Alternative Source for Protein Production

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Abstract
There has been a general increase in feed production, which needs to be funded more costly every year. The majority of proteins used in European feed is acquired overseas. In 2011 already, the European Parliament appeared uneasy in terms of the growing dependence from South American imports (soybeans) in the sector and NGOs observed the ecological consequences of the protein production (deforestation of tropical rain forest, water pollution etc.) critically. Options will be presented to increase the European protein production for feed. Soybeans, cultivated in Europe, would be the most promising long-time alternative. Other particular sustainable feeding options would include algae, and meat and bone meal. Potentially, also leaf proteins, aquatic proteins and insects could be suitable in the long term, given that their nutritional value could be determined. As a short-term alternative, peas are a possible protein source, although the plants were very sensitive for pathogens and pests.

Introduction
The total EU protein crop production (e.g. legumes, soybeans) currently occupies only 3% of the EU's arable land (Euractiv, 2011). In 2014, 34 million tonnes of soybeans and soybean cakes, equivalent to 14.3 million ton protein, were imported in the EU (FEFAC, 2015). These protein sources mainly originated from Latin America. In terms of land use abroad, these imports represent 10% (20 million ha) of the EU's arable land (Euractiv, 2011).
There are increasing concerns about the amount of imported feed proteins from outside the EU. The reasons of concern differ between stakeholders, e.g. governments, NGO's, and consumers. In 2011, The European Parliament adopted a resolution on 'the EU's protein deficit', putting forward a series of measures to reduce the dependency on imports of protein crops for animal feed, primarily from the US, Argentina, and Brazil (Euractiv, 2011). The European Parliament is concerned that such massive dependency on imports makes the EU livestock sector extremely vulnerable to price volatility and trade distortions, causing feed price to rise, thereby increasing farmers' production costs and reducing the sectors' profitability. A major concern of NGO's is the deforestation of tropical rain forest, to fulfil the need of arable land for soybean cultivation (WNF, 2011; Van Gelder and Kuepper, 2012). As a consequence of conversion of natural ecosystems into agriculture, the rate of biodiversity loss (proportion of extinct species) increases, whereas the current status has already more than ten times exceeded the proposed boundary (Rockström et al., 2009). Moreover, large scale soybean cultivation may increase water and soil pollution, and drive small farmers and the native population out of business (WNF, 2011). Other reasons for enhancing the EU protein crop production are the increased possibilities for crop rotation, which might reduce sensibility for crop diseases and might stabilise farmers' income, and an increased influence on socially desirable cultivation (e.g. non GMO soybean production) (Westhoek et al., 2011). According to Westhoek (2011), however, EU protein crop cultivation will not positively affect the EU phosphate balance, whereas there is a risk on increased land use and consequently a higher use of phosphate fertilizer. The world stock of phosphorus is rather limited, and therefore a very conscious use of this mineral is required. A too high level of phosphate fertilization might result in phosphate emission to ground and surface water, consequently affecting aquatic and marine and biodiversity.
A group of captains of industry in the Netherlands (Commissie Van Doorn, 2011) formulated the goal that in 2020 at least 50% of the protein-rich feed should originate from Europe (27% in 2011), under the condition that this results in a more sustainable feed production compared to the current situation. If Europe still should import protein-rich ingredients from outside Europe, from January 2014 onwards these ingredients should be produced according to sustainable standards. In case of soybean meal and Palm oil, these standards are according to the requirements of RTRS (Round Table on Responsible Soy) and RSPO (Round Table on Sustainable Palm Oil), respectively.
Wageningen UR Livestock Research conducted a study aiming to describe the conditions for successful cultivation, processing and applying use of protein sources in (organic) pig and poultry diets under European climatic conditions, thereby taking sustainability characteristics, and legislative aspects into account (Van Krimpen et al., 2013). Because of new regulations with respect to regional cultivation of feed and the ban on the use of conventional feed ingredients including synthetic amino acids, the organic livestock production has an urgent need for regionally produced high quality protein sources (Van Krimpen et al., 2016). Therefore, the organic sector seems to be an appropriate sector for applying new protein sources and may also serve as a pilot for increased use of novel protein sources in conventional intensive animal production systems.

Material and methods

First of all, a long list of 62 feed ingredients was composed, containing a wide range of protein sources. Then, criteria were applied to select the protein sources that potentially might contribute to increase the European protein production:

- the protein source should be able to perform well in the climate conditions of North West Europe;
- the cultivation of the protein source in Europe is currently no common practice;
- In long term (after 2020) the protein source is still applied in feed and not in food.

