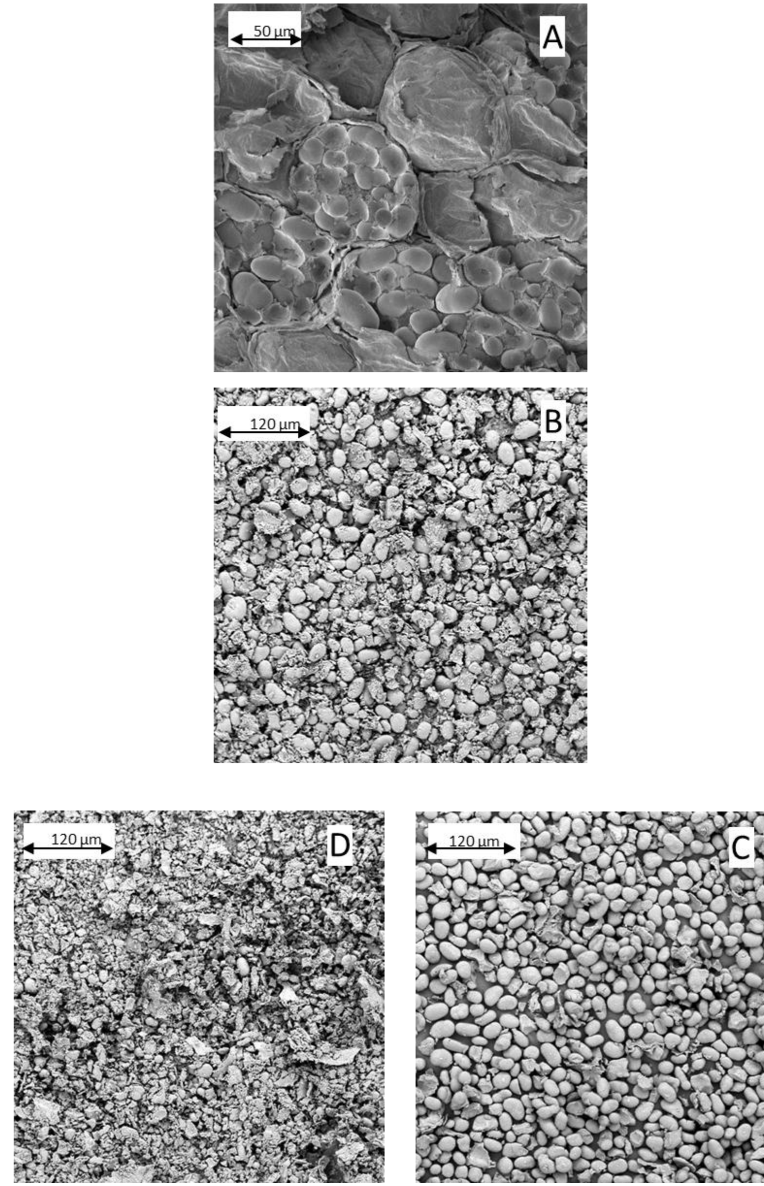
Schutyser, M. A. I. and A. J. Van der Goot (2011). Trends in Food Science & Technology ***22****(4): 154-164.*

