Novel European protein sources for livestock

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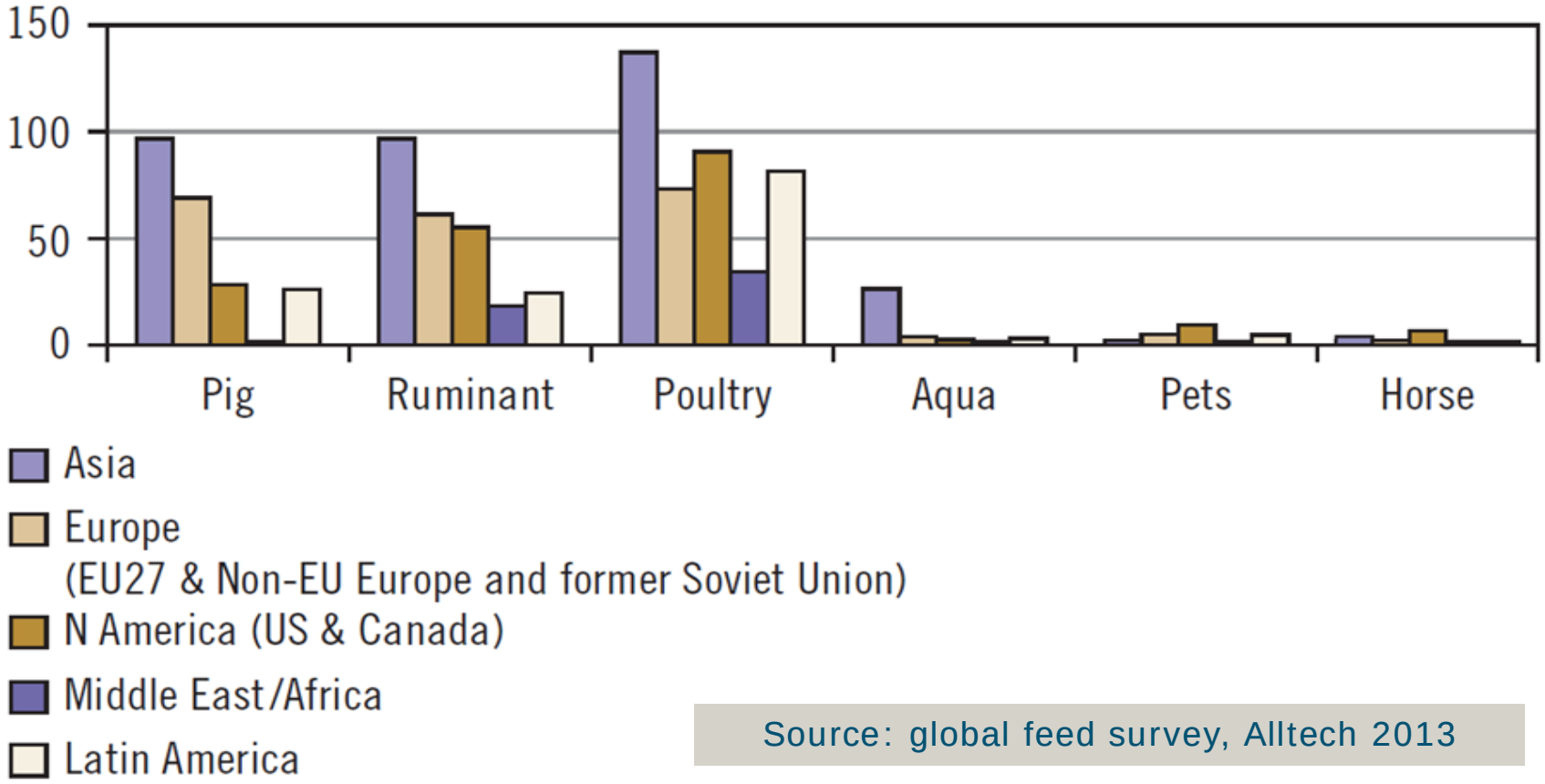
Current global feed consumption

- Estimated: 950 million ton manufactured feed in total
- Prospect: 1500 million ton in 2050

