Rape Seed Proteins, 
Current Issues and Future Prospects

Dr. J.-P. Krause, Prof. Dr. J. Kroll*, Dr. F. Pudel

PPM - Pilot Pflanzenöltechnologie Magdeburg e.V., Magdeburg,  
*Universität Potsdam, Germany

jpkrause@ppm-magdeburg.de
Contents

- Seed Structure and Components
- Protein Properties and Interactions
- Basic Concepts for Processing
- PPM - Research Topics
- Summary
Rapeseed Production in Europe

- Rapeseed production in Europe has significantly increased over the years.
- Germany's production is highlighted with red bars.
- The diagram shows a trend of increasing production, especially in the EU-25 and EU-15 regions.
- In 2006, Germany produced approximately 1 Mio. t of protein.
- Overall, EU-25 and EU-15 produced around 3 Mio. t of protein.

Oil and Meal prices:

- There is a notable increase in oil and meal prices over the years.

Rapeseed processing:

- The processing of rapeseed has also been on the rise, as indicated by the green arrow.
Rapeseed Byproducts

2007:

- Processing: 8 Mio t
  - Expeller: 4.5 – 5.0 Mio t
  - Cake: 0.4 – 0.5 Mio t

- Feed: 120 €/t
- Co-ferment: 30 - 100 €/t
- Solid fuels: 80 - 120 €/t
- Proteins: 1 – 4 €/kg
Rapeseed Proteins

Market

- Middle-term interest of oil-mill Industry in value-adding to by-products by protein extraction
- World wide demand in plant proteins
- Highly nutritional and functional potential
- Wide range of food and non-food applications
- Well investigated
- No industrial production of rapeseed proteins!
Seed Structure

Cell dimension: 30 x 20 x 20 µm
## Seed Components

<table>
<thead>
<tr>
<th>Component</th>
<th>Seed %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude oil</td>
<td>39 – 45</td>
</tr>
<tr>
<td>Crude proteins</td>
<td>20</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>22</td>
</tr>
<tr>
<td>Crude fibres</td>
<td>8 – 11</td>
</tr>
<tr>
<td>Ash</td>
<td>4</td>
</tr>
</tbody>
</table>
Phenolics

- Amount: 10-fold of soy
- Free phenolic acids: 73% sinapic acid
- Choline ester - sinapine
- Condensed tannins

- Complexation with proteins via surface phenomena

- Dark colour, bitter taste, astringency

![Sinapic Acid]

Sinapic acid
Phytic acid

- Amount:  
  - 4% in whole rapeseed  
  - 5% in defatted meal  
  - 7% in protein concentrates  
  - 10% in protein isolates

- Binding of essential cations as calcium, magnesium, zinc, iron
- Formation of insoluble, electrostatic complexes with globulin
Glucosinolates

Highly reactive at:
T = r.t.
pH 5 - 9

Activity Optimum:
pH 6.5 – 7.5
T = 30 – 40 °C

Reaction with proteins at:
- SH-groups
- ε-amino groups of lysine
- side groups of tryptophane

Hydrolysis of aliphatic glucosinolates; the breakdown products are toxic to fungi
from: Osbourn (1996)
### Proteins

<table>
<thead>
<tr>
<th></th>
<th>Globulin (Cruciferin)</th>
<th>Albumin (Napin)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isoelectric Point (pH)</td>
<td>7,2</td>
<td>≈ 10</td>
</tr>
<tr>
<td>$S_{20,W}$ (S)</td>
<td>12,7</td>
<td>1,7</td>
</tr>
<tr>
<td>Molecular Weight (g/mol)</td>
<td>280.000-300.000</td>
<td>12.000-17.000</td>
</tr>
<tr>
<td>Subunits</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>$\alpha$-helix %</td>
<td>10</td>
<td>40 – 46</td>
</tr>
<tr>
<td>$\beta$-sheet %</td>
<td>50</td>
<td>12</td>
</tr>
<tr>
<td>Solubility</td>
<td>saline</td>
<td>water</td>
</tr>
</tbody>
</table>
Protein Structure

Globulin (Cruciferin)

“nonpolar-in, polar-out“ rule

Albumin (Napin)
Protein Structure

Elektropherograms (SDS-PAGE)