Mechanism dry fractionation legumes

Starch-rich

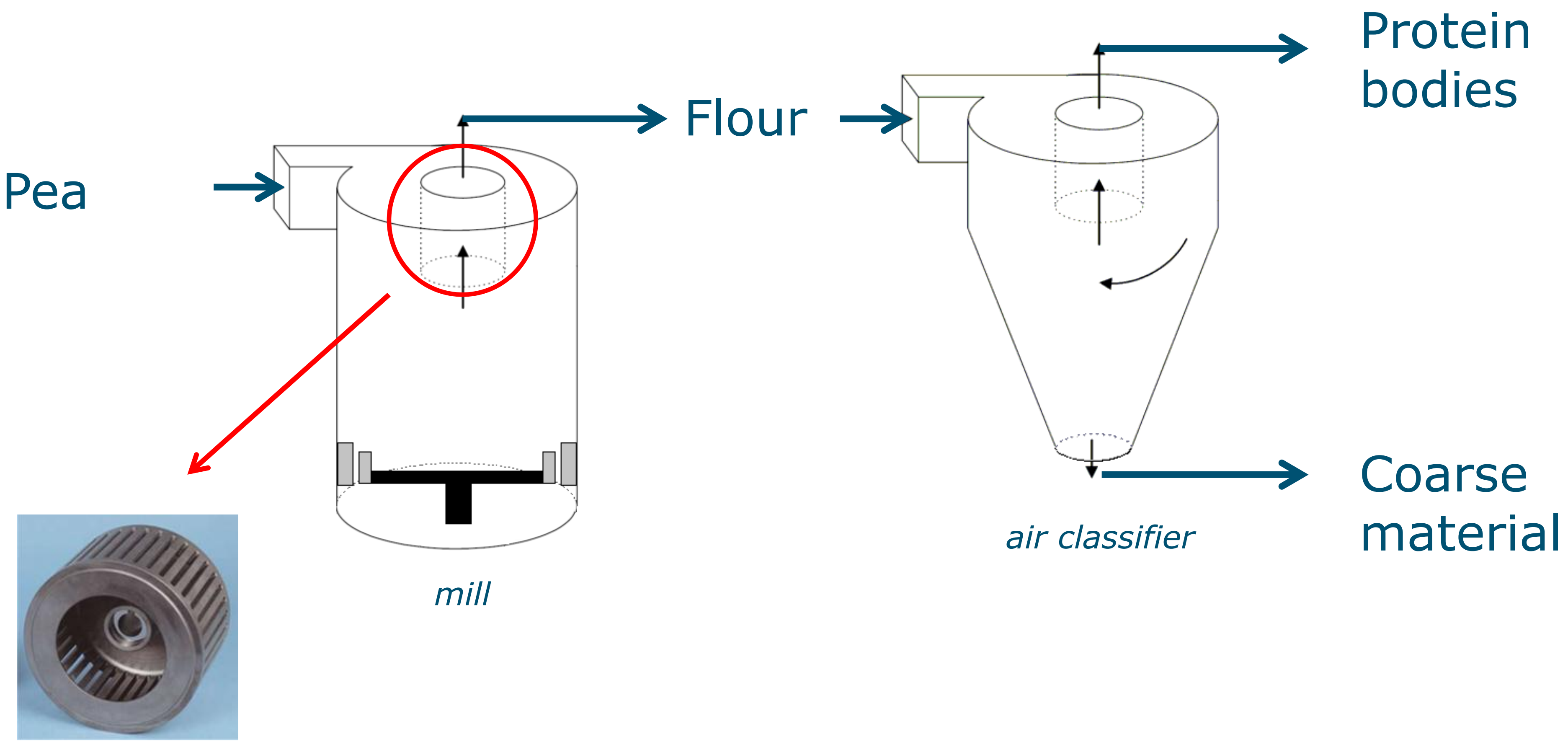
pea





- 23% protein bodies (3µm)
- 56% starch granules (22µm)
- 13% fibres

Milling and air classification



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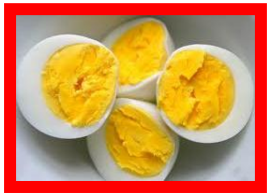
Multi-processing system (Hosokawa-Alpine, Augsburg, Germany)

Dry fractionation versus wet fractionation

- Dry fractionation consists of combined milling and dry separation. Key advantages:
  - Less water, less energy
  - Retains native protein functionality
    - E.g. protein concentrates with high solubility
    - Retained potential for structuring

- Protein purity 55%(pea) – 59% (lupine)
  - Focus on functionality rather than purity
- Dry enriched legume proteins: are low in fat rich in protein, dietary fibre and a variety of micronutrients and phytochemicals

Aim

- Explore more sustainable processing routes.
- Increase our understanding of:
  - material properties of the legume seeds.
  - process conditions relevant to the combined milling and dry separation of legumes.

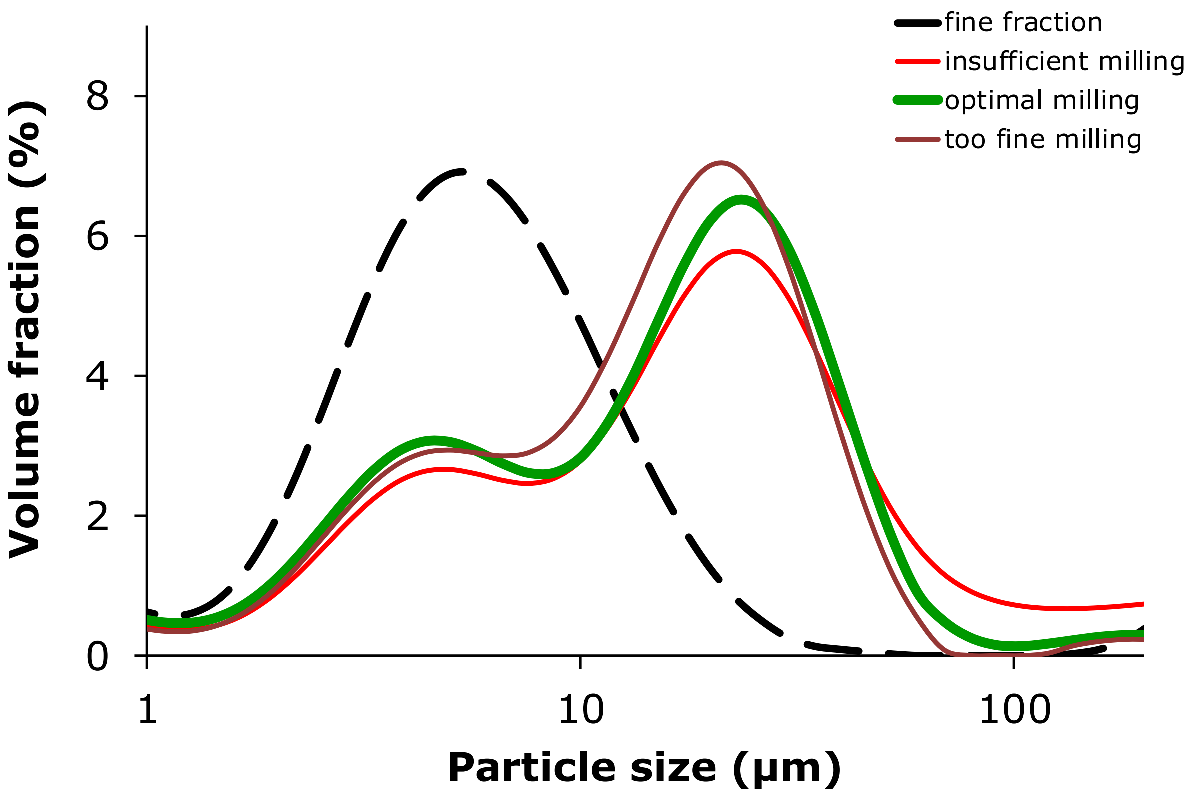
  Milling of starch- and oil-rich legumes

  Dry separation challenges
- Obtain functional ingredient protein fractions rather than molecular pure proteins.

  Functionality of pea and lupine fractions

Milling of starch-rich legumes

- Milling speed influences disclosure



- Insufficient: no complete disentanglement
- Optimal: loose protein bodies and starch granules
- Too fine: damage to starch granules

Composition of pea fractions

Sample	Starch content (g/100 g dry matter)	Protein content (g/100 g dry matter)	Fibre* (g/100 g dry matter)	NSI (%)
Starch isolate	84.3 ± 0.7	ND	15.7 ± 0.7	ND
Coarse	67.2 ± 1.6	9.5 ± 0.0	23.3 ± 1.6	89.4 ± 1.7
Flour	47.6 ± 1.0	22.4 ± 0.8	30.0 ± 1.3	85.8 ± 3.3
Fine	1.7 ± 0.0	49.7 ± 0.2	48.6 ± 0.2	85.0 ± 1.9
Protein isolate	ND	83.5 ± 0.2	16.5 ± 0.2	24.8 ± 2.2

*ND: not detected, *included minor additional components, i.e. 2 g/100 g dry matter fat and 3 g/100 g dry matter ash.*

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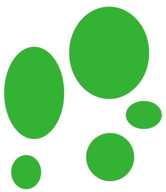
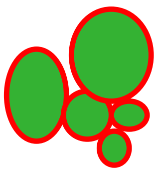
Milling of oil-rich legumes (lupine)

