Electrostatic separation of soybean for protein concentration

Protein for Life Symposium

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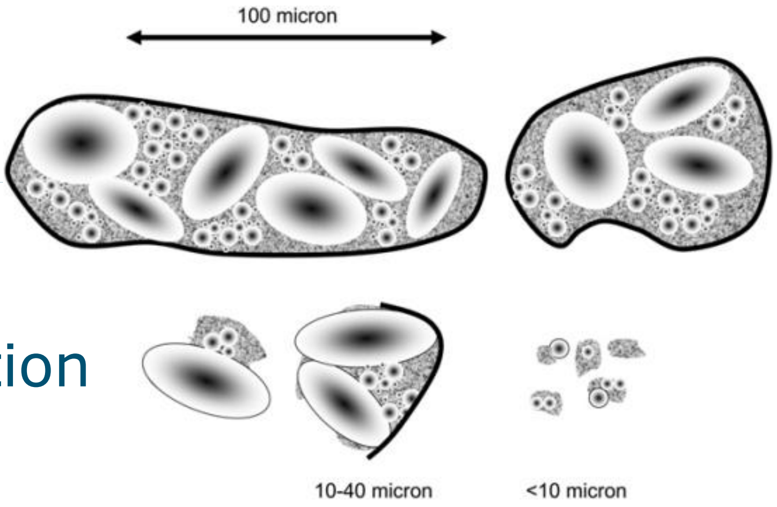
Dry fractionation



- More sustainable
  - Less or no water consumption
  - Less energy consumption
- More mild
  - Retaining native functional
- But, less pure
  - Functionality is more import
- Conventional dry fractionation
  - Milling & air classification

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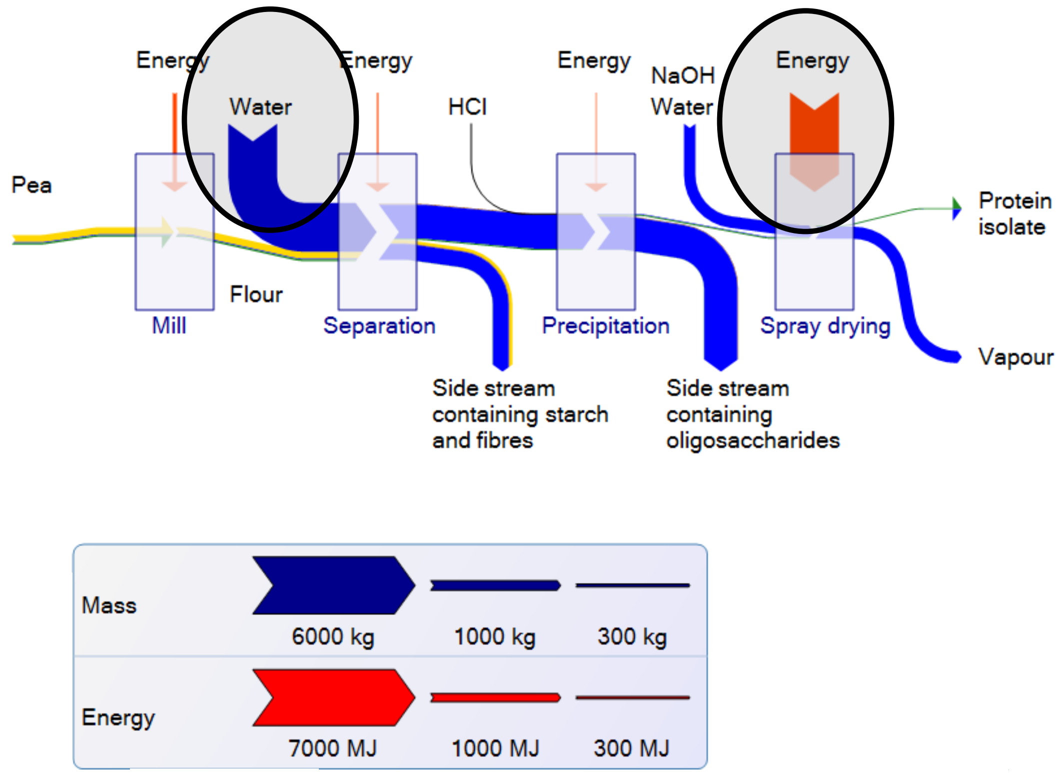
Sustainability of legume protein sources

