Plant Proteins for Technical Applications

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Topics of presentation

1. Main european crops
2. Plant protein processing
3. Structure and properties of native protein
4. Modification and related functionality with respect to technical applications
5. Technical applications
6. Summary

Renewable resources in Europe

- oilseed and starch crops:

Wheat	**245.000 ha**
Mais	**245.000 ha**
Cotton	**508.000 ha**
Linseed	**314.000 ha**
Sunflower	**354.000 ha**

- protein crops:

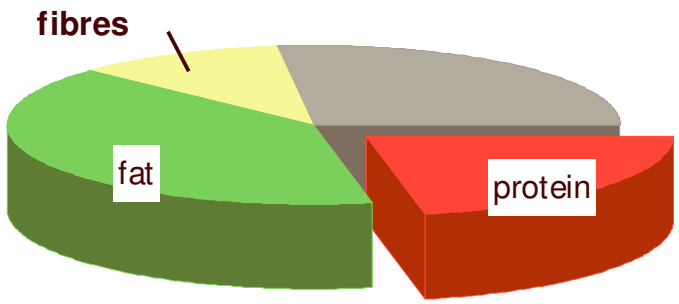
Lupin	**78.000 ha**
Soybean	**800.000 ha**

(figures from 1998, www.naro.de)

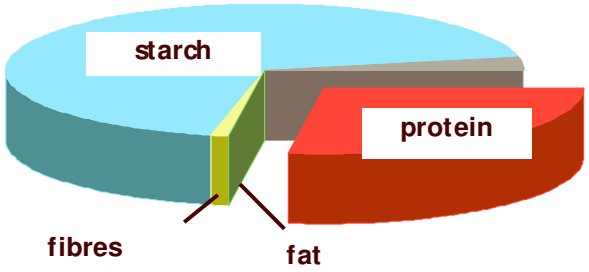
- **Only few R&D on plant proteins as technical biopolymers is available!**

Raw materials

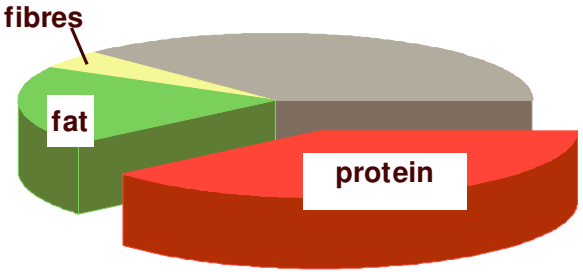
Oilseed crops (rapeseed):



Starch crops (pea):

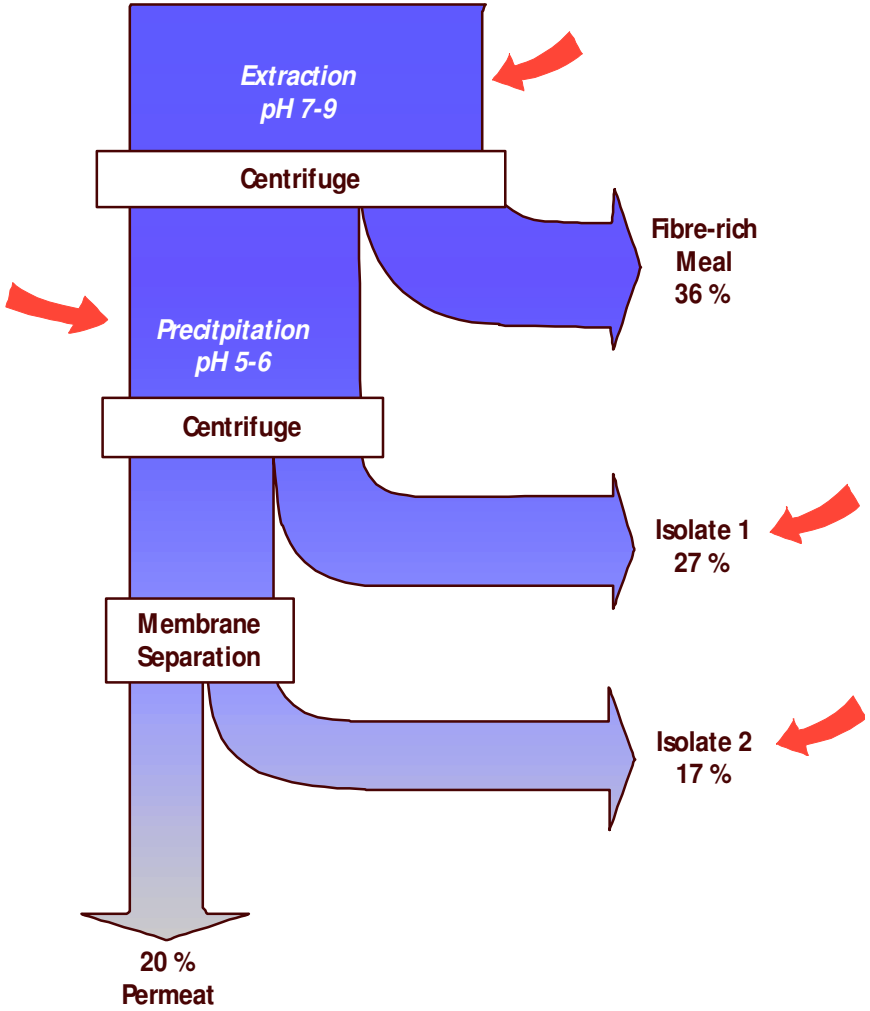


Protein crops (lupine/soybean):