- Problem:
  - Lupine contains fat



powder without fat

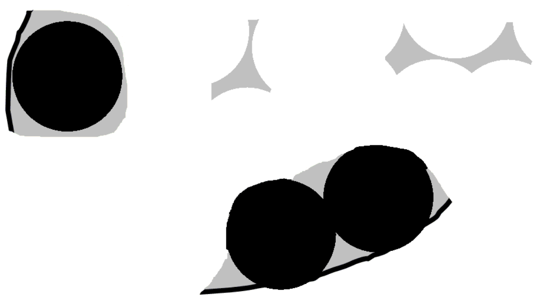
non sticky



powder with fat

sticky

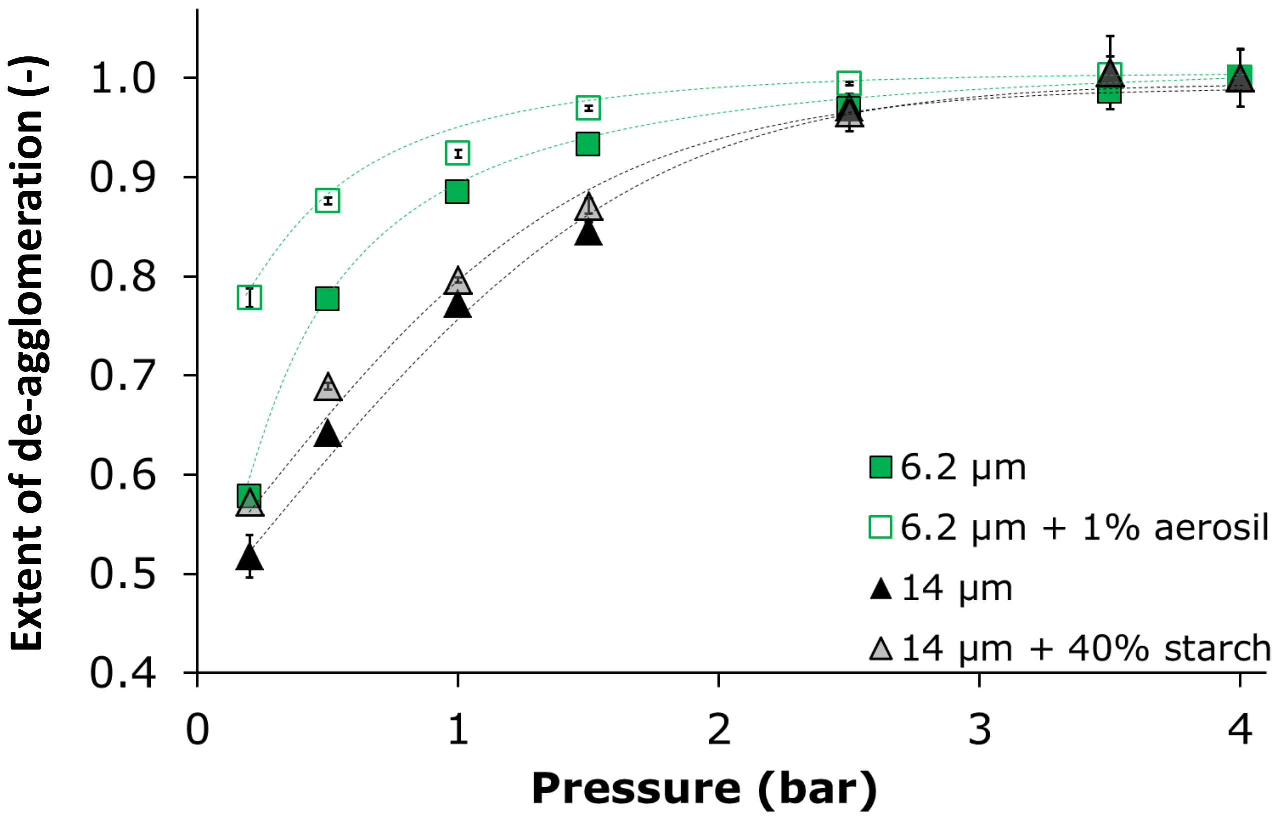
  - Milling reduces the size of fibre to that of protein bodies



- Solution: mill coarse

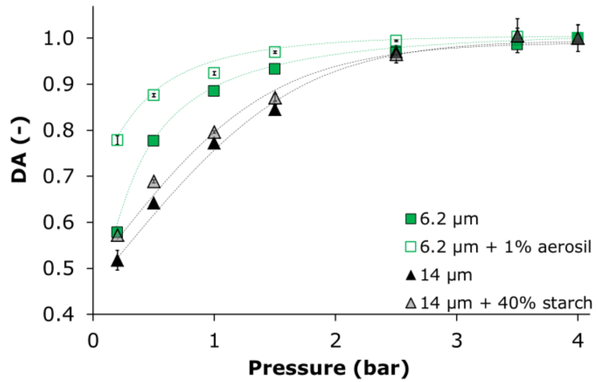
Air classification challenges

- Problem: low dispersibility (yield)



Air classification challenges

- Problem: low dispersibility (yield)



- Solution: add dispersant for higher yield

Sample	Protein content fine fraction (w/dw)	Protein separation efficiency (%)	Yield fine fraction % (w/w)
Lupine	58.9 ± 0.1	10.0 ± 0.3	6.1 ± 0.1
Lupine + aerosil	49.7 ± 0.5	21.3 ± 5.8	13.9 ± 3.9