Animal protein

*4-11 g protein/MJ**

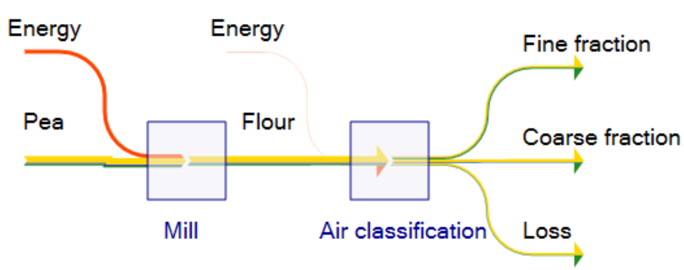
Wet fractionation

14.6 g protein/MJ



Dry fractionation

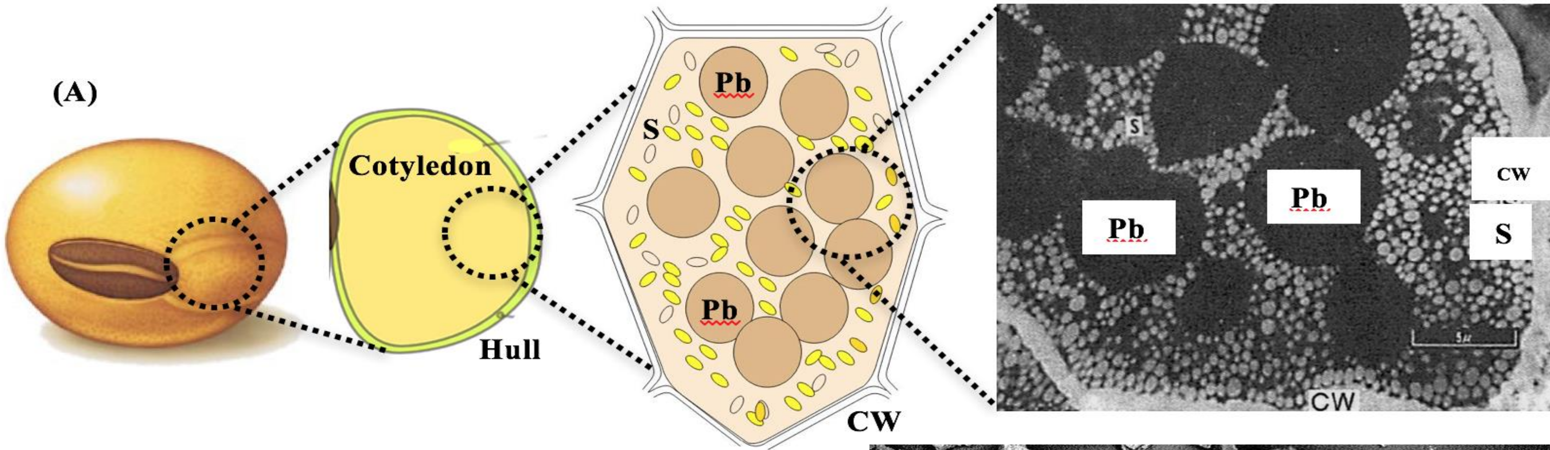
55.8 g protein/MJ

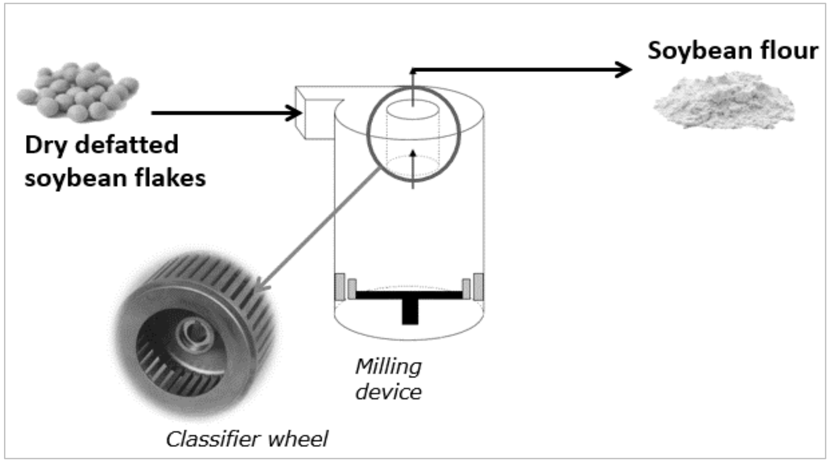


[*] González, A. D., B. Frostell, et al. (2011). Food Policy 36(5): 562-570.

Milling & dry separation

- Soybean: cellular structure and milling





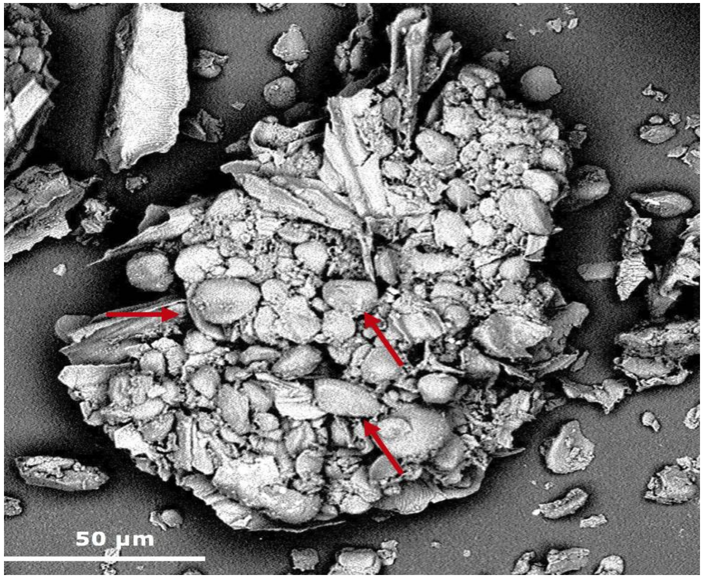


Figure 5. SEM image of protein bodies (PB) kept inside cellular structure

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Objective

Evaluate the potential of **electrostatic separation** as a more sustainable route for production of **protein-enriched fractions** of **soybean**, by a experimental combination of

- **oil extraction,**
- **milling and**
- **electrostatic separation.**

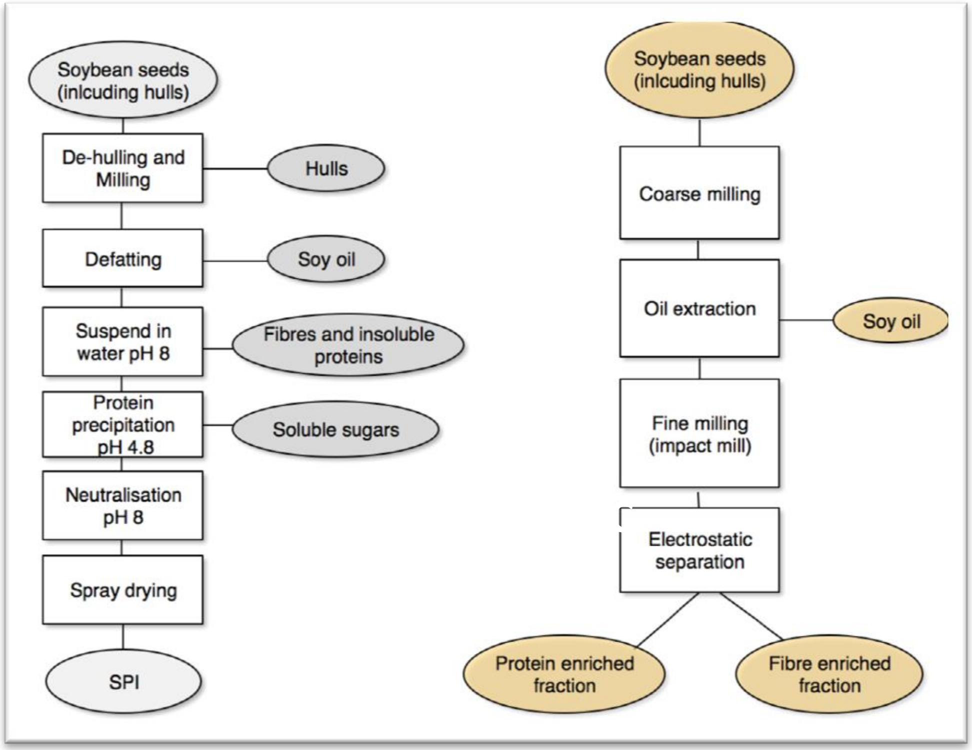

Figure 3. Conventional wet extraction vs. dry fractionation

Background

- Electrostatic charging and separation

The ‘Triboelectric series’