Based on these criteria, the following protein sources were identified as potentially interesting alternatives (Table 1).

Table 1 Short list of potentially interesting protein sources to increase EU feed protein production

Category	Protein source
Oil seeds	Proteins of defatted soybeans, rapeseed and sunflower seed
Grain legumes	Peas, *Vicia faba*, lupines and their concentrates, chick peas
Forage legumes	Lucerne (alfalfa)
Leaf proteins	Grass, sugar beet leaves
Aquatic proteins	Algae, both macro- (seaweed) and microalgae, duckweed
Cereals and pseudo cereals	Proteins from oat and quinoa
Insects	E.g. mealworm, housefly, house cricket[1]

[1]) The nutritional aspects of insects were studied in a separate project and presented in the report 'Insects as a sustainable feed ingredient in pig and poultry diets – a feasibility study' (Veldkamp et al., 2012).

Results

Plant cultivation

From a plant cultivation point of view grain legumes, especially peas and beans, are very interesting due to their high protein content (17-35%) and because cultivation practises are already available and implemented. However, these crops are very sensitive to pests and pathogens. Soybeans might be interesting because of the high protein content, although the current yield is too low for making cultivation attractive for the European farmers. Breeding steps for high yielding cultivars with a short growing season still need to get more input. Rapeseed (meal) is already cultivated in considerable amounts in the EU with a reasonable protein yield per hectare. The protein quality of oats and quinoa are interesting, but at this moment the yield per hectare is low compared to wheat. It still needs intensive breeding input, but with adequate attention from breeders, the production level could reach that of wheat. Aquatic protein sources are very interesting because of a high protein content (duckweed, several micro-algae and some macro-algae) and very high yields, but processing and feasibility for application as feed still needs much research. Not only the high yield per hectare, as for duckweed, and the high protein level is interesting, but also the fact that these new putative protein sources do not need good agricultural soil for cultivation. For all protein sources with a high water content, such as (left-over) leaf material, duckweed, micro- and macro algae, a drying step for storage and transport is required.

Processing

Further processing of ingredients, thereby reducing the level of anti-nutritional factors (ANFs) and increasing the protein content to levels of 65% or higher, would fulfil the need for high quality proteins for application in all kind of organic diets and in conventional diets for young animals (piglets, broilers, rearing hens). Processing of the selected feed resources to enhance their protein content is generally still in development and not yet well established.

On the short term, attractive protein enriched resources might be:

- Regarding oil seeds: rapeseed protein concentrates. Protein enrichment of defatted sunflower meal seems to be less attractive.
- Regarding legumes: protein concentrates prepared by dry fractionation from peas and faba beans. The former are already on the market. Lupines are less attractive.

For the longer term protein enrichment of leafs/grasses might deliver attractive feed ingredients. Particularly grass protein concentrates seem to be promising because their development is already in the pilot stage. Lucerne and sugar beet leafs processing is in a less advanced stage than grass processing. Processing to enhance the protein content of the aquatic resources algae and duckweed is still in its infancy. They may offer new opportunities on the long term (> 10 years).

Nutritional aspects

Proteins derived from oil seeds are very useful for application in pig and poultry diets, while there is already a widespread use of soybean, rape seed, and sunflower seed meal in these diets. These protein sources are well known in terms of chemical composition and nutritive value. It is assumed that the nutritional characteristics of European cultivated soybean meal are similar to the ones cultivated in South America, but until now this has not been proven. Less information is available with respect to concentrates of these protein sources. Results of one experiment showed that rape seed (canola) protein concentrate can be used up to 10% in piglet diets.

Legumes, e.g. *Vicia faba*, lupines and peas, and chickpeas, can significantly contribute to the protein supply of pigs and poultry, although their anti-nutritional factors have to be taken into account. Results of a piglet trial showed that the digestibility of pea protein concentrate was similar or even better than that of whole peas. Moreover, piglets that were fed a diet supplemented with pea protein concentrate performed very well. Based on these results, and considering that the production process of protein concentrates from legumes is sustainable and already commercially available, it was concluded that these concentrates are a promising category of European produced high quality protein, especially for application in organic diets.
The nutritional value of leaf proteins for pigs and poultry has not been studied yet.
Some aquatic proteins, e.g. micro algae and duckweed, might be valuable protein sources for pigs and poultry, whereas intact seaweed seems less suitable. In addition to the necessary development regarding protein extraction from these sources, more research is required to determine the nutritional characteristics of these ingredients, cell wall degradation characteristics, feed safety, and legislative aspects.
Oat protein has a good nutritional value for monogastrics and can be used as high quality protein in diets for young piglets. Although quinoa might have some promising nutritional properties, current knowledge is not sufficient for accurate supplementation of this ingredient in diets of pigs and poultry.