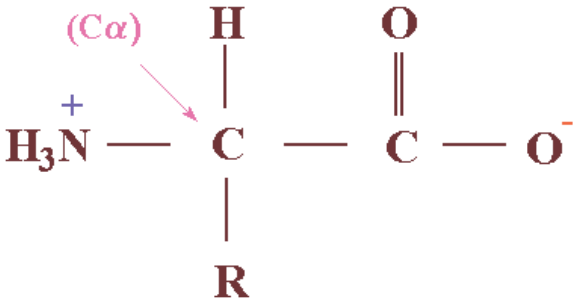


Protein extraction

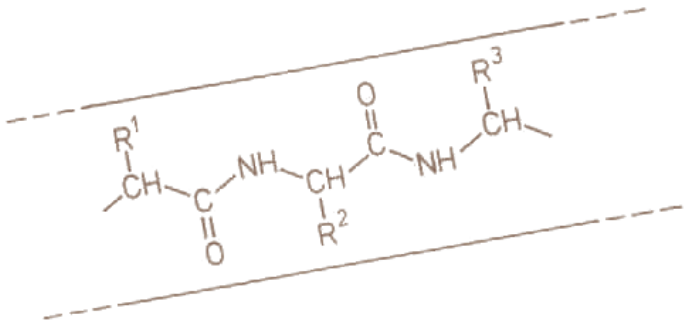
Example: rapeseed



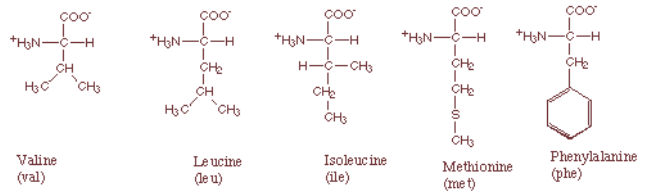
Functionality of side chains



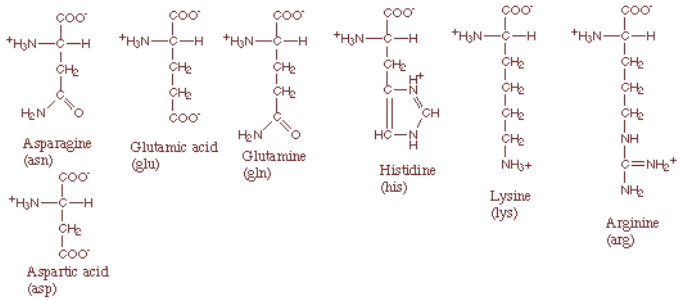
Amino Acid



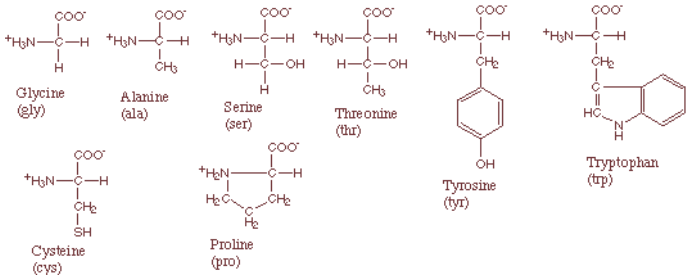
Amino acids with hydrophobic side groups