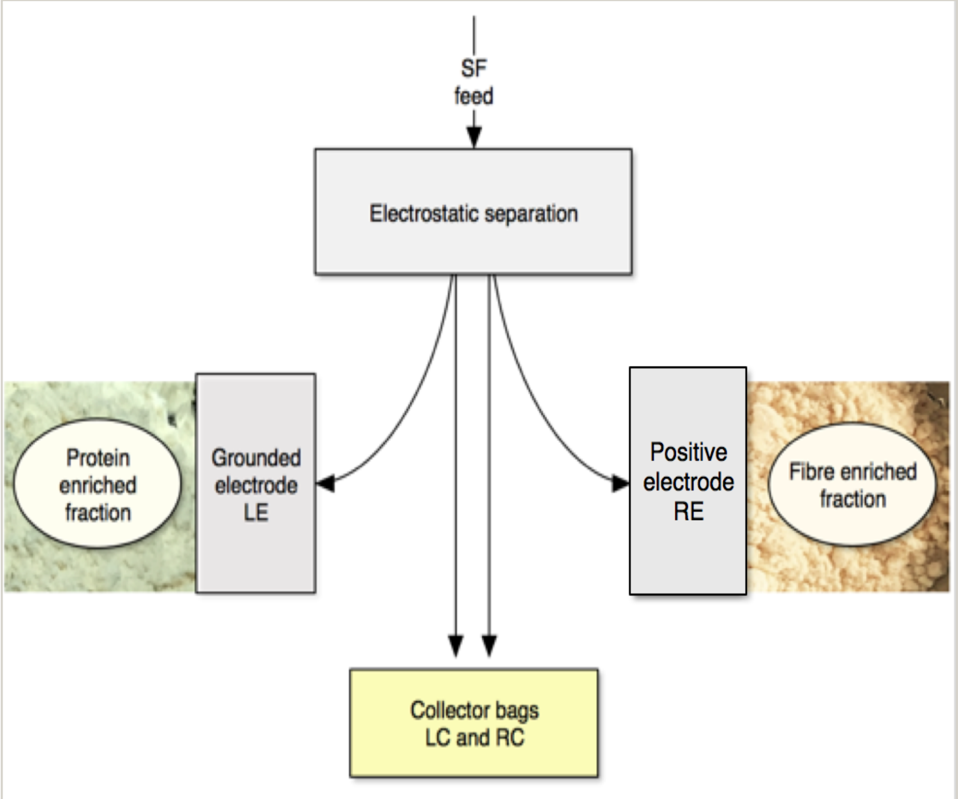

Figure 6. Electrostatic separation principle

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Material and Methods

- Electrostatic separator: Technical set-up

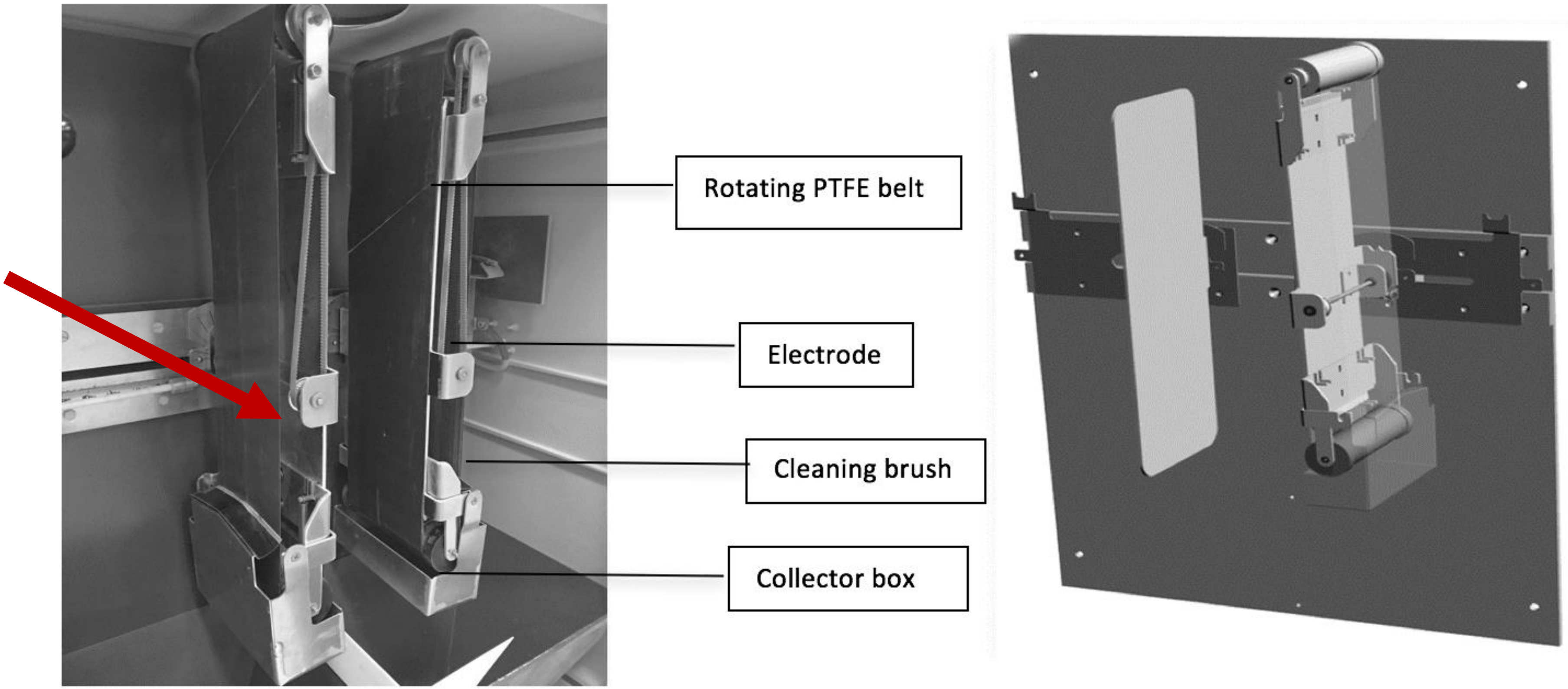

Figure 7. (A) Schematic drawing of pilot-scale electrostatic separator set-up and (B) actual separator, located at Wageningen University, Netherlands (graph adapted from Wang et al. 2015).