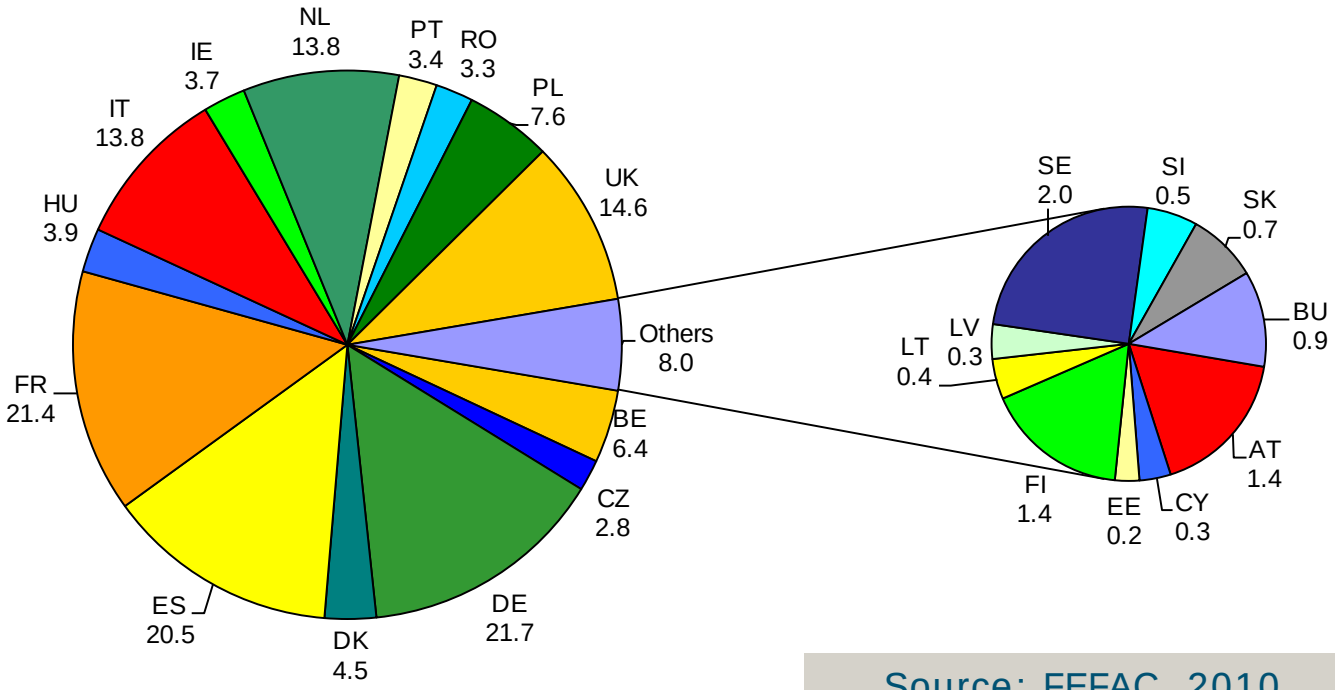
Feed tonnage per region per species (million ton, 2012)



Source: global feed survey, Alltech 2013

Compound feed production in EU-27

- Estimated at 150 million tons
  - Pig 35%, Poultry 33%, Cattle 25%, Other 7%



Source: FEFAC, 2010

Reasons for European protein production?

- 70% of protein-rich feed ingredients in EU imported !!
  - Pact of “Den Bosch” in the Netherlands: decrease this to 50% in 2020
- Concerns about large imports of soybean products from South-America (42 million ton in 2009):
  - EU: too much dependent from S-America (European Parliament)
  - Deforestation of tropical rain forest, loss of biodiversity, soil and water pollution, negative impact on small farmers and native population (NGO’s)
  - Societal debate on GMO versus non-GMO crops

Factors limiting the use of novel feed resources in feed formulation

- Nutritional aspects
  - variability in nutrient level and quality
  - presence of naturally occurring anti-nutritional and/or toxic factors
  - presence of pathogenic micro-organisms
  - need for supplementation
- Technical aspects
  - seasonal and unreliable supply (need for storage)
  - bulkiness, wetness and/or powdery texture
  - processing requirements
  - lack of research and development efforts