Amino acids with hydrophilic side groups



Amino acids that are in between



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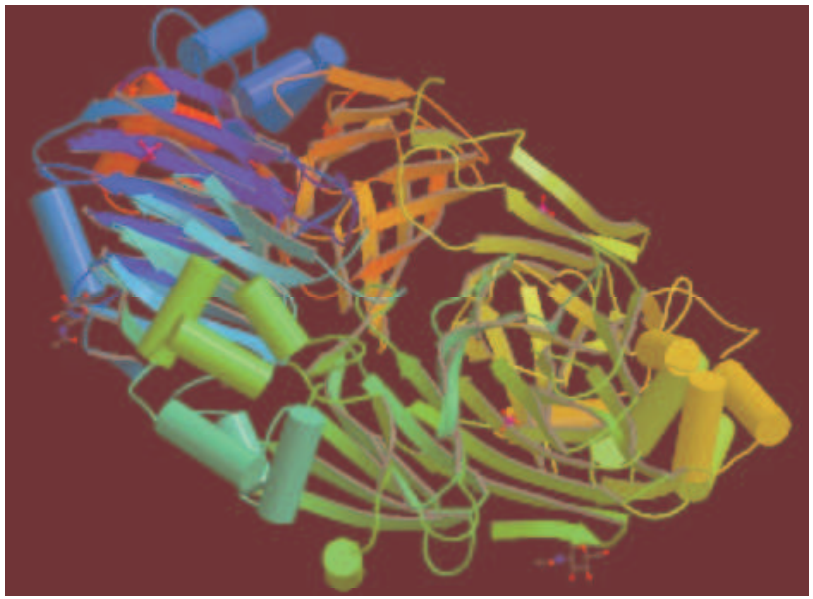
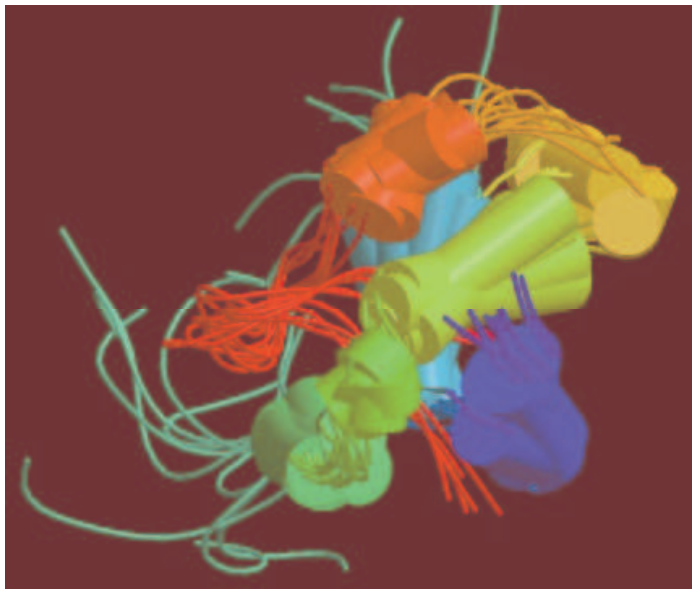
Complex molecular structure



from: Lawrence M.C. et al.: J. Mol. Biol. 238, 748 (1994):