Material and Methods

- Experimental set-up overview

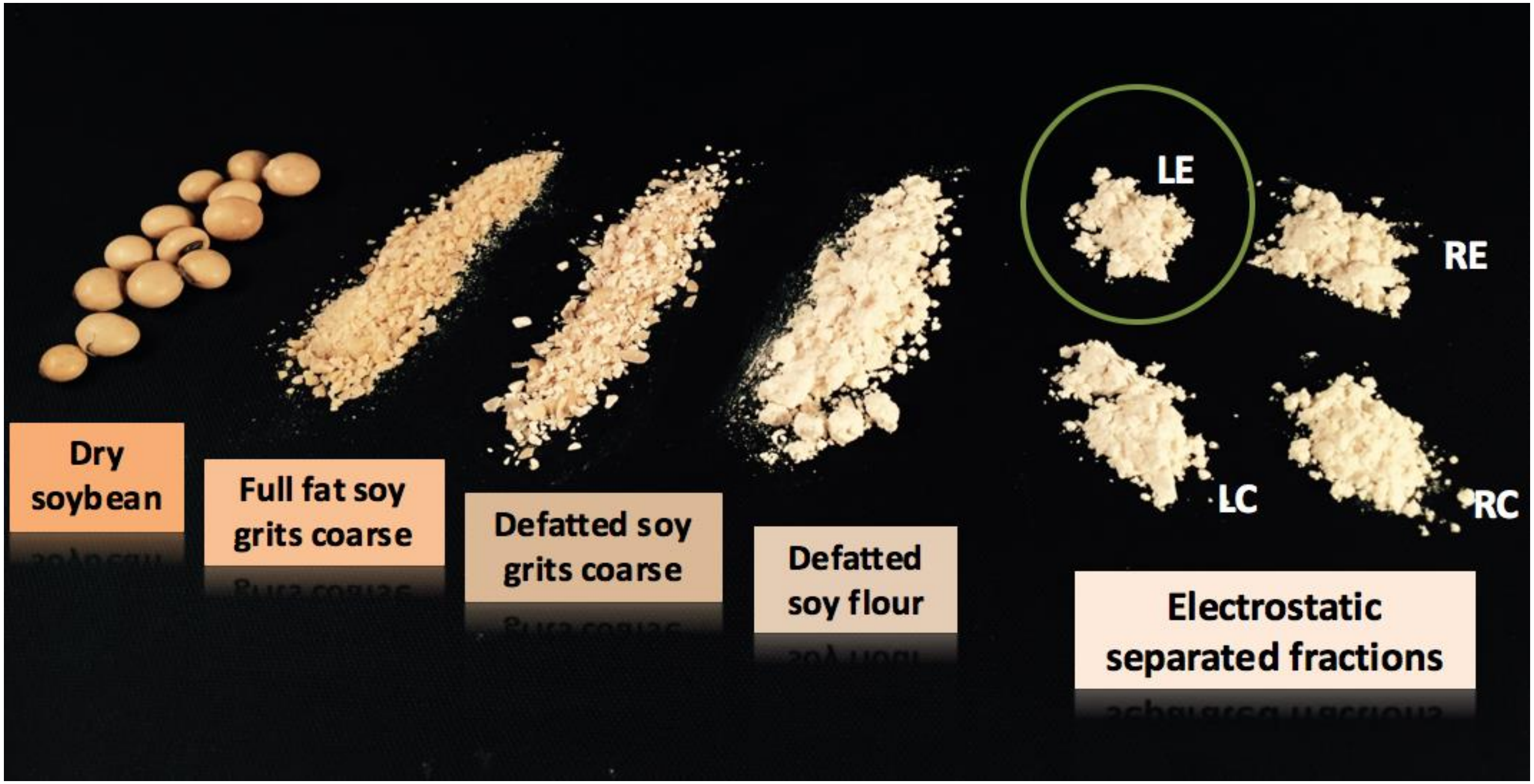

Figure 8. Overview of milling and separation process, each stage indicated by pictures of the obtained materials/flours/fractions.

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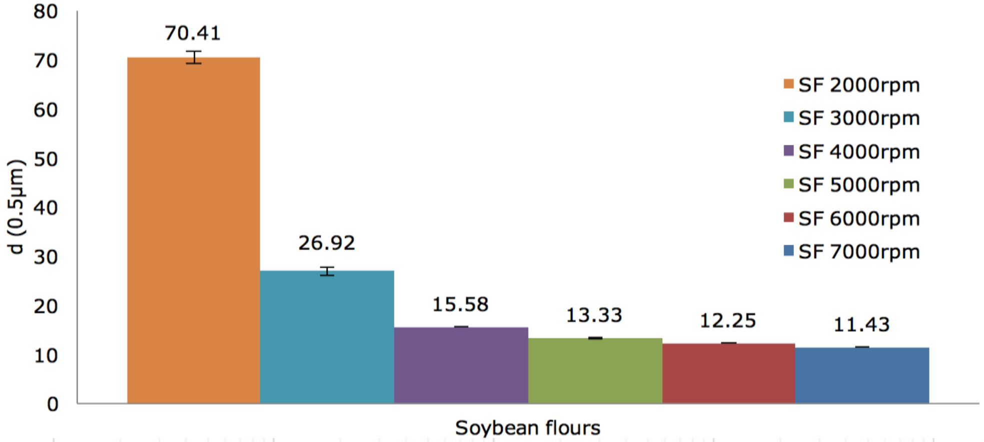
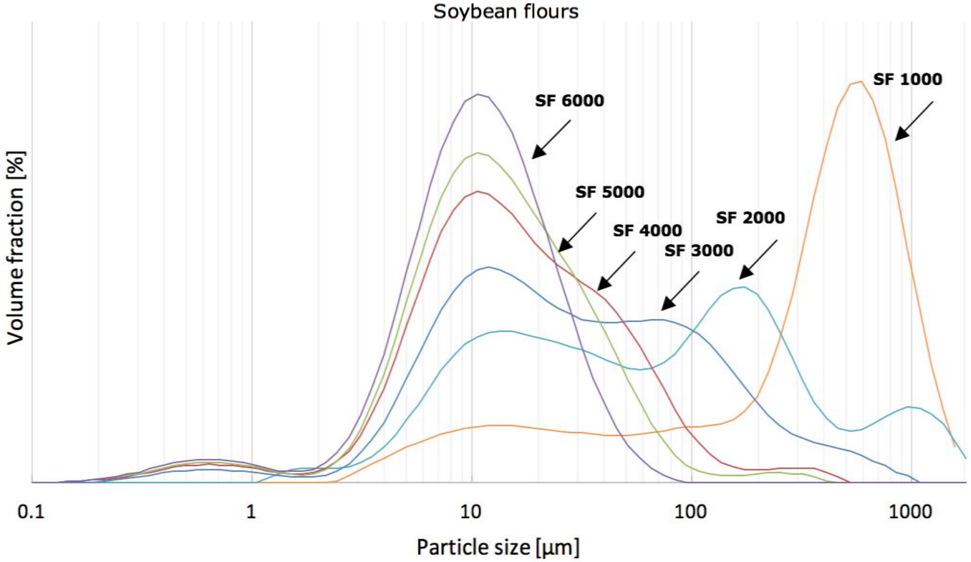
Results

