Cultivation Of Protein Crops – Possibilities And Challenges In Northern Europe

PLANT PROTEINS IN FOOD AND DIETS” CONFERENCE
SORØ, DENMARK MAY 21, 2019
Protein crops for northern Europe - Denmark

- Protein crops are crops that provide substantial protein, a large class of naturally occurring complex combinations of amino acids.
- Important protein crops are the pulses as well as soya, rapeseed and sunflower.
- The FAO notes that the term "pulses" is limited to legumes harvested solely for dry grain, thereby excluding legumes that are harvested green for food (green peas, green beans, etc.) which are classified as vegetable crops.
- Cultivation of field peas, faba bean and lupine provides a good cool-season alternative for regions not suited for growing soybeans due to their climate conditions, as peas, faba bean and lupine are less sensitive to frost and long days and thus may tolerate low temperatures and high latitudes for germination and growth.
**Faba beans** (*vicia faba*)

Faba beans, also known as fava beans, field beans, horse beans, broad beans or tick beans, represent an annual legume that is well adapted to cool climates, and thus is preferably cultivated in regions with mild winters and adequate summer rainfall.

According to their seed size, *Vicia faba* can be classified in three subspecies:

- *Vicia faba minor* (small seeded),
- *Vicia faba major* (large seeded) and
- *Vicia faba equina* (intermediate seed size).
Faba beans in Denmark, organic plus conventional, ha

- 2009: Faba beans organic: 1000 ha, Faba beans conventional: 1000 ha
- 2010: Faba beans organic: 2000 ha, Faba beans conventional: 2000 ha
- 2011: Faba beans organic: 3000 ha, Faba beans conventional: 3000 ha
- 2012: Faba beans organic: 4000 ha, Faba beans conventional: 4000 ha
- 2013: Faba beans organic: 5000 ha, Faba beans conventional: 5000 ha
- 2014: Faba beans organic: 6000 ha, Faba beans conventional: 6000 ha
- 2015: Faba beans organic: 7000 ha, Faba beans conventional: 7000 ha
- 2016: Faba beans organic: 8000 ha, Faba beans conventional: 8000 ha
- 2017: Faba beans organic: 9000 ha, Faba beans conventional: 9000 ha
- 2018: Faba beans organic: 10000 ha, Faba beans conventional: 25000 ha

Total for 2018: Faba beans organic: 10000 ha, Faba beans conventional: 25000 ha
Field pea (*Pisum sativum*)

Field pea *Pisum sativum* (L.), is widely adapted to cooler climates. The major pea producers are Canada, parts of Europe, the United States, and Australia.

Pea is used as animal feed as a grain crop and human food, both as a grain crop and as a popular vegetable.
Field peas in Denmark, 1950-2018, ha
Lupins (*Lupinus albus, Lupinus angustifolius, Lupinus luteus*)

Cultivated species of include white lupin (*Lupinus albus*), narrow-leafed lupin (*Lupinus angustifolius*) and yellow lupin (*Lupinus luteus*), and they all originate from the Mediterranean area.

Lupins used as feed ingredient for pigs, ruminants and poultry mainly and to a lesser extent as a food (or food ingredient).
Chemical composition of untreated peas, lupines and faba beans

- **Peas**
  - Crude protein: 300 g kg\(^{-1}\) DM
  - Crude fat: 100 g kg\(^{-1}\) DM
  - Crude fibre: 100 g kg\(^{-1}\) DM
  - Starch: 200 g kg\(^{-1}\) DM

- **Lupins**
  - Crude protein: 400 g kg\(^{-1}\) DM
  - Crude fat: 50 g kg\(^{-1}\) DM
  - Crude fibre: 100 g kg\(^{-1}\) DM

- **Faba beans**
  - Crude protein: 350 g kg\(^{-1}\) DM
  - Crude fat: 50 g kg\(^{-1}\) DM
  - Crude fibre: 100 g kg\(^{-1}\) DM
  - Starch: 200 g kg\(^{-1}\) DM
Yield: Spring barley, field peas and faba beans. Variety trials 2010-2018