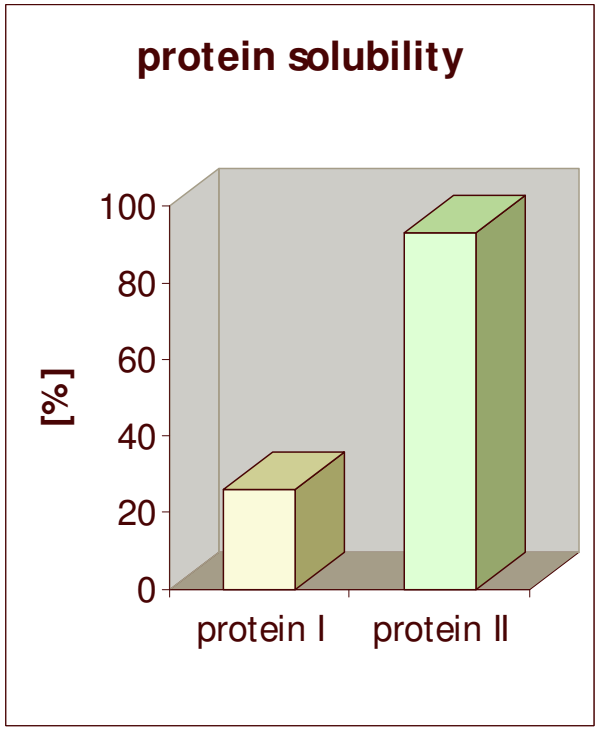
Vicilin from Phaseolus vulgaris

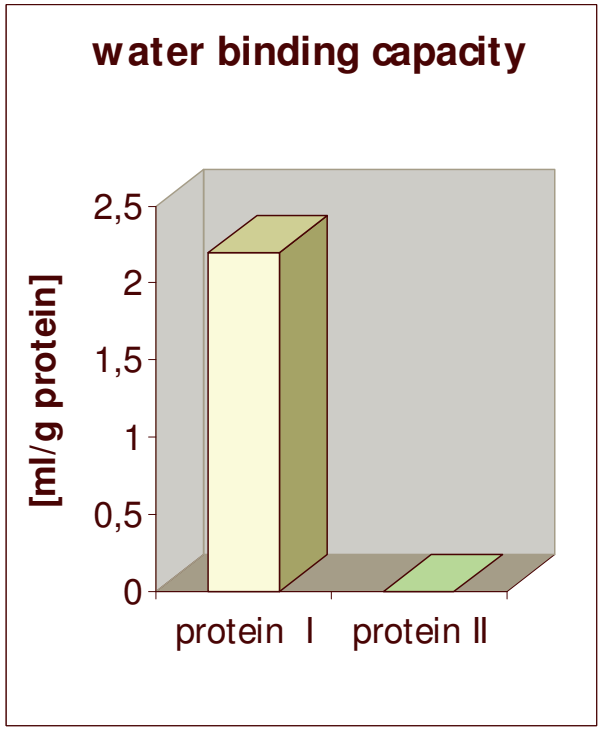


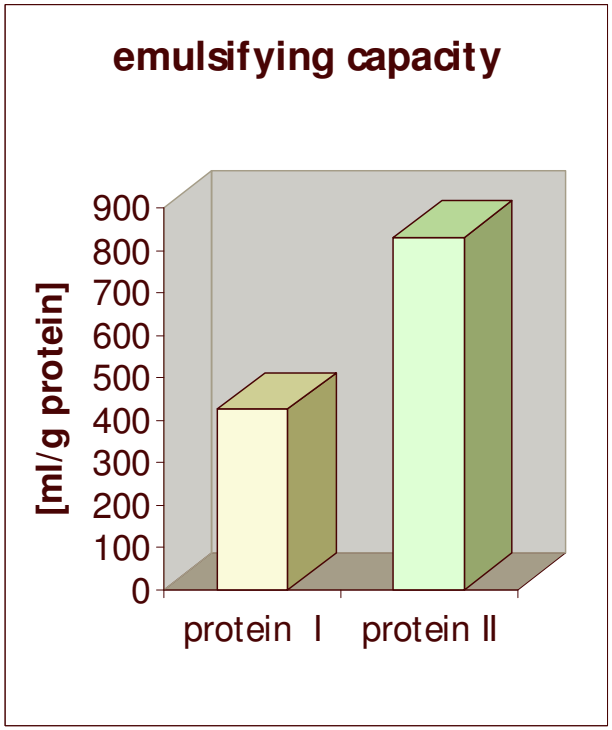
from: Rico M., Biochemistry 35, 15672 (1996)

2 S Napin from B. napus

Properties of native rapeseed protein

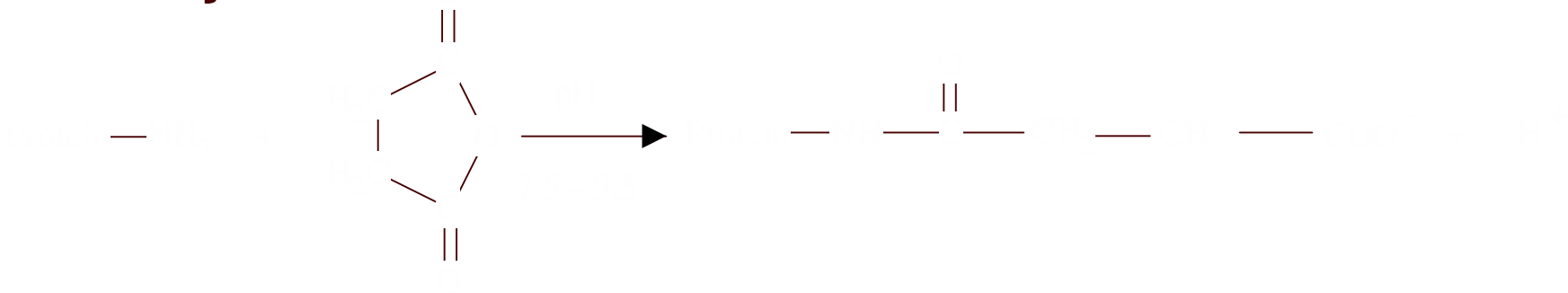




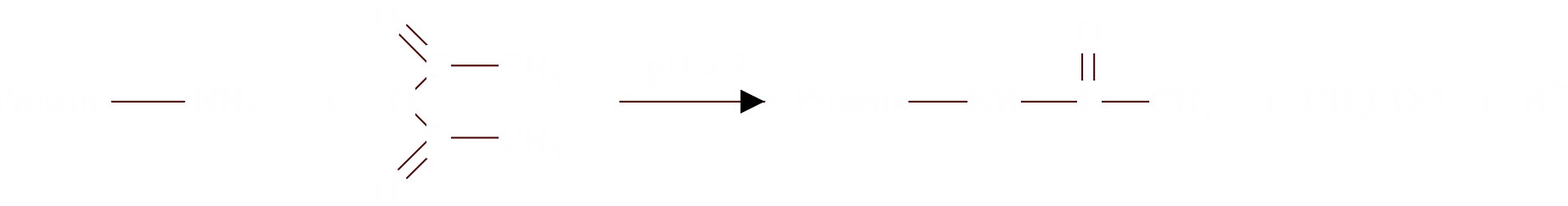


Chemical modification

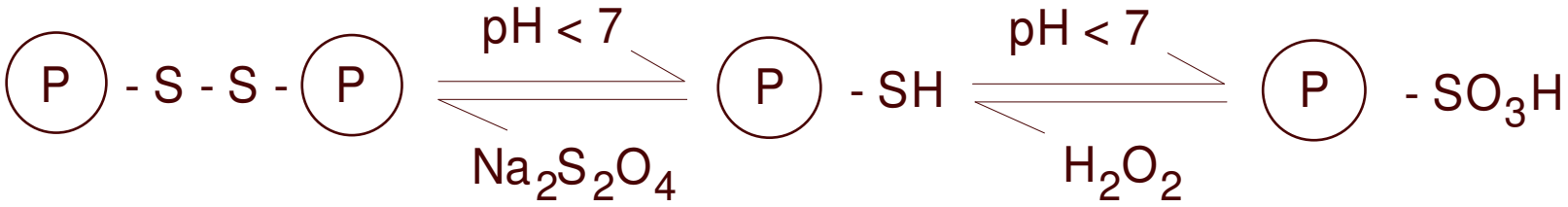
Succinylation



Acetylation



Reduction/Oxidation



Advanced functionality

Acylation

Succinylation

causes increased electrostatic repulsion and therefore defoulding and dissociation