- Milling: fine and coarse





Impact mill system ZPS
Airflow 80 m^3/h

Classifier wheel speed from 1000-7000 rpm

Milling yields of **82 – 89 %**

Optimum between **too fine** and **too coarse** milling

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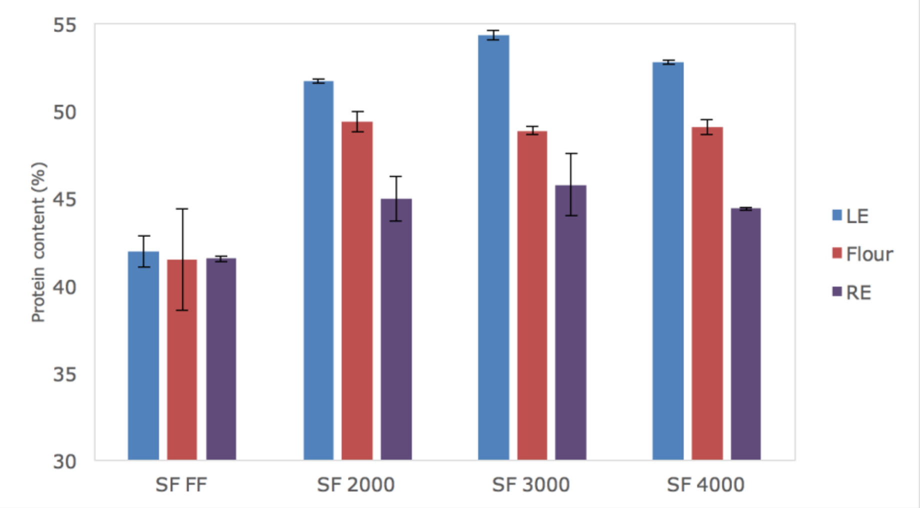
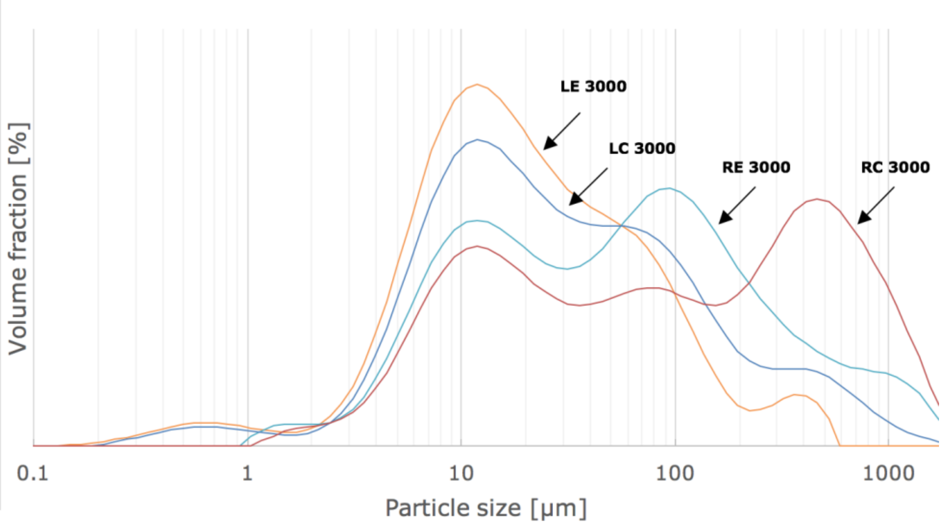
Results

- Electrostatic separation

Milling Conditions	Particle size [μm]	Protein Content [% wet basis]	[% dry basis]	Yield [%]	Protein recovery [% dry basis]
Flour 3000rpm	26.92	45.93	48.86	100.00	-
Enriched fraction	24.46	50.73	**53.97**	**18.70**	**23.68**
Depleted fraction	44.23	43.03	45.78	26.26	**28.21**





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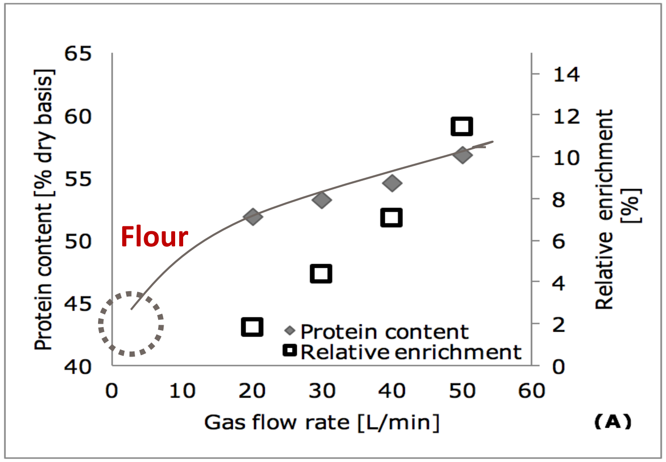
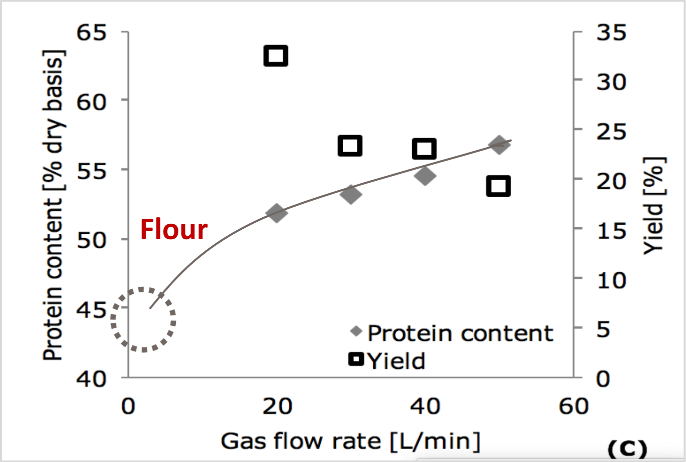
Optimization

- Role of carrier gas velocity





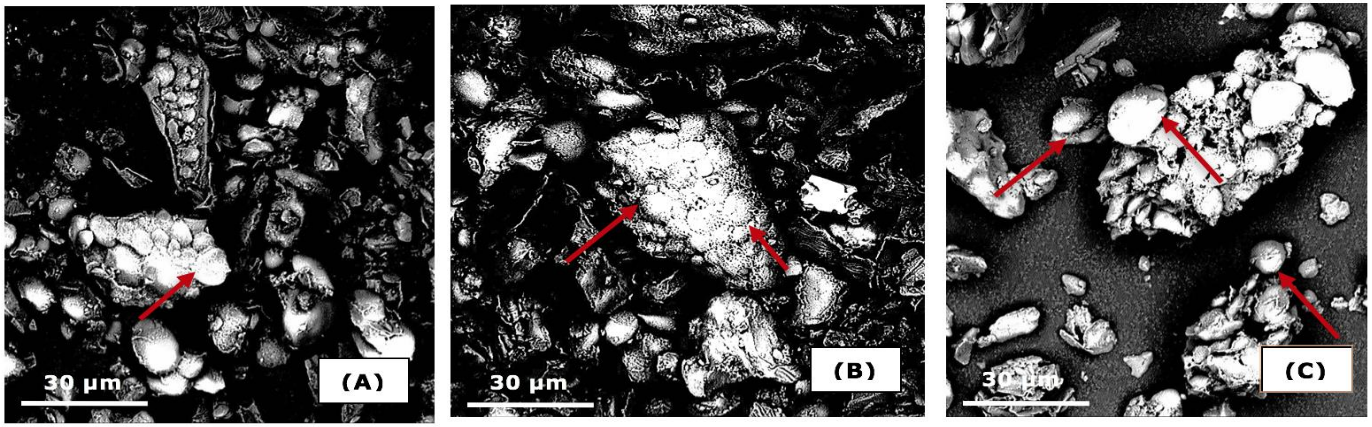


Figure 9. SEM of LE (protein enriched) fraction

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Optimization

- Role of hull particles

	Protein content (% dm)	Gas flow rate (L/min)	% RE	% LE	% RC	% LC
SF 3000 hulled	**57.66**	55	25.12 ± 3.17	**17.98 ± 0.99**	9.05 ± 0.41	5.12 ± 1.36
SF 3000 de-hulled	**58.03**	55	22.26 ± 3.65	**13.63 ± 2.68**	8.67±1.10	7.80 ± 0.99