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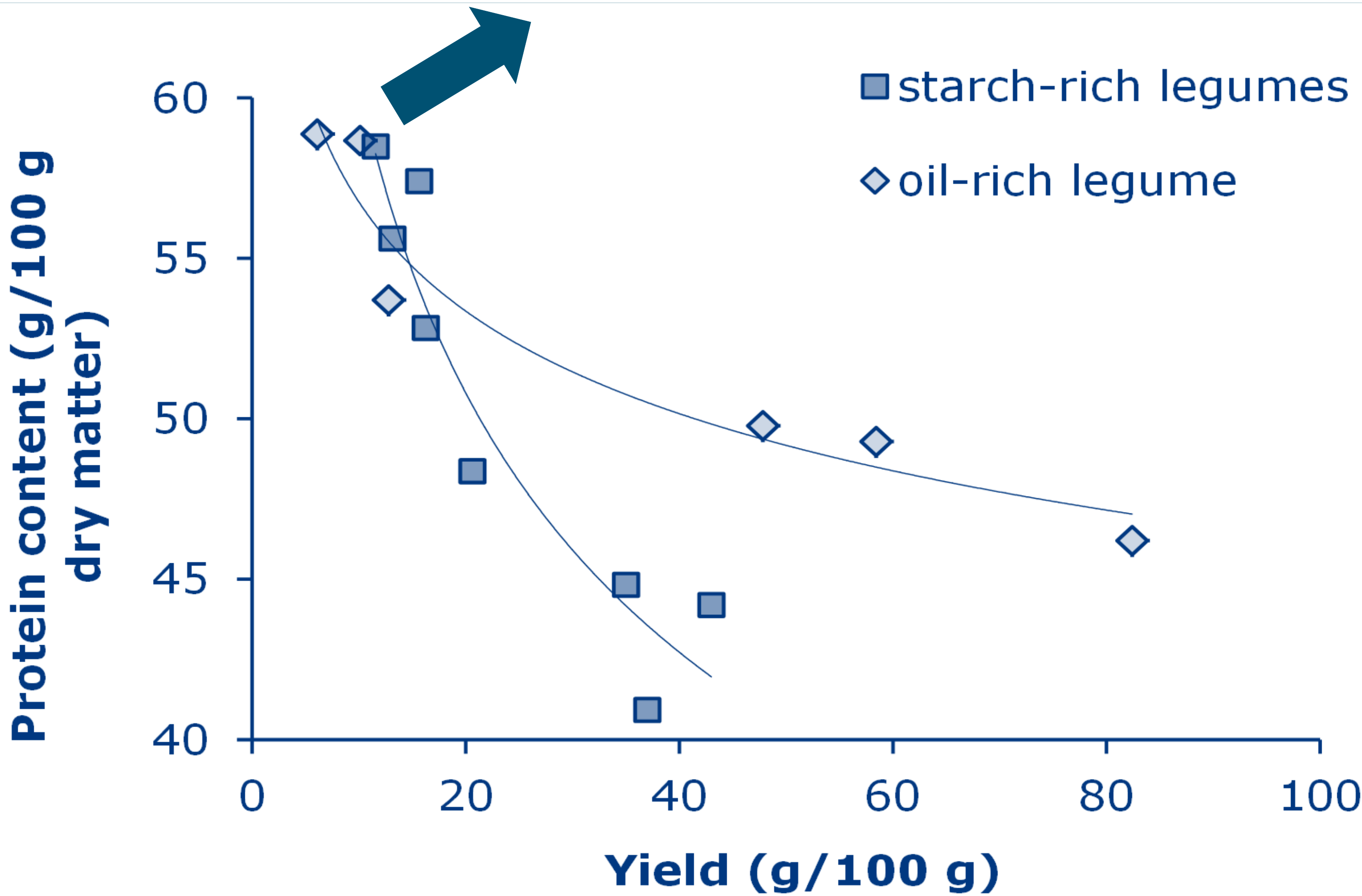
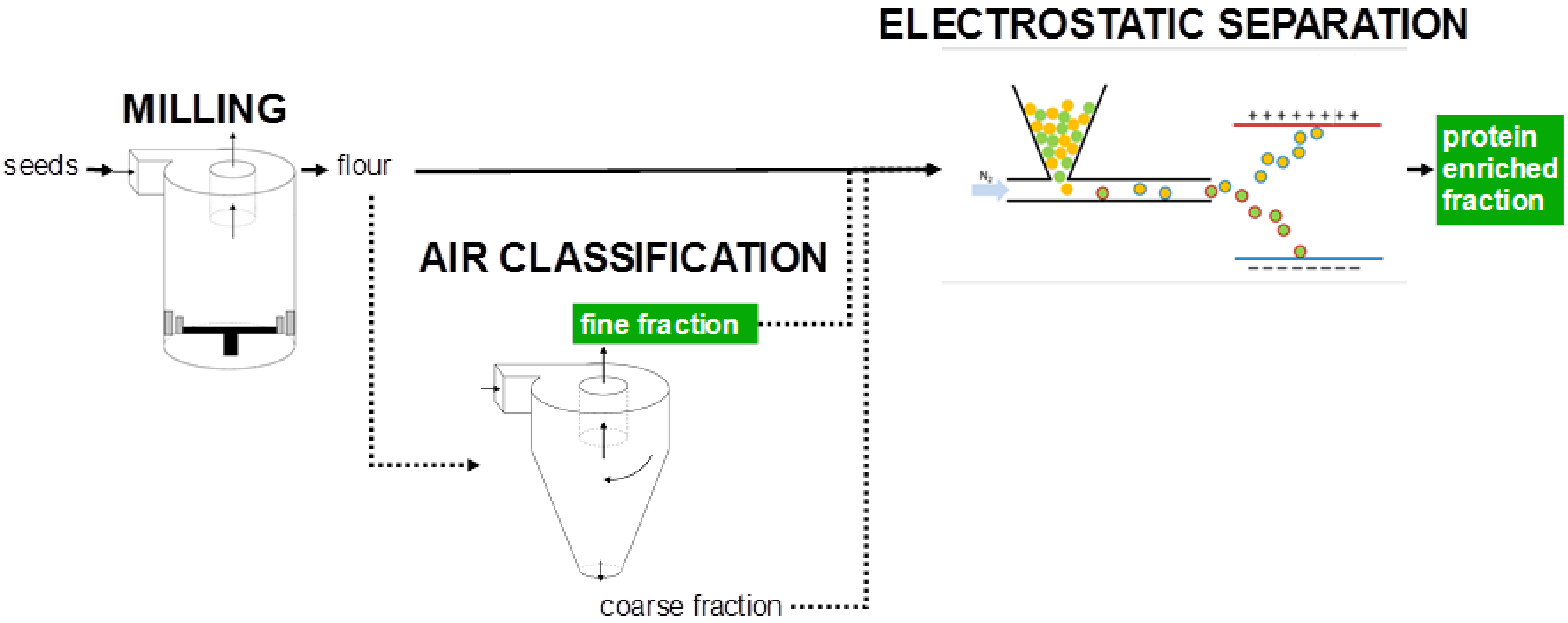
Pelgrom, P.J.M., et al 2014. LWT - Food Science and Technology 59, 680-688.