Source: Ravindran & Blair, 1991

Considerations for alternative proteins

- ‘Alternative’ = replacement of soybean products from South America
- Considerations:
  - Good growth potential under climate conditions in N/W Europe
  - Applicable in diets for (young) pigs and poultry
  - Addition in organic diets allowed
  - Need for further processing?
  - Conflicts with current legislation?
  - Long term availability for feed (vs. food)
  - Sustainability aspects (CO_2-equivalents)
  - No focus on ingredients that are already current practice

List of ingredients that meet the criteria

Category	Protein source
Oil seeds	Proteins of soybeans, rapeseed and sunflower seed, after oil removal
Grain legumes	Peas, field beans, lupine, chickpeas, and their concentrates
Forage legumes	Lucerne (alfalfa)
Leaf proteins	Grass, sugar beet leaves
Aquatic proteins	Algae, both macro- (seaweed) and microalgae, duckweed
Cereals and pseudo cereals	Protein concentrates from oat and quinoa
Insects	E.g. mealworm, housefly

Crop and protein yield per hectare

	Protein content	Yield in EU conditions (DM/ha/y)	Protein yield (ton/ha/y)
Oil seeds – soybean	40%	1.5-3 tons	0.6-1.2 tons
Oil seeds – rapeseed	25%	3 tons	0.75 ton
Oil seeds – sunflower	23%	3 tons	0.7 ton
Legumes (pulses) – peas/beans/ lupine	17-35%	4-6 tons	1-2 tons
Legumes (forage) – lucerne	19%	13 tons	2.5 tons
Cereals – oat	12-15%	3-5 tons	0.4-0.75 ton
Pseudo cereals – quinoa	12-18%	3 tons	0.4-0.5 ton
Leaves – grass	12%	10-15 tons	1.2-2 tons
Leaves – (e.g. sugar beet leaves)	12%	4.5 tons	0.5 ton
Macro algae - seaweed	10-30%	25 tons	2.5-7.5 tons
Micro algae	25-50%	15-30 tons	4-15 tons
Duckweed	35-45%	30-40 tons	10-18 tons

Assessment of alternative protein sources

Protein yield (kg protein / ha)

- = < 500 kg/ha;
+/- = 500 – 1000 kg/ha;
+ = 1000 – 2000 kg/ha;
++ = > 2000 kg ha

Protein value

- = Protein digestibility < 75%
+/- = Protein digestibility > 75% and < 80%
+ = Protein digestibility > 80% and < 85%
++ = Protein digestibility > 85%

Sustainability (Carbon FootPrint; Landuse and Landuse change Luluc); N-requirement)

- = CFP > 1000 CO_2-eq; LuLuc > 1000 CO_2-eq; N-efficiency > 50 g N/kg yield
+/- = CFP > 500 CO_2-eq; LuLuc > 500 CO_2-eq; N-efficiency > 25 g N/kg yield
+ = CFP > 250 CO_2-eq; LuLuc > 250 CO_2-eq; N-efficiency > 10 g N/kg yield
+/+ = CFP < 250 CO_2-eq; LuLuc < 250 CO_2-eq; N-efficiency < 10 g N/kg yield

Availalability in the EU

- = > 10 years
+/- = 5 – 10 years
+ = 0 – 5 years
+/+ = currently available

Applicable in organic diets

- = no
+ = yes

Assessment of criteria (1)

	Protein yield (kg/Ha)	Protein Digestibility (%)	Carbon Footprint (CO_2-eq)	Luluc (CO_2-eq)	N-input (kg) / kg yield	Availability In EU on short term	Applicable In organic diets
Oil seeds							
Soybean meal EU	+	+/+	+/-	+	+	+/-	-
Soybean concentrate EU	+	+/+	+/-	+	+	+/-	+
Rapeseed meal	+/-	+/-	+/-	+/+	-	+/+	-
Rapeseed concentrate	+/-	+/-	+/-	+/+	-	+/+	+
Sunflower meal	+/-	+	+	+	+	+/+	-
Sunflower concentrate	+/-	?	+	+	+	-	+
Grain legumes							
Pea	+	+/+	+/-	+/-	+	+/+	+
Pea concentrate	+	+/+	+/-	+/-	+	+/+	+
Vicia Faba	+	+/-	+/-	+	+	+/+	+
Vicia Faba concentrate	+	+/+	+/-	+	+	+	+
Lupine	+/-	-	+/-	-	+	+/+	+
Lupine concentrate	+/-	?	+/-	-	+	+	+
Chickpea	-	+/-	?	?	?	+/-	+