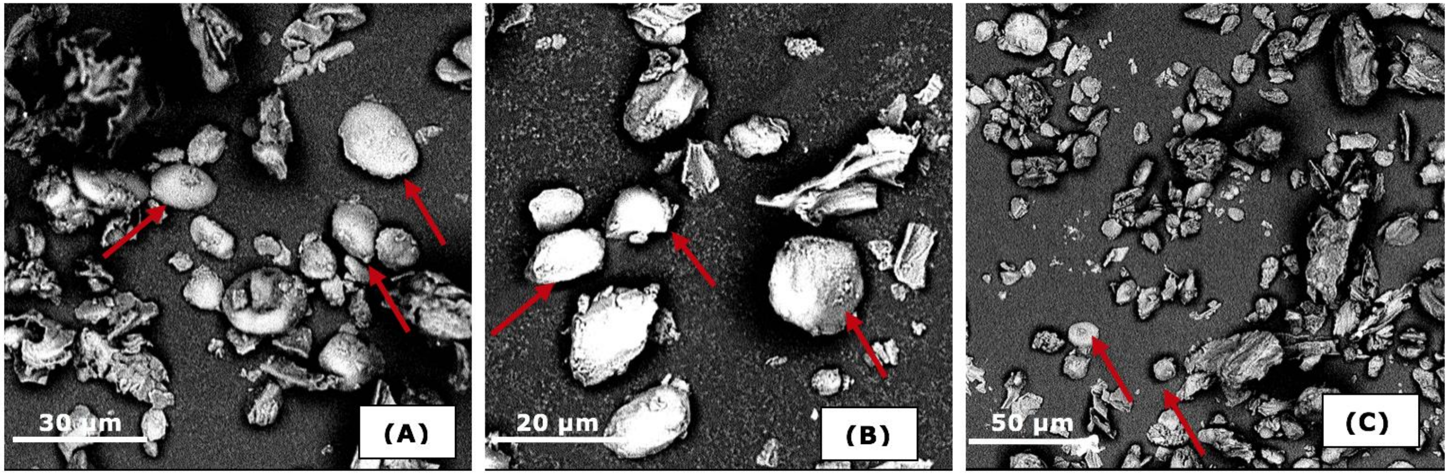

Figure 10. SEM of LE (protein enriched fraction)

Conclusions

I. Role of milling

II. Role of hull particles

III. Carrier gas velocity

-> **formation of agglomerates**
is the limiting factor in the current separation

Conclusions

- Final **protein purity** of enriched fraction from **41.5 (full fat)** to **58.1 g** protein/100g dry basis with a **yield** of **13.6 g**/100g flour.
- All components in ***native state***
- ***Protein-enriched*** and ***fibre-enriched*** fraction
- Sound basis for further processing or fractionation –> ideal method to start for food or non-food application

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Outlook

- Further development of dry fractionation:
  - Optimise milling & dry separation
  - Use combination of driving forces for separation
  - Select legume varieties 'designed' for dry fractionation
- Demonstrate functionality of dry-enriched fractions:
  - Suitable for high protein beverages and gels
  - New structured products (meat replacers or new structures)

3D Printing with legume flour fractions

58% Coarse

58% Flour

58% Fine

Acknowledgements

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Thank You !

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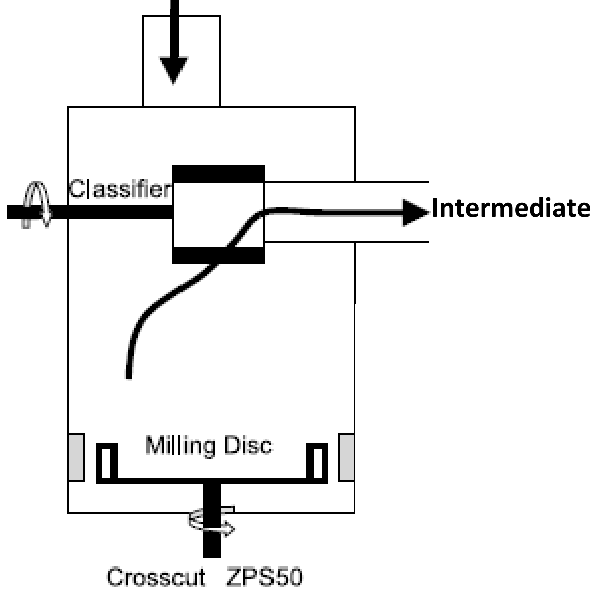
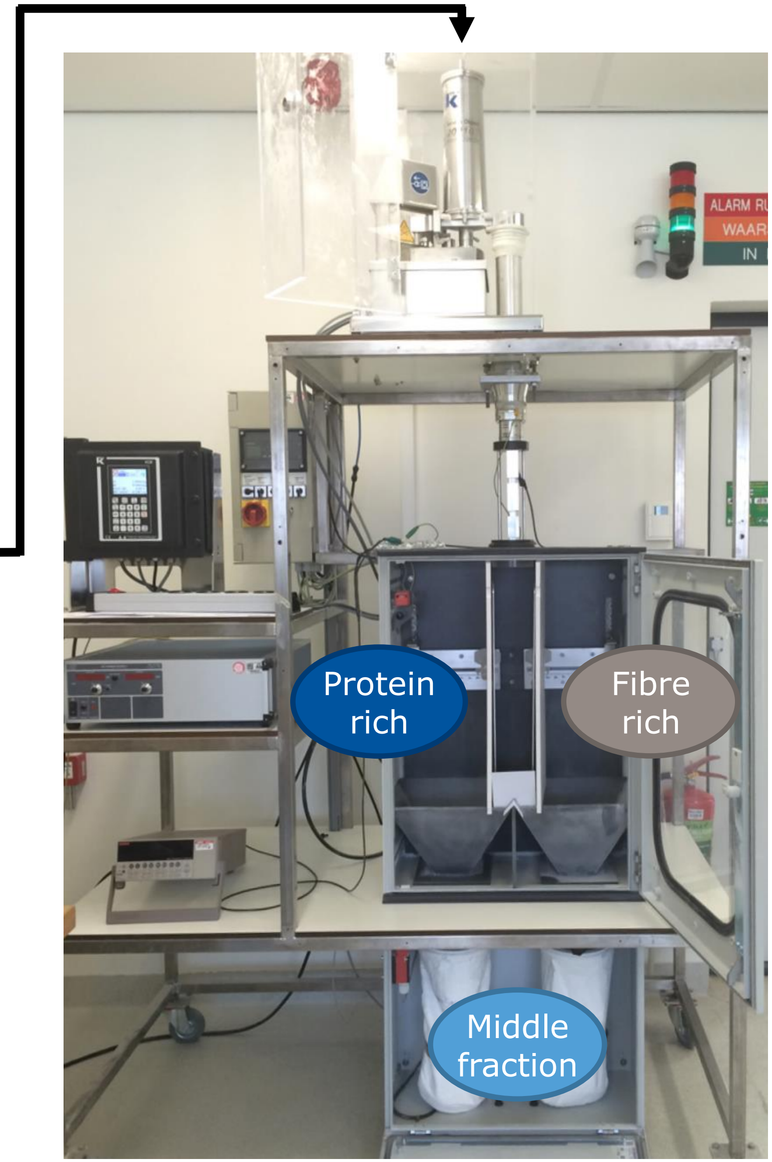
ES of lupine flour to enrich protein