- **increase of hydrophilic character and solubility/dispersing**
- **improved heat stability**
- **significant increase of negative netto load and thus shift ing of IP to more acidic pH**

Acetylation

causes defoulding and makes functional groups available

- **increase of solubility and water binding capacity (gel forming!)**
- **significant increase of negative netto load**

Reduction/Oxidation

causes denaturation by thermal load

- **decrease of solubility**
- **significant increase of water binding capacity**
- **increase of negative load**

Technical applications

Native and modified proteins applied as

- Paper coating
- Labeling adhesive
- Oxygen barrier coating

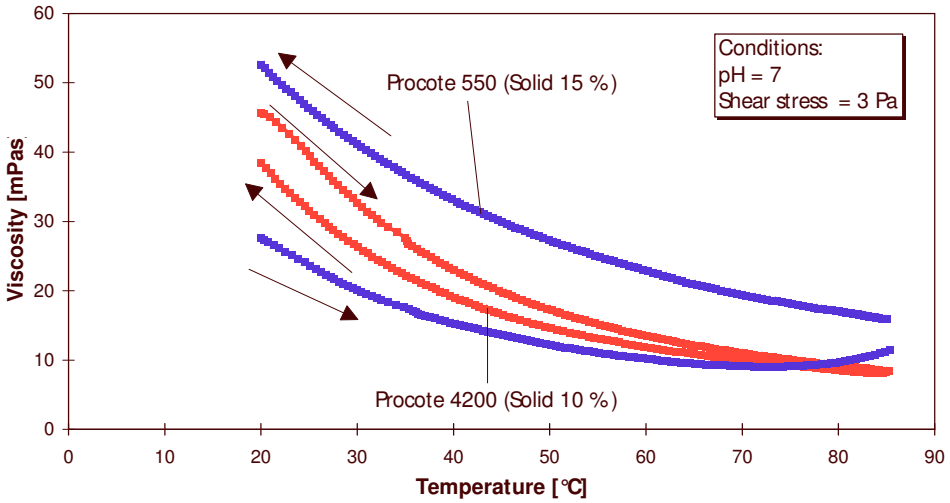
Paper coating

With respect to processing temperature application demands a heat stability from 20 °C to 85 °C.

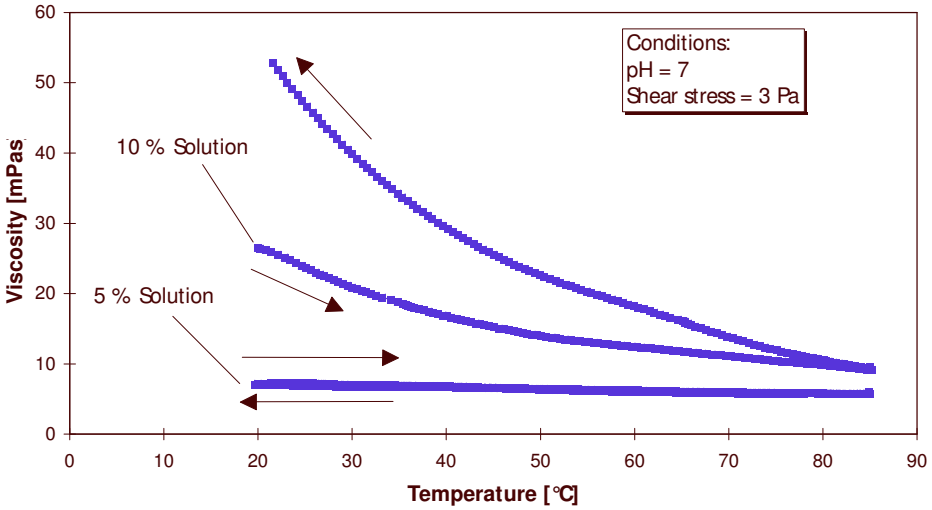
- **modification: succinylation**

	Commercially available protein binder	Succinylated lupine protein
dry matter	93 %	96 %
nitrogen content	13%	15.3 %
protein (N x 6.25)	80 %	96 %
oil (acid cooking)	2 %	2 %
ash (550 °C)	10 %	5.5 %
protein solubility (pH 7)	59 %	94 %