Assessment of criteria (1)

	Protein yield (kg/Ha)	Protein Digestibility (%)	Carbon Footprint (CO_2-eq)	Luluc (CO_2-eq)	N-input (kg) / kg yield	Availability In EU on short term	Applicable In organic diets
Oil seeds							
Soybean meal EU	+	+/+	+/-	+	+	+/-	-
Soybean concentrate EU	+	+/+	+/-	+	+	+/-	+
Rapeseed meal	+/-	+/-	+/-	+/+	-	+/+	-
Rapeseed concentrate	+/-	+/-	+/-	+/+	-	+/+	+
Sunflower meal	+/-	+	+	+	+	+/+	-
Sunflower concentrate	+/-	?	+	+	+	-	+
Grain legumes							
Pea	+	+/+	+/-	+/-	+	+/+	+
Pea concentrate	+	+/+	+/-	+/-	+	+/+	+
Vicia Faba	+	+/-	+/-	+	+	+/+	+
Vicia Faba concentrate	+	+/+	+/-	+	+	+	+
Lupine	+/-	-	+/-	-	+	+/+	+
Lupine concentrate	+/-	?	+/-	-	+	+	+
Chickpea	-	+/-	?	?	?	+/-	+

Assessment of criteria (2)

	Protein yield (kg/Ha)	Protein Digestibility (%)	Carbon Footprint (CO_2-eq)	Luluc (CO_2-eq)	N-input (kg) / kg yield	Availability In EU on short term	Applicable In organic diets
Forage legumes							
Lucerne	+/+	-	-	+	+	+/+	+
Leaf proteins							
Grass protein	+	-	+/-	-	-	+	+
Sugar beet leaf protein	-	-	+/+	+/+	+/+	+/-	+
Aquatic proteins							
Algae	?	?	-	+/+	?	+/-	?
Seaweed	+/+	-	-	+/+	+/+	-	?
Duckweed	+/+	?	-	+/+	?	+	?
Cereal concentrates							
Oat protein	-	+/-	+	+	-	?	+
Quinoa protein	+/-	?	?	?	?	?	+
Insects	+/+	+/-	?	+/+	+/+	+/-	?