Protein content versus yield

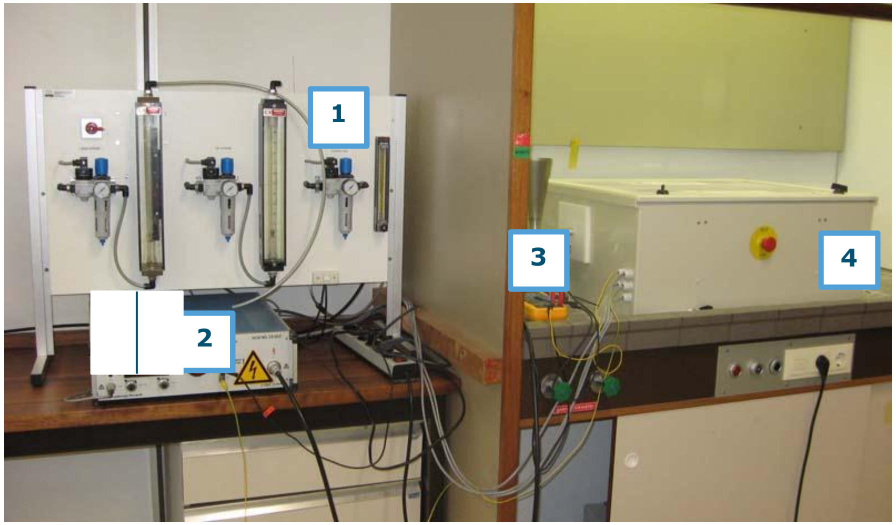


Dry fractionation - Different driving forces



Laboratory-scale E-Separator

- Experimental set-up:
  - 1: N_2 Flow meter
  - 2: Power supply
  - 3: Feeder funnel & charging tube
  - 4: Separation chamber



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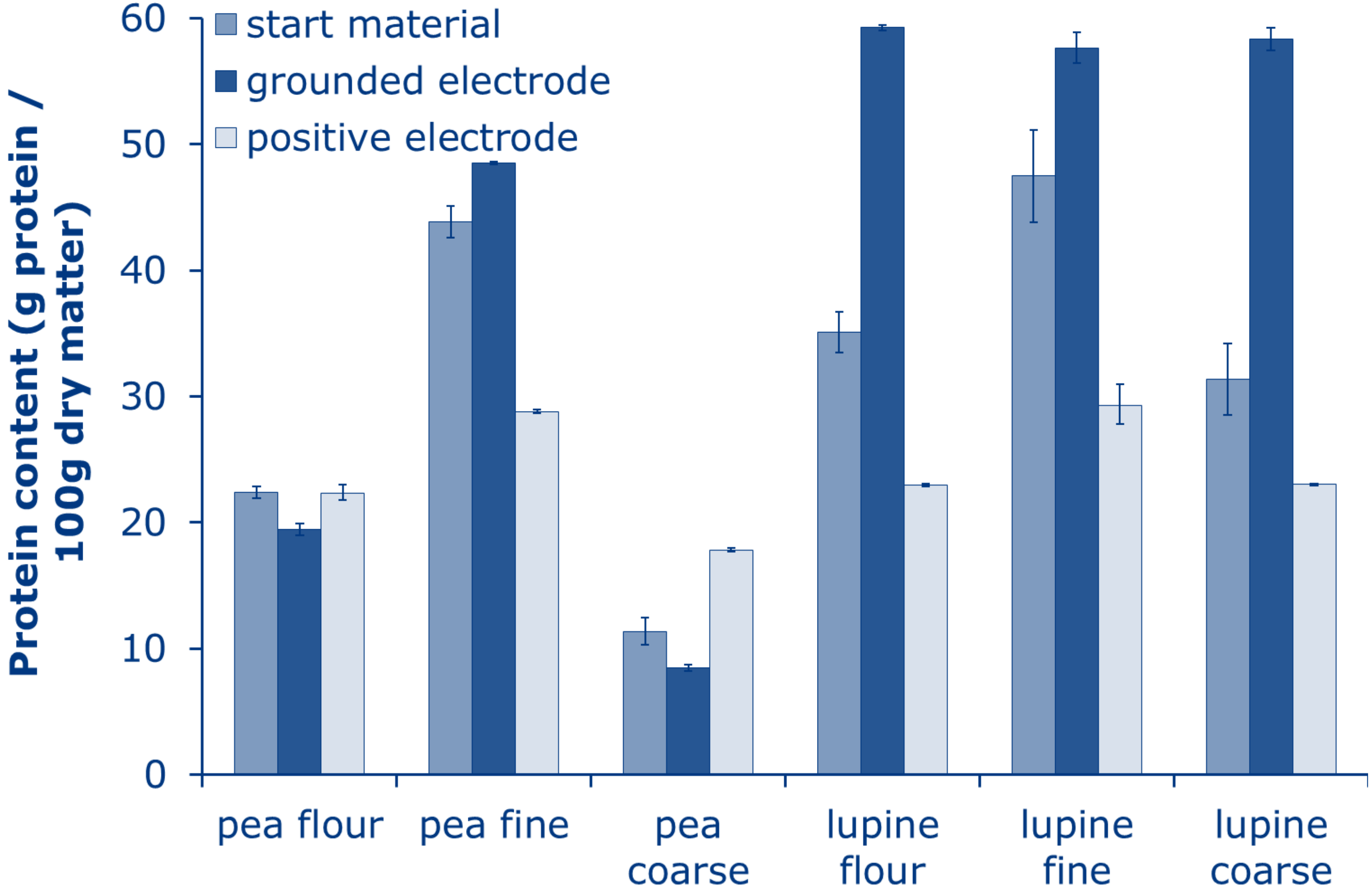
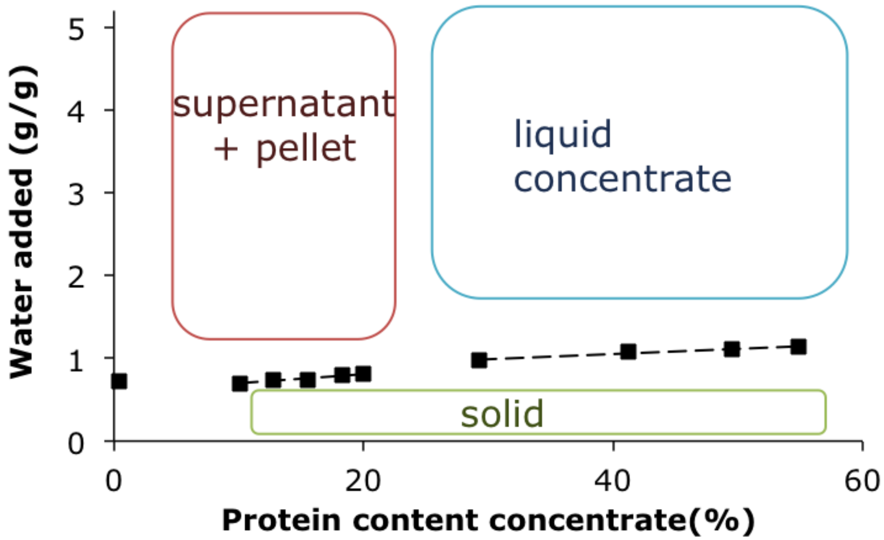
Lab-scale E-separation results