Commercially available protein binder



Succinylated lupine protein

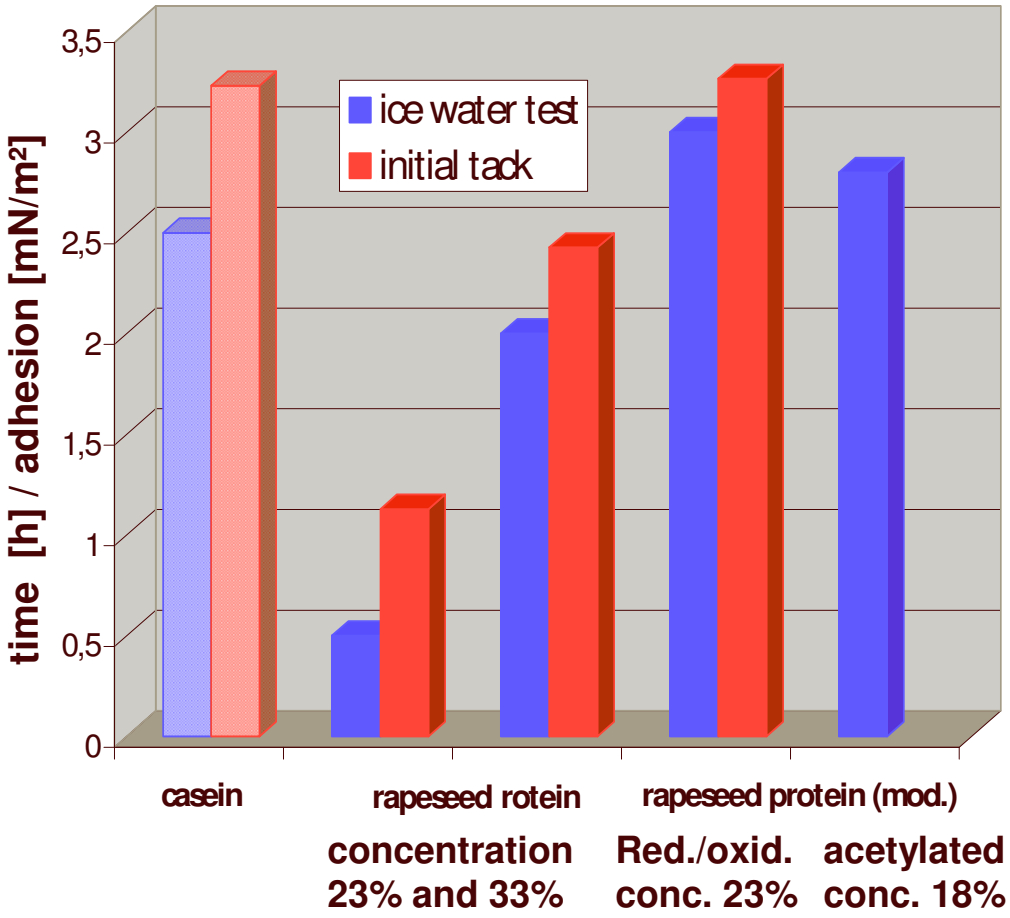


Paper coating

Résumé:

- Heat stability was reached in case of modification > 70%.
- The process of succinylation was transferred into pilot scale.
- Succinylation should be integrated in process of protein isolation with respect to costs and solubility.
- Production costs are mainly influenced
  by the price of modification agents;
  through imrpoved reaction conditions economic feasibility can be reached.