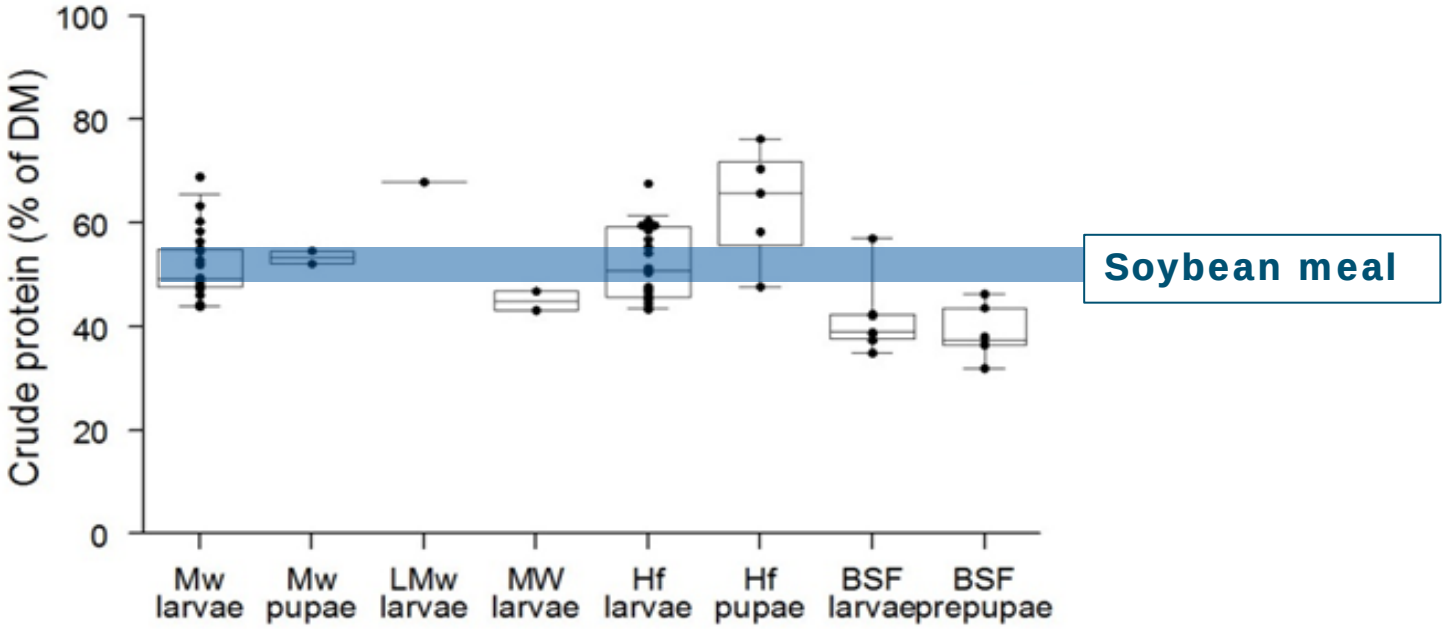
Assessment of criteria (2)

	Protein yield (kg/Ha)	Protein Digestibility (%)	Carbon Footprint (CO_2-eq)	Luluc (CO_2-eq)	N-input (kg) / kg yield	Availability In EU on short term	Applicable In organic diets
Forage legumes							
Lucerne	+/+	-	-	+	+	+/+	+
Leaf proteins							
Grass protein	+	-	+/-	-	-	+	+
Sugar beet leaf protein	-	-	+/+	+/+	+/+	+/-	+
Aquatic proteins							
Algae	?	?	-	+/+	?	+/-	?
Seaweed	+/+	-	-	+/+	+/+	-	?
Duckweed	+/+	?	-	+/+	?	+	?
Cereal concentrates							
Oat protein	-	+/-	+	+	-	?	+
Quinoa protein	+/-	?	?	?	?	?	+
Insects	+/+	+/-	?	+/+	+/+	+/-	?

Insects as protein source

- Insects are able to grow on waste substrates
- Insects are cold-blooded and efficient in converting substrates into protein
- Insects are protein (and fat) rich ingredients

Nutritional characteristics insects



- Crude protein content meal worms and housefly ≥ soybean meal (DM base)
- Dry matter content ranges between 35 – 45%
- Fat content ranges between 4% and 46% of DM

Conclusions (1)

- European cultivated soybeans seems most promising alternative for South American soybeans
  - crop yield needs to increase to 5 ton/ha
  - 10 years of plant breeding required?
- Peas most promising alternative for the short-term?
  - Plant is sensitive for pathogens and pests
  - Pea protein concentrate -> organic diets
- Lucerne has high protein yield/ha
  - Nutritional value is low for mongastrics
  - Drying requires energy (Carbon footprint)

Conclusions (2)

- Leaf proteins probably potential in long term
  - Cost effective protein extraction technique
  - Determination of nutritional value
- Aquatic proteins potentially interesting (low land use, protein yield/ha)
  - Determination of nutritional value
  - Energy costs for drying/biorefinery
- Insects possible alternative in long term (low land use, conversion of wastes)
  - Need for reducing costs of production
  - Legislative aspects
  - Determination of nutritional value

Acknowledgement:
all colleagues involved in:

- *Cultivation, processing and nutritional aspects for pigs and poultry of European protein sources as alternatives for imported soybean products* (Van Krimpen et al., 2013)

- *Insects as a sustainable feed ingredient in pig and poultry diets – a feasibility study* (Veldkamp et al., 2012)

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