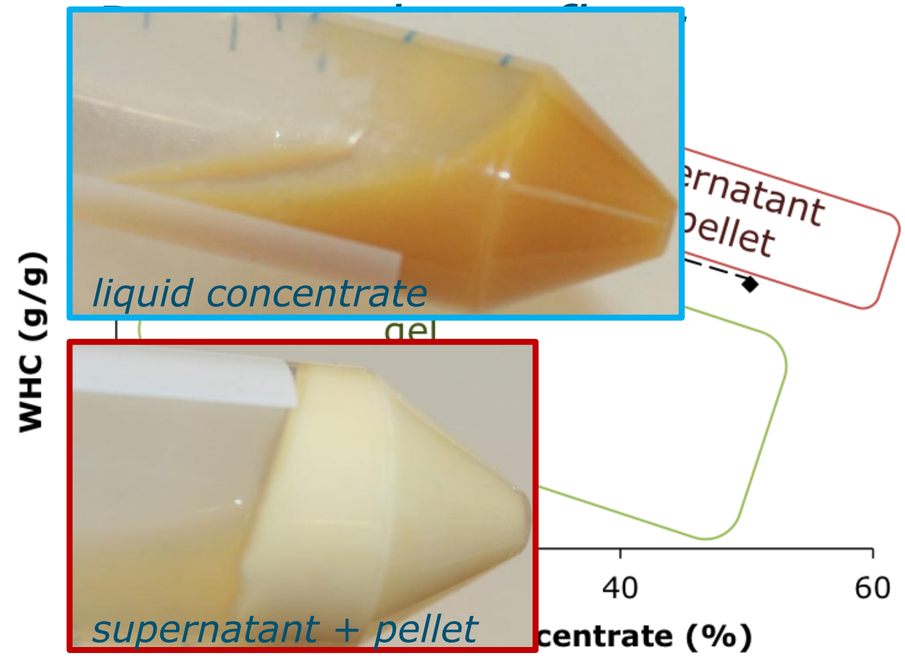


Functionality of pea

Hypothesis: starch/protein ratio influences WHC

Native pea flour

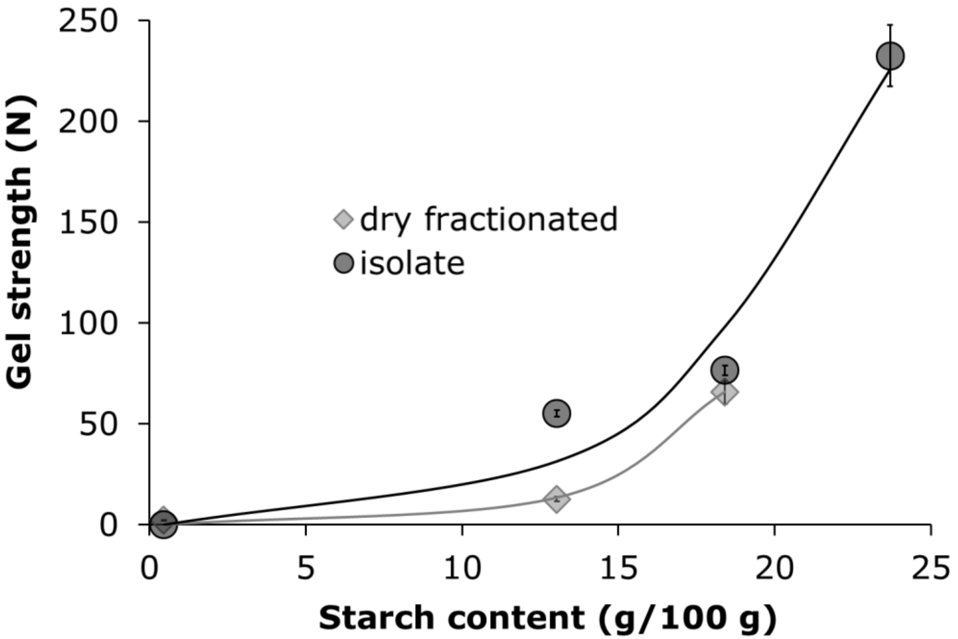


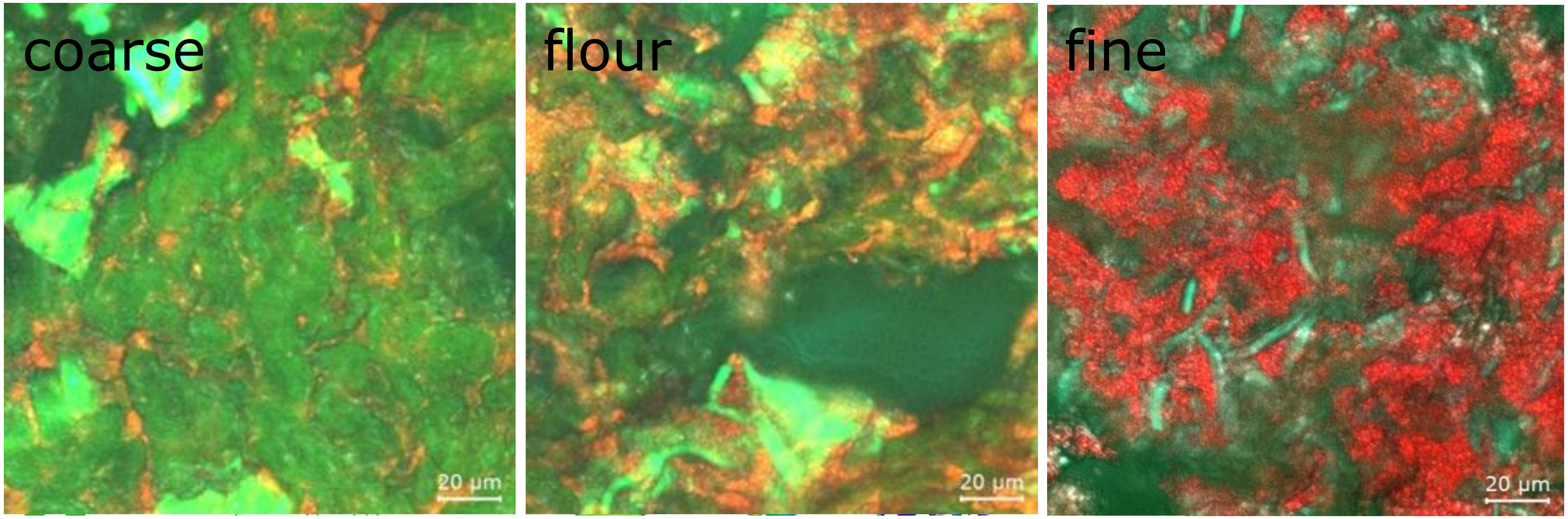


- Native: protein contents > 30% → concentrated liquid, due to high solubility
- Denatured: high WHC, due to gelatinized starch

Pea: Heat-induced gel formation

- Gel strength increases with increasing starch content
- Protein and fibres form domains that weaken the gel

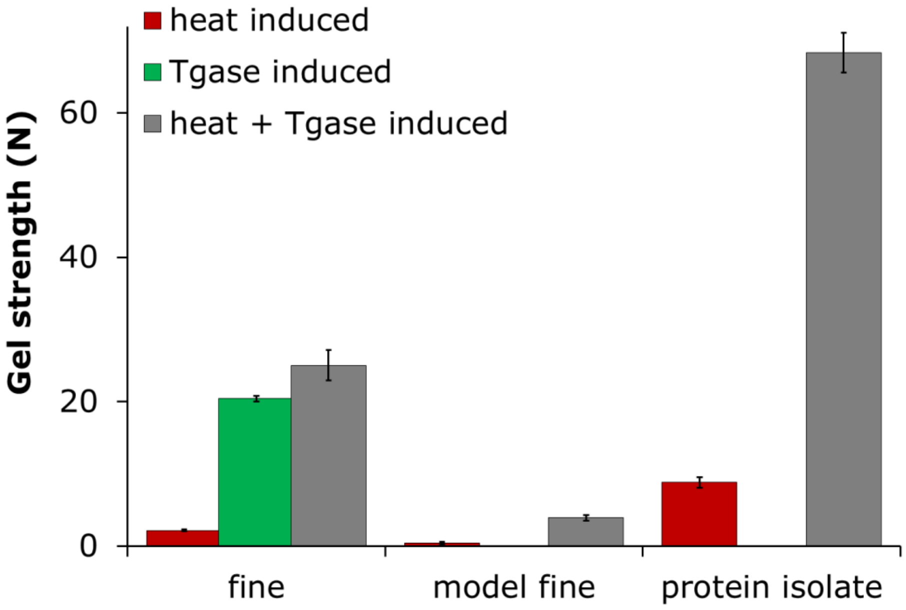




Green: aqueous phase, red: protein, light blue: cell wall (cellulose)