Labeling adhesive



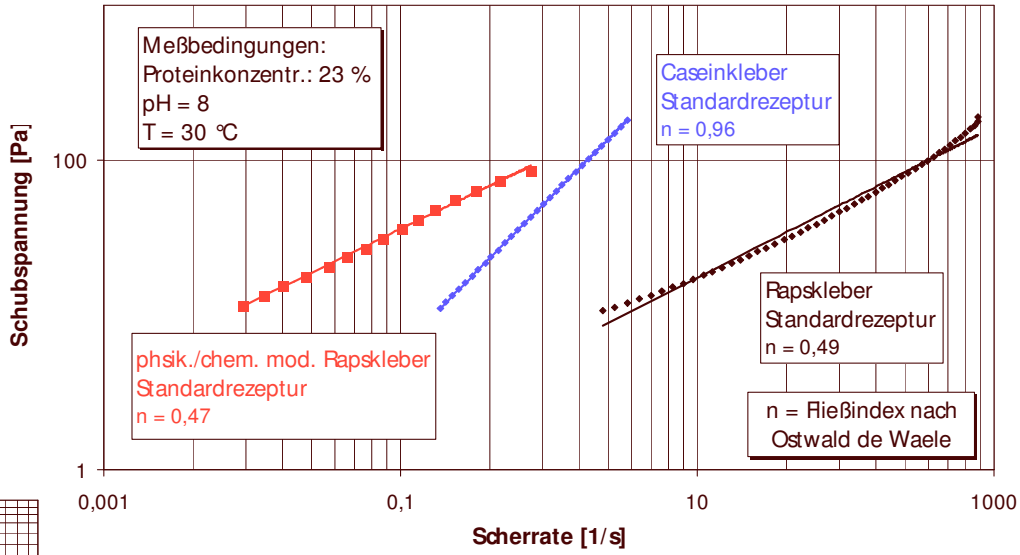
formulation

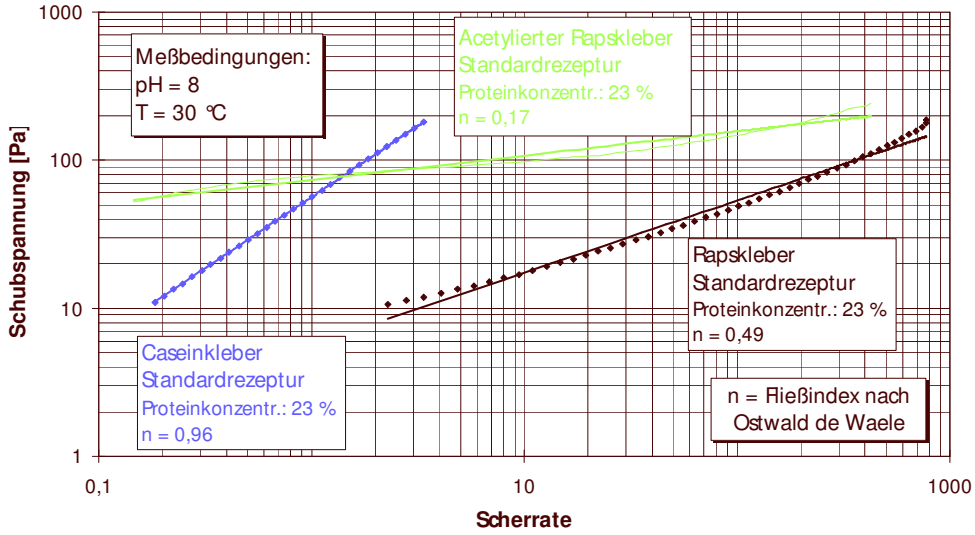
66 T water
23 T rapeseed protein (native/mod.)
6 T urea
2,5 T borax
0,4 T defoamer
0,4 T wetting agent
1,3 T Na_2PO_4
0,4 T preservation agent

(formulation: Hinterwaldner, München, 1996)

Labeling adhesive

Reduction/oxidation leads to significant increase of viscosity being even higher than in case of casein.





The acetylated protein shows high viscosity at low shearing rates. With increasing mechanical load viscosity strongly decreases.

Labeling adhesive

Labeling trial with lupin protein in cooperation with Collodin GmbH:

- **initial tack good**
- **temperature 20-30°C**
- **25.000 bottles/h**

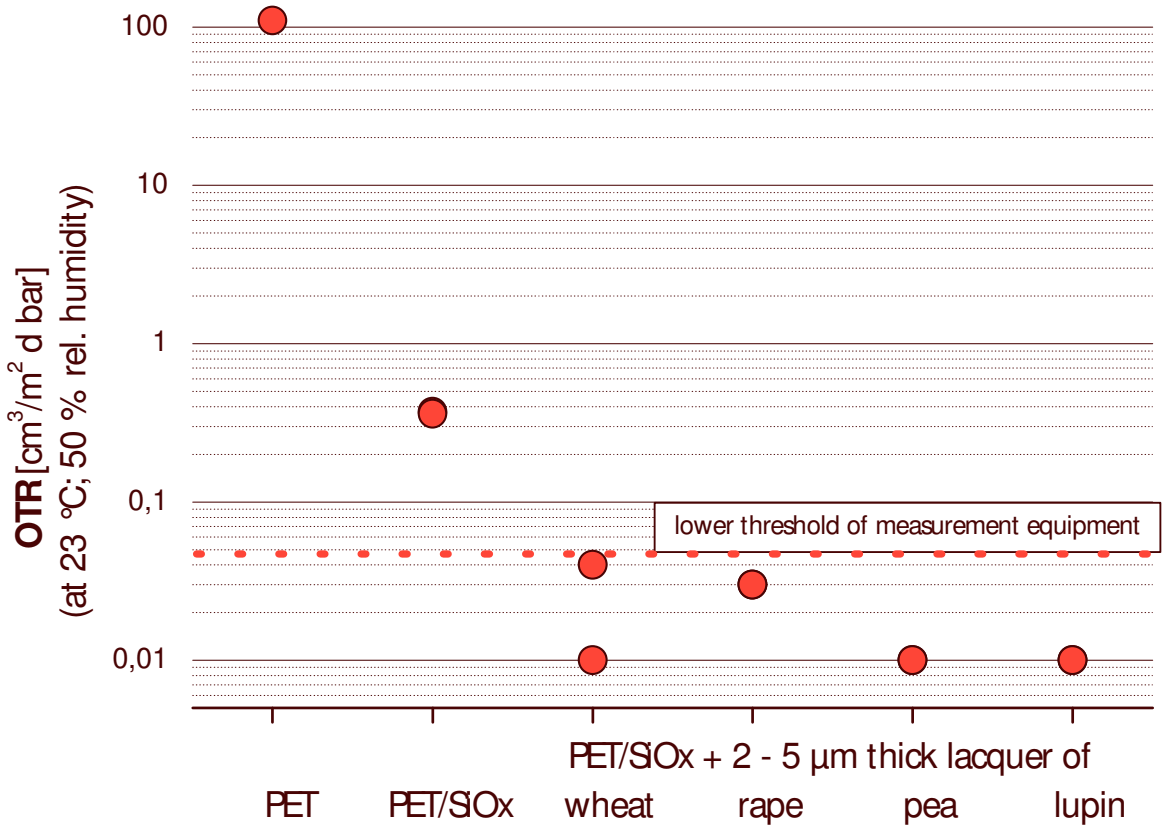
Labeling adhesive

Résumé:

- **Application specific tests proved the advantage of modified proteins.**
- **The pilot trial with native lupin protein proved that e.g. viscosity can be adapted by formulation.**
- **For economic reasons the balance between adaption of properties via modification versus formulation has to be find.**

Oxygen barrier coating

Protein laminating reduced oxygen transmission rate < 0.05 $cm^3/(m^2*d*bar)$.