# Nutritional Potential

Comparison of FAO/WHO/UNO suggested pattern of amino acid requirements with the composition of various protein sources (mg per 100 mg protein)

<table>
<thead>
<tr>
<th>AA</th>
<th>FAO</th>
<th>Beef</th>
<th>Milk</th>
<th>Wheat</th>
<th>Soy</th>
<th>Rape</th>
<th>Cruciferin*</th>
<th>Napin**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lysin</td>
<td>5,5</td>
<td>7,6</td>
<td>7,6</td>
<td>2,3</td>
<td>6,3</td>
<td>5,7</td>
<td>3,45</td>
<td>9,03</td>
</tr>
<tr>
<td>Thr</td>
<td>4,0</td>
<td>4,7</td>
<td>4,3</td>
<td>2,8</td>
<td>4,0</td>
<td>4,8</td>
<td>4,05</td>
<td>3,14</td>
</tr>
<tr>
<td>Cys+Met</td>
<td>3,5</td>
<td>4,2</td>
<td>3,2</td>
<td>3,2</td>
<td>3,6</td>
<td>4,8</td>
<td>1,91</td>
<td>9,18</td>
</tr>
<tr>
<td>Val</td>
<td>5,0</td>
<td>5,3</td>
<td>6,1</td>
<td>4,1</td>
<td>4,8</td>
<td>6,1</td>
<td>6,01</td>
<td>5,51</td>
</tr>
<tr>
<td>Ile</td>
<td>4,0</td>
<td>5,0</td>
<td>5,6</td>
<td>3,7</td>
<td>4,2</td>
<td>4,6</td>
<td>5,23</td>
<td>3,95</td>
</tr>
<tr>
<td>Leu</td>
<td>7,0</td>
<td>8,2</td>
<td>10,1</td>
<td>6,6</td>
<td>7,9</td>
<td>8,5</td>
<td>8,79</td>
<td>8,25</td>
</tr>
<tr>
<td>Tyr</td>
<td>6,0</td>
<td>3,8</td>
<td>4,9</td>
<td>2,5</td>
<td>4,6</td>
<td>3,0</td>
<td>3,2</td>
<td>1,38</td>
</tr>
<tr>
<td>Phe</td>
<td>6,0</td>
<td>4,3</td>
<td>5,1</td>
<td>4,7</td>
<td>6,1</td>
<td>4,7</td>
<td>5,93</td>
<td>3,50</td>
</tr>
</tbody>
</table>

# Nutritional Potential

## Biological evaluation of seed proteins (in % of Casein (C)):

<table>
<thead>
<tr>
<th></th>
<th>PER</th>
<th>% C</th>
<th>NPU</th>
<th>% C</th>
</tr>
</thead>
<tbody>
<tr>
<td>safflower</td>
<td>1.51</td>
<td>60.4</td>
<td>48.52</td>
<td>75.56</td>
</tr>
<tr>
<td>sunflower</td>
<td>1.61</td>
<td>64.4</td>
<td>49.31</td>
<td>72.73</td>
</tr>
<tr>
<td>Linseed</td>
<td>1.59</td>
<td>63.6</td>
<td>47.39</td>
<td>69.9</td>
</tr>
<tr>
<td>rapeseed</td>
<td>1.84</td>
<td>73.6</td>
<td>93.63</td>
<td>138.1</td>
</tr>
</tbody>
</table>

PER... Protein Efficiency Ratio  
NPU... Net Protein Utilization

Functionality
Structure of the Cruciferin

Hydrophobicity
Charge
Amino acids
Adsorption
Adhesion
Glues
Emulsions
Foams
Thin Layers
Gels
Foils
Protein Networks
Cohesion
Film Formation
Degree of unfolding

Functional Potential

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**Functional Potential**

α- and β-Chains

**Modification**
- Physical
- Enzymatic
- Chemical

**Dissociation in Subunits**

**Structures of Interfaces / Formation of Films**

**Stabilisation of Interfaces / Formation of Films**

**Formation of Networks**

**Unfolding of Polypeptid chains**

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Comparison of functional properties of rapeseed and sunflower protein isolates with soy protein isolate (Data of soy were set to be 1.0)

