Vegetable protein processing

Joosep Masik
What we’ll talk about today

- Agenda

- Vegetable protein potential
- Types of raw materials
- Oilseed crop pre-treatment and basic process
- Starch crop pre-treatment and basic process
- Solutions for effluent management
- Why Alfa Laval?
Vegetable protein potential
- Market growth and source diversity

• Plant-based protein market expected to reach $16.3 billion by 2025
• Plant-based protein market CAGR of 5.7% between 2017–2025
• Ahead: More diverse plant-based protein sources with various by-products

Source: European Vegetable Protein Association

Protein types as % of new F&B launches tracked with plant-based protein (EU, 2017)

Types of vegetable protein feedstocks

Raw material

Oilseeds

Starch crops
Conventional processing of oilseeds

Oilseed

Oil – high value in very high demand for food uses

Meal – low value and used as animal feed
Oilseeds

- Extracting protein out of the meal by-product

• Instead of animal feed, high protein products (approx. 80%) and low fibre products (less than 5%) could be produced for human consumption

• Potential feedstocks for oilseed vegetable protein production: soybean, sunflower, rapeseed, cottonseed, lupin, and linseed

• De-oiled meal as raw material – focus on oil extraction conditions
Oilseed processing
- Potential raw material for vegetable protein found in meal

- Processing 1,000 kg of sunflower seeds yields:
  - 428 kg oil
  - 433 kg meal
  - Meal protein content ≈ 32%

- This translates into 138 kg of pure protein that could be recovered

Mean composition of sunflower cake

<table>
<thead>
<tr>
<th>Component</th>
<th>Mean composition (%)</th>
<th>Data from different publications* (%)</th>
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<tbody>
<tr>
<td>Moisture</td>
<td>9.0</td>
<td>8.0–9.0–10.4</td>
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<tr>
<td>Dry matter</td>
<td>91.0</td>
<td>91.0–92.0–89.6</td>
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<tr>
<td>Crude proteins</td>
<td>32.0</td>
<td>29–34–32</td>
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<tr>
<td>Crude lipids</td>
<td>1.5</td>
<td>1.15–2.00</td>
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<tr>
<td>Ash</td>
<td>6.5</td>
<td>6.0–4.3–6.6–7.1</td>
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<tr>
<td>Total phenolics</td>
<td>3.5</td>
<td>3.4–2.4–4.7</td>
</tr>
<tr>
<td>Crude fibre</td>
<td>41.0</td>
<td>29–50–43</td>
</tr>
<tr>
<td>Lignin</td>
<td>26.8–8.4</td>
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<tr>
<td>Hemicelluloses</td>
<td>13.0</td>
<td>12.6–12.9</td>
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<tr>
<td>Cellulose</td>
<td>23.0</td>
<td>22.9–22.5</td>
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* Boni et al. (1987), Bautista et al. (1990), Parrado and Bautista (1993), Dominguez et al. (1995), Ramachandran et al. (2007) and Genèue-Sbartaï et al. (2008)

Source: AOCS

Source: Anne Lomascolo et al. (2012)
Oilseed processing

- Typical process to pretreat sunflower seeds for vegetable protein extraction

1. Dehulling
2. Pressing
3. Solvent extraction and desolventization
4. White flakes
5. Oil
6. Shells
7. Oilseed

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Alfa Laval oilseed technology

- Extracting protein, fibre and sugar syrup from oilseed white flakes

Oilseed white flakes → Protein
Oilseed white flakes → Fibre
Oilseed white flakes → Oligosaccharides syrup
Oilseed process

- Typical flow chart for vegetable protein processing
Starch crops

- Vegetable protein processing

• Besides vegetable protein manufacturing, focus is also on food- or technical grade starch and, in some cases, food-grade fibre production

• Potential feedstocks: yellow pea, faba bean, mung bean, chickpea, lentil, etc.