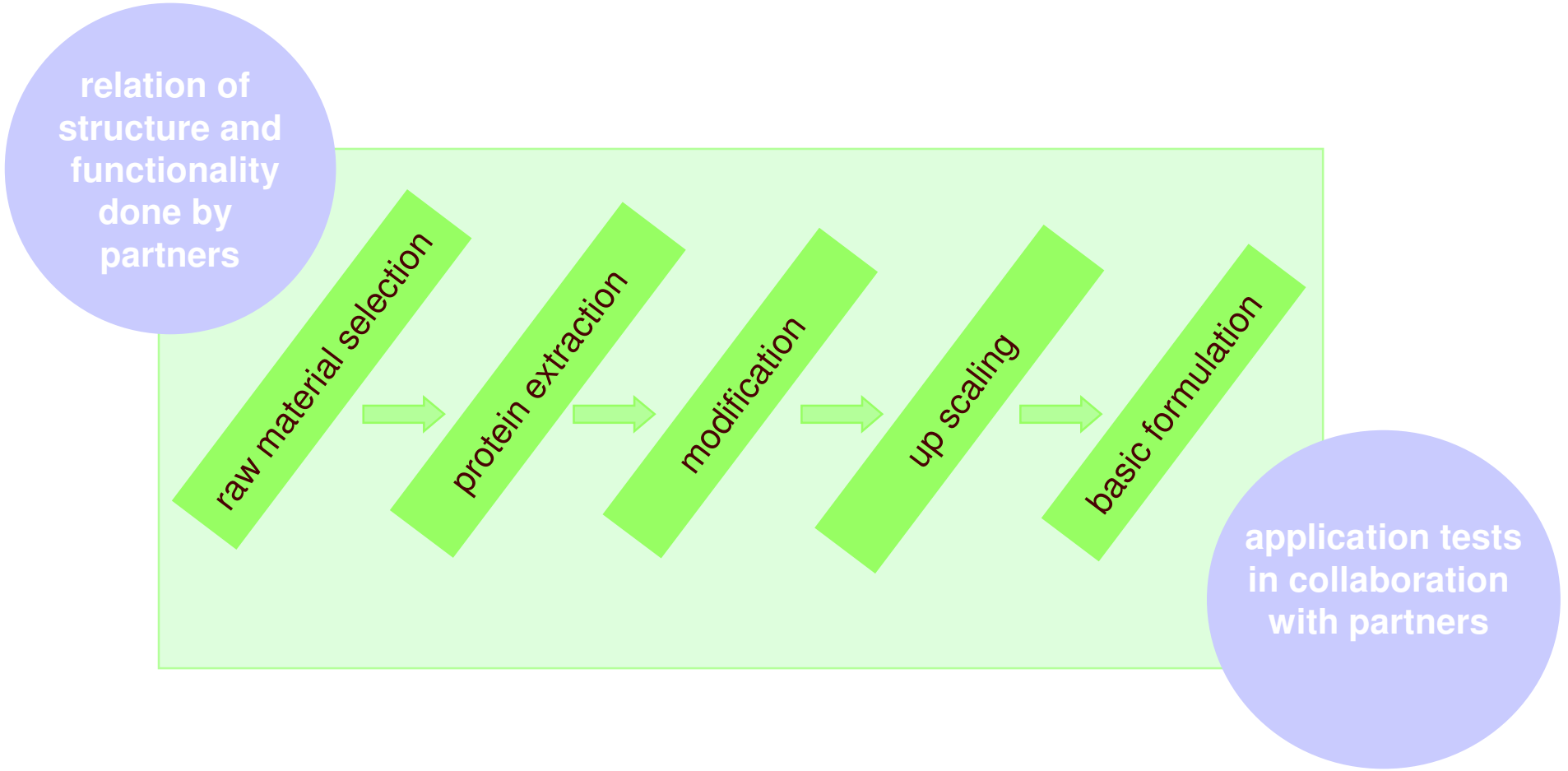
Summary

- **Oxygen barrier coating:**
  The principal technical suitability was proved in lab scale.

- **Adhesives:**
  The principal technical suitability of plant proteins was shown. Further investigations are necessary to develop an optimised strategy for adapting properties via modification in combination with formulation.

- **Paper coating:**
  For succinylated lupin proteins the technical feasibility was shown in a pilot plant run (EU-project FAIR CT 983778). From the economic point of view this application seems to be very prospective, too.

Plant proteins at IVV



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- Bioraf, Denmark
- UPM Kymmene, Finland

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- Federal Ministry of Consumer Protection, Food and Agriculture
- European Community, DGXII

Plant proteins for technical applications

Thank you for your attention!

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