<table>
<thead>
<tr>
<th>Isolat</th>
<th>PDI</th>
<th>Absorption</th>
<th>Emulsion</th>
<th>Foaming</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Water</td>
<td>Fat</td>
<td>Capacity</td>
</tr>
<tr>
<td>Sunflower</td>
<td>0.83</td>
<td>0.65</td>
<td>1.34</td>
<td>1.38</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>0.90</td>
<td>1.57</td>
<td>1.26</td>
<td>0.57</td>
</tr>
</tbody>
</table>

Functional Potential
Gelation of rapeseed proteins

Surface-pressure protein-concentration isotherms for rapeseed proteins

Functional Potential

Film forming behaviour


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Solubility of modified rapeseed protein isolates

- RI succinylated
- RI phosphorylated
- RI acetylated
- RI

pH
Functional Potential

Film forming behaviour modified rapeseed protein isolates


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Sources for **Essential Amino Acids** for food and feed

- **Texturised Proteins**
  - Meat Extenders and Replacers
  - fibers for textiles
- **Emulsions and Foams**
  - Food Dressings
  - Asphalt Emulsions
  - Fire Control Foams
- **Films and Coatings**
  - Fruits Moisture Control
  - roof coatings
  - packaging film
  - leather substitutes
  - particle board
  - plastics
  - polymers
  - adhesives
  - composites
  - nutraceuticals
  - fertilizer
Oil-Protein-Processing

Requirements on meal:

- Retention of a high protein dispersibility index (PDI)
- Low oil and hexane content (<1 %)
- Low amount of minor components
- Particle size < 160 µm
- High protein accessibility
Customary Oil Processing

- **Seed**: 42% oil, 20% crude proteins
- **Cake**: 10-15% oil, 35% crude protein
- **Meal**: <1% oil, 40% crude protein (30-35% hexane)

**Advantages**
- High oil yield
- Facilitated deoildification
- Decrease of toxic components
- High protein content

**Disadvantages**
- Danger of explosion
- Myrosinase activation
- Protein denaturation
- High energy requirements
- Low protein solubility
- Limited markets
- Decreasing prices

**Press**
- Conditioning
- Conditioning

**Extractor**
- Conditioning
- Conditioning
PDI in variously processed rapeseed meals


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# Detoxification

<table>
<thead>
<tr>
<th>Components</th>
<th>Processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myrosinase</td>
<td>Deactivation by temperature, low moisture, pH</td>
</tr>
<tr>
<td>Glucosinolates</td>
<td>Base-catalized degradation using ammonia</td>
</tr>
<tr>
<td>Polyphenols (Sinapine, Tannins)</td>
<td>Pre-extraction with alcohol Membrane processing</td>
</tr>
<tr>
<td>Phytic acid</td>
<td>- Dehulling</td>
</tr>
<tr>
<td></td>
<td>- Pre-extraction at the I.P.</td>
</tr>
<tr>
<td></td>
<td>- High ionic strength</td>
</tr>
<tr>
<td></td>
<td>- Meal treatment with phytase</td>
</tr>
</tbody>
</table>
Oil-Protein-Processing

I. meal
- Desolventiser
- Milling

II. Solid separation
- Alkaline Extraction
- Separation
  - Solids: 80 – 95 %
  - Proteins

III. Protein
- I.P. Precipitation: 25 – 50 %
- UF / DF: 25 – 50 %
- Isolation
- Separation
- Drying
  - Protein Isolate

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PPM - Research Topics

New technique for seed conditioning

Direct extraction of oil from rapeseed
Careful desolventizing / detoxifying process

Membrane processing for protein isolation

1. FEED
2. NON-FOOD
3. FOOD

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1. Rapeseed is a valuable source for highly nutritional and functional proteins and should be used in large scale

2. Protein production from rapeseed especially for human nutrition is much more complicated than from other sources

3. Protein properties can be tailored by the procedure used and modification

4. Breeding and technology are keys for value-added rapeseed processing

5. Rapeseed proteins are „novel foods“
Contact:
PPM Pilot Pflanzenöltechnologie Magdeburg e.V.
Berliner Chaussee 66
39 114 Magdeburg

www.ppm-magdeburg.de

PPM – Pilot Pflanzenöltechnologie Magdeburg e.V.

Gewinnung und Eigenschaften von Rapsprotein

Dr. J.-P. Krause
Prof. em. Dr. J. Kroll (Universität Potsdam)
Dr. H. M. Rawel (Universität Potsdam)

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