- Spring barley: 62.3, 70.4, 66.8, 62.3, 73.8, 75.8, 73.7, 72.3, 70.0
- Field peas: 42.9, 48.0, 46.1, 51.9, 47.1, 51.5, 53.5, 44.6, 49.9
- Faba beans: 42.4, 40.7, 49.0, 53.3

Average yields:
- Spring barley: 64.7
- Field peas: 46.8
- Faba beans: 53.3
International and national focus on protein crops and pulses
The global protein challenge

- Paris Climate Agreement: < 2,0 °C
- Agriculture crops and cattle ranching drives deforestation, which is associated with the climate change problem
- Production of soy outside the EU is associated with sustainability issues
- Agriculture production has negative ecosystem effects
- How to feed more than 9 billion people in 2050 in a sustainable way?
- Increased demand for feed and food proteins
The global protein challenge

- Why this global attention on protein crops and pulses?
- What is the challenge?
- Does our production and intake of animal and plant-based protein have anything to do with the global protein challenge?
- Can we change crops and farming systems to address the protein challenge here in northern Europe?
Agricultural land is a limited resource

Agricultural area per capita

Agricultural land area per capita, measured in hectares per person. The UN Food and Agricultural Organization define 'agricultural area' as the sum of arable land, permanent crops, permanent meadows and pastures.

Source: Agricultural area per capita - FAO (2017)
Agricultural land is a limited resource

Global surface area allocation for food production

The breakdown of Earth surface area by functional and allocated uses, down to agricultural land allocation for livestock and food crop production, measured in millions of square kilometres. Area for livestock farming includes grazing land for animals, and arable land used for animal feed production. The relative production of food calories and protein for final consumption from livestock versus plant-based commodities is also shown.


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The data visualization is available at OurWorldinData.org. There you find research and more visualizations on this topic.
Animal protein production require a lot of land

Land use per gram of protein, by food type
Average land use area needed to produce one unit of protein by food type, measured in metres squared (m²) per gram of protein over a crop’s annual cycle or the average animal’s lifetime. Average values are based on a meta-analysis of studies across 742 agricultural systems and over 90 unique foods.

Source: Environmental footprint by food type (protein) - Clark & Tilman (2017) OurWorldInData.org/yields-and-land-use-in-agriculture/ • CC BY
The international climate goals and protein production

Greenhouse gas emissions per gram of protein, by food type

Average greenhouse gas emissions per unit protein, by food type measured in grams of carbon dioxide equivalents (CO₂e) per gram of protein. Average values are based on a meta-analysis of studies across 742 agricultural systems and over 90 unique foods.

<table>
<thead>
<tr>
<th>Food Type</th>
<th>CO₂e (g/gram protein)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef/Mutton</td>
<td>221.63</td>
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<tr>
<td>Fresh Produce</td>
<td>37.17</td>
</tr>
<tr>
<td>Pork</td>
<td>36.33</td>
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<tr>
<td>Dairy</td>
<td>35.07</td>
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<td>Poultry</td>
<td>31.75</td>
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<tr>
<td>Eggs</td>
<td>24.37</td>
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<tr>
<td>Rice</td>
<td>21.16</td>
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<tr>
<td>Wheat</td>
<td>4.62</td>
</tr>
<tr>
<td>Maize</td>
<td>4.42</td>
</tr>
<tr>
<td>Pulses</td>
<td>0.58</td>
</tr>
</tbody>
</table>

Source: Clark & Tilman (2017)

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The world is not enough!

Dietary land use vs. beef consumption, 2011

The percentage of global habitable land area needed for agriculture if the total world population was to adopt the average diet of any given country versus annual per capita beef consumption, measured in kilograms per year. We currently use approximately 50% of habitable land for agriculture, as shown by the grey horizontal line.

Source: Food Balance Sheets - FAO (2017), HALF Index (Land Use) - Alexander et al. (2016)
OurWorldInData.org/meat-and-seafood-production-consumption/ • CC BY
We have a low consumption of pulses in northern Europe

Average per capita supply of pulses
Per capita supply of pulses crops, measured in kilograms per person per year. Food supply denotes food availability at the consumer level prior to any wastage at the household or consumer level.