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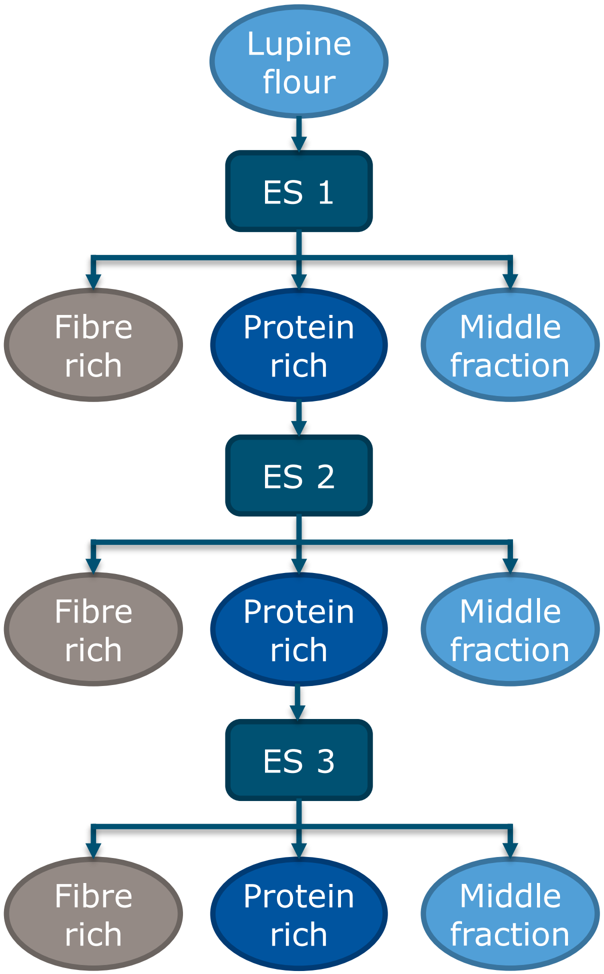
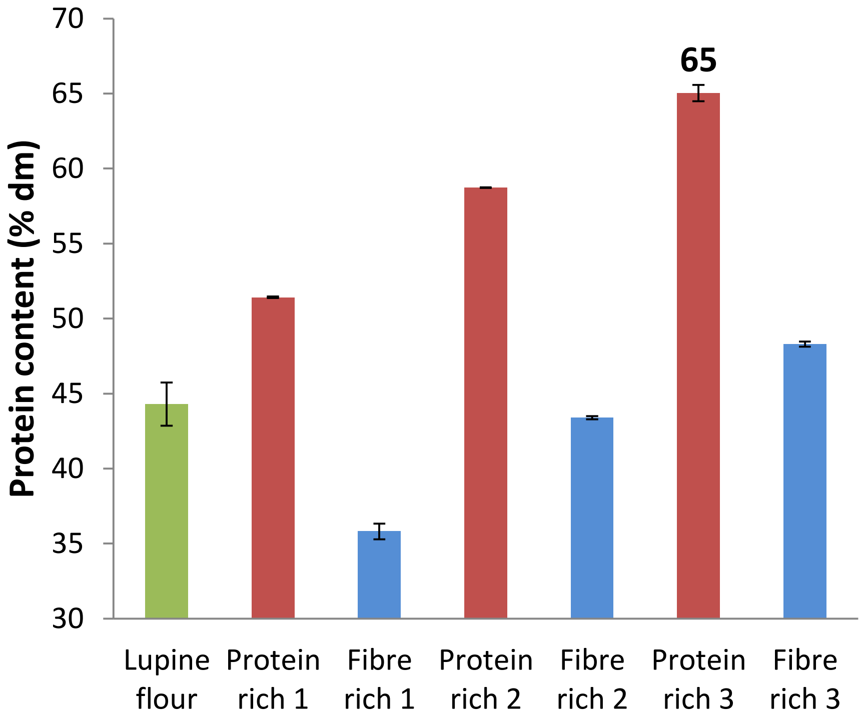
Multiple-step ES (MSES)





15% more enrichment than air classification (~59% dm)