• Milled flour, either hulled or dehulled, as raw material
Starch crop process

- Fractionation of yellow peas into starch, protein and fibre

- Raw material
- Dehulled raw material
- Hulls
- Flour
- Starch
- Protein isolate
- Fibre
Starch crop process
- Typical process

Lye solution  →  Flour

<table>
<thead>
<tr>
<th>Concentrator</th>
<th>Clarifier</th>
<th>Extraction decanter</th>
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<tr>
<th>Protein decanter</th>
<th>Acid</th>
<th>Water</th>
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<th>Starch washing</th>
<th>Water</th>
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<th>Fibre screen</th>
<th>Fibre</th>
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<table>
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<tr>
<th>Protein isolate</th>
<th>Process water</th>
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<table>
<thead>
<tr>
<th>Starch</th>
<th>Water</th>
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Fibre screen
Heat treatment of protein
- Pasteurization systems before drying

- UHT-type at high temperature and short residence time
- The protein is rapidly heated and cooled
- Limited protein denaturation
Foodec decanter centrifuge

- Key values

- High-performance two-phase separation for vegetable protein applications
- Easy control
- Cleanability: Fully CIP-able, automatic CIP sequences
Pressurized liquid discharge

- Paring disc

- Reduces foam formation
- Closed and pressurized liquid discharge (up to 5 bar)
- Limits air uptake in decanter
Challenges in protein isolate production

- Wastewater treatment
- Protein wet fractionation process uses high volumes of water
  - 1:18 for oilseed crops
  - 1:6 for starch crops
- Ambition is to reduce water intake
Possibilities for whey treatment

- Recovery of water and valuable by-products

Evaporation systems

Membrane systems
Possibilities for whey treatment
− Recovery of water and valuable by-products

Evaporation systems

• Efficient thermal or mechanical vapor compression systems
• Compact and simple to install
• Well proven in handling highly viscous process liquids
• Easy to adjust capacity by modifying the number of plates
• Heat exchanger design prevents fouling
• Long processing times and less downtime
Possibilities for whey treatment

- Recovery of water and valuable by-products

- Highly selective ultrafiltration and diafiltration membranes that capture and purify proteins

- Reverse osmosis membranes
  - Recover more water by treating condensate from evaporator or permeate from ultrafiltration system
  - Reduce hydraulic load on wastewater plant
  - Reduce freshwater intake
Whey processing

- Example for process

Whey → Coagulation decanter → Evaporation system → Membrane system → Effluent to wastewater treatment plant

Whey 

Steam

Coagulated protein

Concentrate

Recovered water

Effluent to wastewater treatment plant
Whey processing
- Example for a syrup process

Whey → Ultrafiltration membrane → Nanofiltration membrane → Ion exchange → Reverse osmosis membrane → Evaporation system → Condensate

Whey → Water-soluble protein → Effluent → Salts → Recovered water → Syrup

- Soluble protein
- Effluent
- Salts
- Recovered water
- Syrup
Hygiene and Cleaning-in-Place

- Broad portfolio of Alfa Laval hygienic components such as pumps, valves, pipes, and fittings
- Alfa Laval process lines are designed with hygiene in mind
- Fully automatic efficient CIP systems
- Ensure consistently high quality of the final product
Why Alfa Laval?

- World leader in separation equipment and wet fractionation
- Holistic approach to complete wet processing line
- Solutions to reduce water use in protein wet fractionation
- Pilot-scale feedstock testing at Alfa Laval’s testing facility
- Case-by-case approach to different raw materials
Alfa Laval Innovation & Test Centre

– Case story with sunflower

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## Alfa Laval vegetable protein systems

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<tr>
<th>Separation equipment</th>
<th>Thermal equipment</th>
<th>Flow equipment</th>
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<tr>
<td>Decanters</td>
<td>Heat exchangers</td>
<td>Agitators</td>
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<tr>
<td>Separators</td>
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<td>Hygienic pumps</td>
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<td>Evaporators</td>
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<td>Hygienic valves</td>
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<tr>
<td>Starch equipment</td>
<td>Direct steam injection</td>
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<td>Membranes</td>
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References

- More than 180 decanters working in various vegetable protein process lines
- More than 50 different wet milling process lines supplied for different feedstocks