Source: Food Balance Sheets - FAO (2017)
OurWorldInData.org/wp-content/uploads/2013/11/ourworldindata_gdp-ppp-per-capita-750x524.png • CC BY
Pulses are minor crops

Global agricultural land use by major crop type
Global land area used for agricultural production, by major crop category, measured in hectares.

Source: Global agricultural land by crop - FAO (2017)

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Global advantages for agricultural production - simplistic

Starch - cereals

Proteins - soya
EU use of proteins and their sources (in million tonnes of crude protein)

In 2016/17, the EU demand for plant proteins amounted to around 27 million tonnes of crude protein.

The feed market is by far the most important outlet (93 % in volume) and mainly supplied by oilseed meals.
Food segment

- Human plant protein intake is on the rise in many EU regions, especially in western and northern Europe.
- Particularly promising is the market for meat and dairy alternatives, with annual growth rates of 14% and 11% respectively.
- This segment is no longer a niche market, as major food companies enter the market, and major retailers under their own brands.
- Around 90% of meat alternatives are consumed by flexitarians.
EU member states’ area shares for protein crops in 2017
Use of field pea, faba bean and lupine in Denmark

Primary use:
- As a protein rich crop for feeding of pigs, cows and other farm animals

New increased interest:
- Arla Foods (the largest producer of dairy products in Scandinavia) focus on non-GMO feed for the production of dairy products
- Focus on locally produced and documented feed traceability (Produce traceability)
- General focus on reduction in imports
- Climate footprint

Other interesting uses of pulses:
- For fish and other non-traditional productions
- For direct human consumption
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Agronomic, environmental and climate benefits of pulses

**Benefits**
- Nitrogen fixation crops
  - *Rhizobia* bacteria in root nodules
- Higher yields in preceding cereal crop (up to 10%)
  - Disease break in cereals and oilseed rape
  - Can improved soil fertility
- Reduction of grass weeds
- Positive effect on biodiversity in low-input agricultural systems
  - good opportunity for pollinating and other beneficial insects
- Can spread the workload

**Challenges**
- Variable yield
- Yield gap to competing crops
  - e.g. wheat
- Sensitive to several pests and diseases
  - Demanding pest and diseases control
- Little agronomic expertise
- Environmental benefits are not guaranteed
- Later sowing of winter wheat after faba bean
- Bad reputation among some farmers
Challenges when growing faba beans in Denmark

- The field must have a:
  - Good water supply – clay soil or irrigated sandy soils
  - Healthy soil structure
  - Low weed pressure at sowing
- Efficient control of pest
  - Pea leaf weevil from 2-4 leaf stage of development:
  - Black bean aphid from start flowering
  - Broad bean weevil from beginning of pod formation
- Efficient control of diseases
  - Chocolate spot, ascochyta blight and broad bean rust
- Multiple number years between pulses in the rotation
  - Minimum 4-5 years
- Late harvest
  - September or October
NORFAB (NORthern FABa); faba bean.

- Researchers from Aarhus University and the University of Copenhagen will now together with Danish plant breeders and researchers from Finland, England and Canada produce new types of beans in Denmark, Northern Europe and North America that will make it economically favourable to produce faba bean protein locally rather than to import soybean protein.

- Goal:
  - Earlier varieties
  - Higher yielding varieties
  - Quality – protein content, content of tannins, vicin and convicin
  - Disease resistant varieties
  - To cultivate 100,000 hectares of beans in Denmark
Challenges when growing field pea and lupine in Denmark

**Field pea**
- Well known crop
- The most grown crop historically in Denmark
- OK yield, but very varying from year to year
- Field peas haven’t generally been able to compete with spring barley

**Lupine**
- Well known crop
- Yield to low
- Interest in organic production
- Very low acreage and yield with the present varieties
- Limited plant breeding activities
Last statement – all crops are potential protein sources

Protein yield per hectare in Danish crops

- Oats
- Rye
- Spring barley
- Oil seed rape
- Wheat
- Field peas
- Lupins
- Faba beans
- Clover grass
- Lucerne
- Red clover

Kg protein pr. ha

0 500 1.000 1.500 2.000 2.500 3.000
Acknowledgement

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