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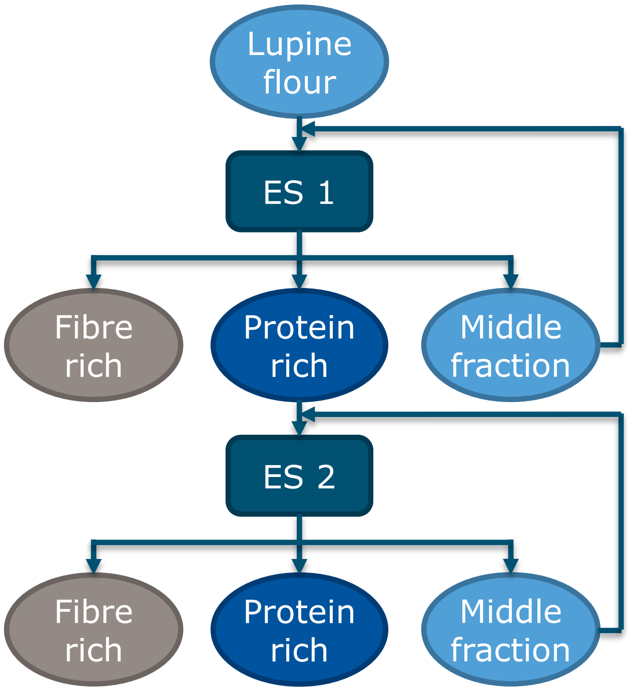
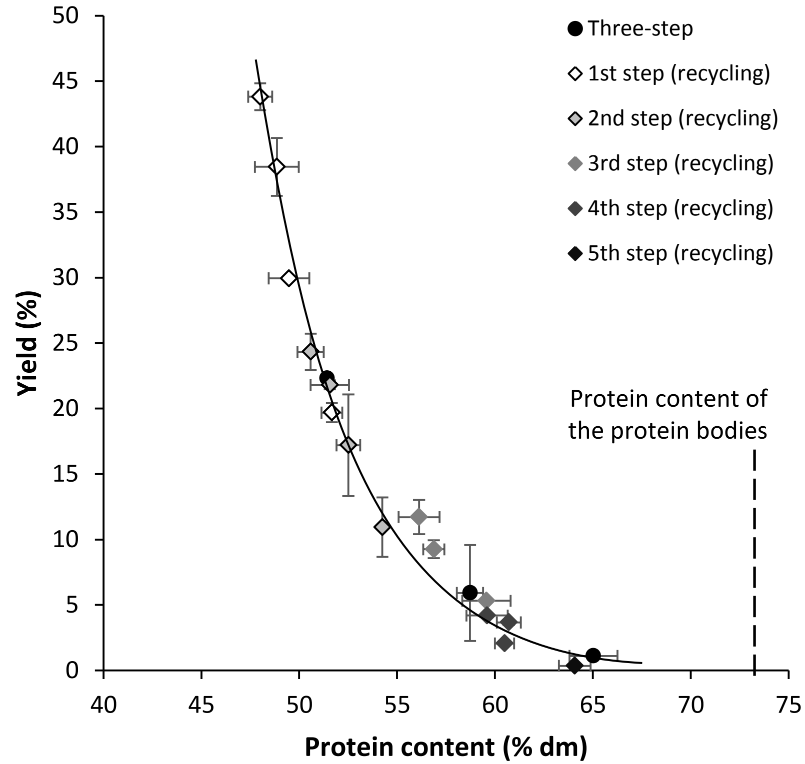
Yield improvement by recycling

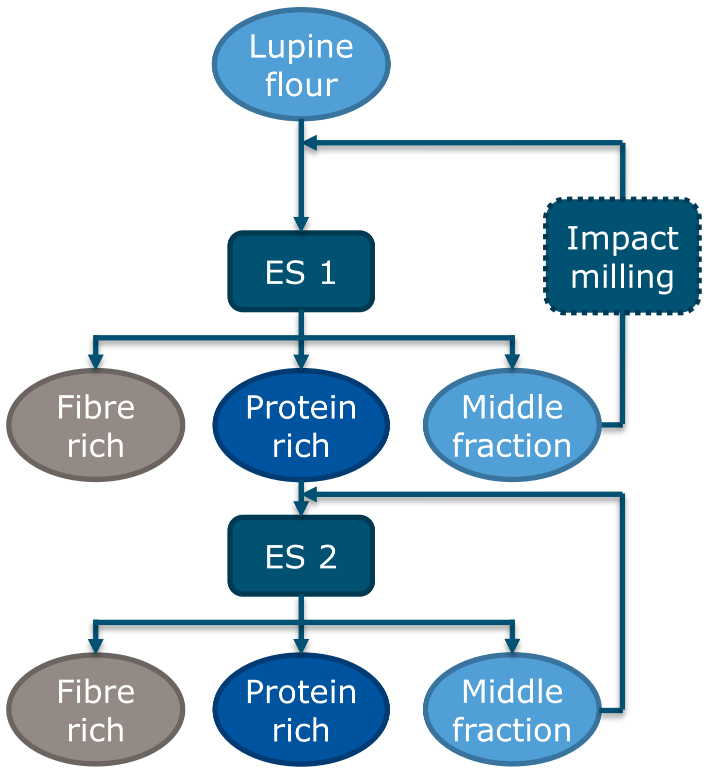


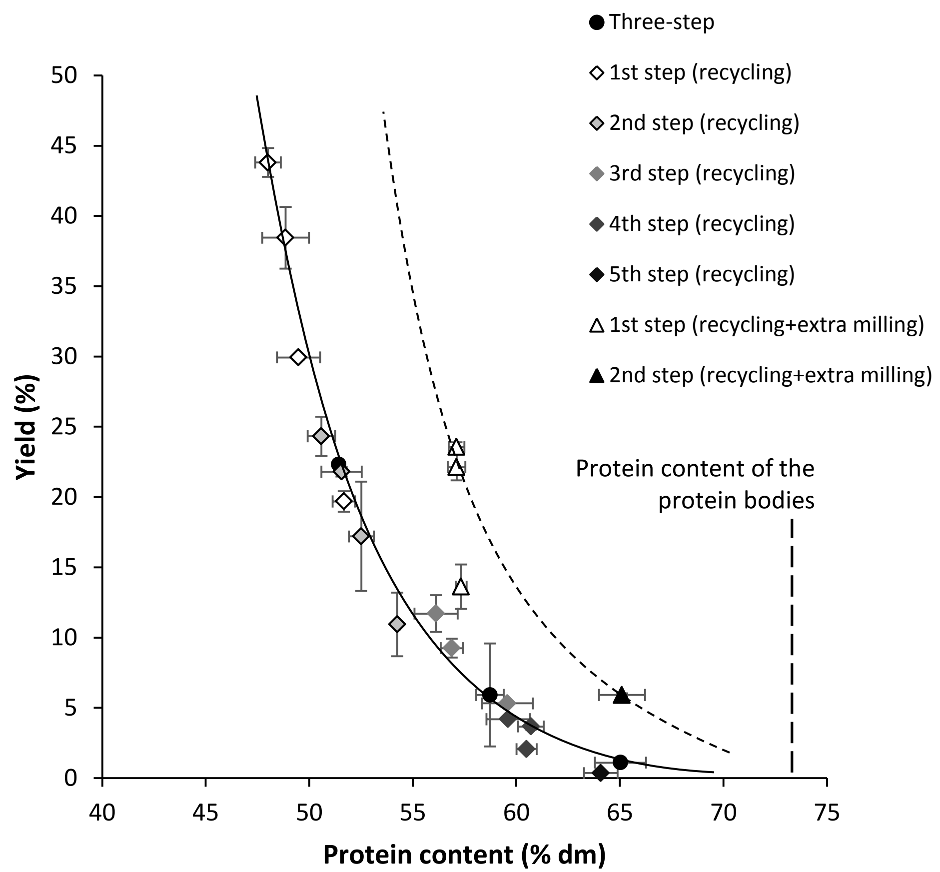


Yield can be doubled for each step…but at cost of purity

Improve disclosure of intracellular content by more intensive milling

Extra milling of middle fraction





A recovery of 10% protein from lupine flours.