Pea: Enzymatic gelation

- Enzymatically-induced pea protein gels are stronger than heat-induced protein gels
- Starch and fibre in the fine fraction absorb water, which increases the protein content and the gel strength.



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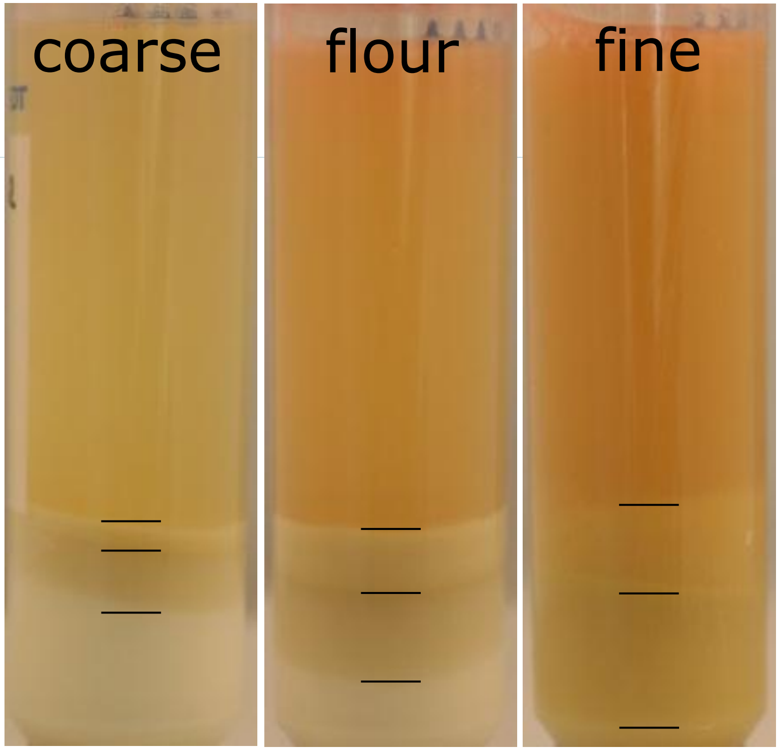
Pelgrom, P. J. M., R. M. Boom, et al. (2015). Food Hydrocolloids ***44****: 12-22.*

Suspensions of fractions

- Suspension phase separate
- Mild separation method: 77.4 g protein/100 g dry matter, yield 63 g/100 g
- Conventional wet fractionation: 80-85 g protein/100 g, yield of 55-65 g/100 g[3]