Conclusions
The selected protein sources differ substantially in terms of environmental sustainability. Products with a low dry matter content, i.e. lucerne, leaves, aquatic proteins are considered to be less sustainable due to the high energy costs for drying. Values are lacking for some of the sources. Besides, more research is necessary to determine if protein extraction processes are sustainable. At this moment it is not possible to draw sound conclusions with respect to the environmental sustainability of the selected protein sources.

Within the category of oil seeds, European produced soybean meal seems to be the most promising alternative for soybean meal from beans imported from South America. Nutritional value and especially protein digestibility of soybean meal is very good. Protein yield of soybean meal produced in Europe should be further increased to make this crop feasible for the farmer. To realize this, varieties have to be selected with an ultra-short growth season.
Within the category of grain legumes, peas seam the most promising alternative for soybean meal, at least for the short-term. The protein yield is reasonably high, but should be further improved. In long-term, leaf proteins and aquatic proteins probably might contribute to reduce soybean imports. Therefore, more knowledge regarding protein separating techniques and nutritional value of these products is necessary.

Leafs and aquatic protein sources are not in direct competition with the land use of other crops. Protein crops have to compete with cereals and root crops (potato, sugar beet) in Europe. Currently, the EU is more than self-sufficient for potatoes. We are self-sufficient for sugar beets as well, but experts expect a drop of 30% in production after the soon expected release of the fixed (high) price for sugar. Therefore, some arable land in the EU might be available for protein crop cultivation. Moreover, it is estimated that 1.8 million ha of fallow land is available in the Danube region, the South-East part of Europe. The estimated minimum land potential for cultivation of protein crops in Europe is 2.4 million ha.

References

Commissie Van Doorn. 2011. Al het vlees duurzaam: De doorbraak naar een gezonde, veilige en gewaardeerde veehouderij in 2020. D. B. Commissie Van-Doorn ed.

Euractiv 2011. Meps want to end 'protein deficit' for eu livestock.

FEFAC. 2015. Feed & food; statistical yearbook 2014. http://www.fefac.eu/files/62107.pdf.

Rockström, J., W. Steffen, K. Noone, Å. Persson, F. S. Chapin, E. F. Lambin, T. M. Lenton, M. Scheffer, C. Folke, H. J. Schellnhuber, B. Nykvist, C. A. De Wit, T. Hughes, S. Van Der Leeuw, H. Rodhe, S. Sörlin, P. K. Snyder, R. Costanza, U. Svedin, M. Falkenmark, L. Karlberg, R. W. Corell, V. J. Fabry, J. Hansen, B. Walker, D. Liverman, K. Richardson, P. Crutzen, and J. A. Foley. 2009. A safe operating space for humanity. Nature 461(7263):472-475.

Van Gelder, J. W., and B. Kuepper. 2012. Verdeling van de economische waarde van de mondiale sojateelt. Profundo ed., Amsterdam.

Van Krimpen, M. M., P. Bikker, I. M. Van der Meer, C. M. C. Van der Peet-Schwering, and J. M. Vereijken. 2013. Cultivation, processing and nutritional aspects for pigs and poultry of european protein sources as alternatives for imported soybean products. Report 662, Wageningen UR Livestock Research, Lelystad, The Netherlands:pp 1-63.

Van Krimpen, M. M., F. Leenstra, V. Maurer, and M. Bestman. 2016. How to fulfill the eu-requirements to feed organic laying hens with 100% organic ingredients? J. Appl. Poult. Res. 25:129-138.

Veldkamp, T., G. Van Duinkerken, A. Van Huis, C. M. M. Lakemond, E. Ottevanger, G. Bosch, and M. A. J. S. Van Boekel. 2012. Insects as a sustainable feed ingredient in pig and poultry diets - a feasibility study. W. U. L. Research ed., Report 638 Lelystad.

Westhoek, H., T. Rood, M. Van de Berg, J. Janse, D. Nijdam, M. Reudink, and E. Stehfest. 2011. The protein puzzle; the consumption and production of meat, dairy and fish in the european union PBL Publishers, The Hague.

WNF 2011. Http://www.Wnf.Nl/nl/wat_wnf_doet/thema_s/bossen/ontbossing/sojateelt/.