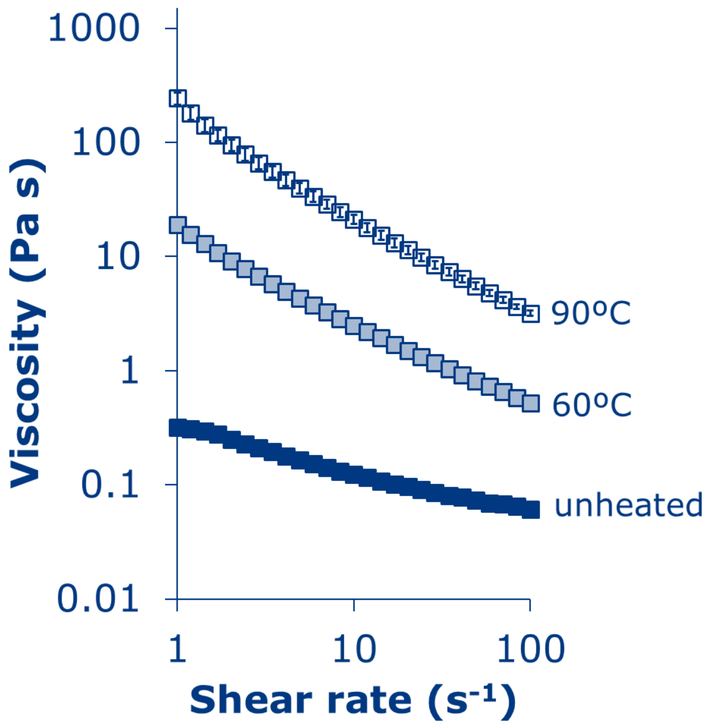


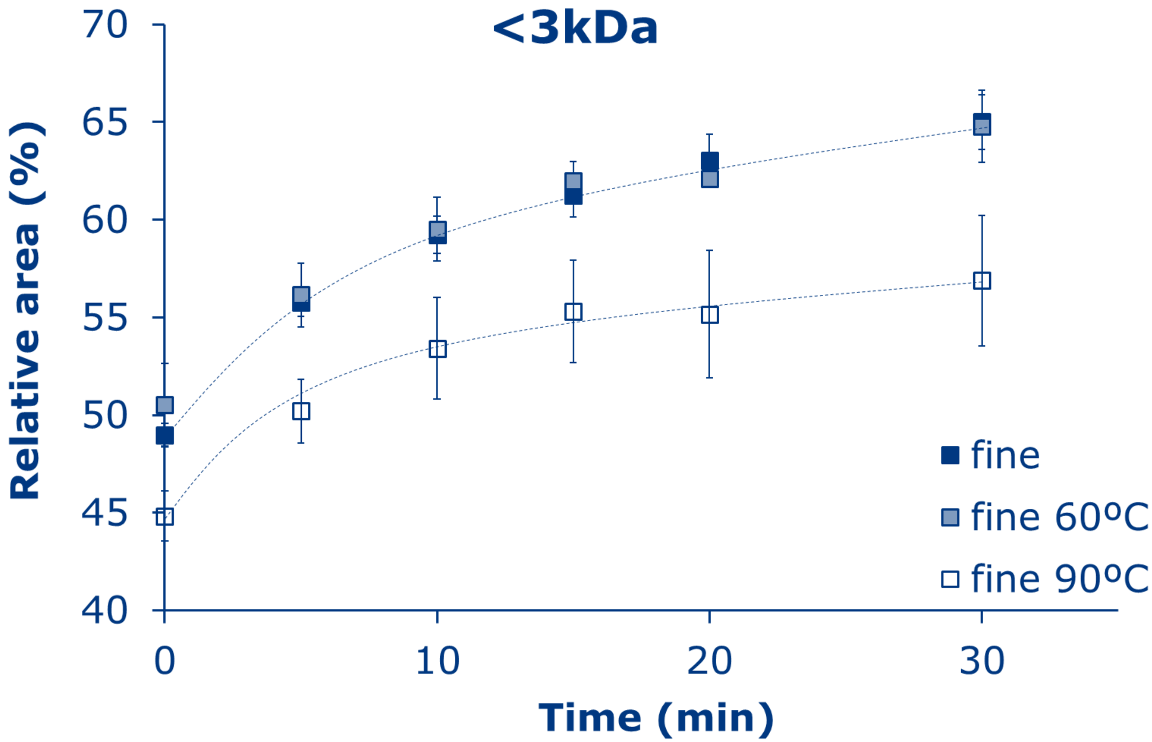
Sample	Protein content layer 1 (g/100 g dry matter)	Protein content layer 2 (g/100 g dry matter)	Protein content layer 3 (g/100 g dry matter)	Protein content layer 4 (g/100 g dry matter)
Coarse	42.5 ± 0.8	61.1 ± 0.6	14.0 ± 0.2	1.4 ± 0.1
Flour	55.3 ± 0.4	65.9 ± 0.3	18.7 ± 0.3	2.2 ± 0.3
Fine	**68.6 ± 0.6**	**67.4 ± 2.7**	27.0 ± 0.2	8.9 ± 2.6

[3] *Boye, et al., 2010; Fredrikson, et al., 2001; Makri, et al.; 2005; Mondor, et al., 2012*

Lupine: Functionality

- Hypothesis: heating (less mild fractionation) changes functional properties





- Viscosity is lower for native proteins
- After digestion more small proteins are available in native proteins

Potential for high protein beverages

Conclusions

- Dry fractionation:
  - Separation is based on legume morphology
  - Is a sustainable way to refine protein
  - Delivers functional and healthy protein fractions

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Outlook

- Further development of dry fractionation:
  - Optimise milling behaviour behaviour
  - Use combination of driving forces for separation
  - Select legume varieties ‘designed’ for dry fractionation
- Develop new product concepts that use functionality of dry-enriched fractions.
  - Suitable for high protein beverages and gels
  - Potential application in structured products (meat replacers)

Acknowledgements

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	Design & Processing 3 Chairs: Prof Cristina Luisa & Christian Malmberg *Sal B*
17:15-17:30	[O1.21] Dry fractionation for sustainable production of arabinoxylan-enriched wheat bran fractions J. Wang*, E. Smits, M. Buisman, R.M. Boom, M.A.I. Schutyser, *Wageningen University, The Netherlands*
17:30-17:45	[O1.22] Glass transitions to facilitate dry fractionation in food processing L.H.G. van Donkelaar*, A.J. van der Goot, R.M. Boom, *Wagenigen Universtiy, The Netherlands*

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