

Protein Crops

CHRIS DE VISSER
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Objective

This paper has the sole intention to serve as input to the first meeting of the EIP Focus Group on Protein Crops. The working area of the focus group is mainly focussed on protein demand by and supply to the feed sector in the EU-27 and the objective of this focus group is to identify the most promising European protein sources (crops) and their roadmap to full development. The paper describes the main drivers in this dossier and will address the pros and cons of alternative protein crop sources from European origin.

Main drivers

Soybean meal is the current main source of protein in the feed sector. According to FAO statistics, the EU-27 yearly imports around 20 Mtons of soybean meal (net import) and 12 Mton of soybean of which some 10 Mton is processed into meal, taking total EU-27 consumption of soybean meal to some 30 Mton. The EU-27 soybean crop production stands at 1 Mton (with around 0.8 Mt soybean meal). So only 2,5 % of the EU-27 soybean meal consumption is produced in the EU-27. Total world consumption of soy bean meal is around 150 Mton, so the EU-27 is consuming around 20% (representing some 15 million ha of arable land). According to the FAO agricultural outlook 2015-2030 total world meat production will continue to increase in this period by 1,5% per year while milk production is estimated to increase at 1.3% annually. Thus, demand for vegetative protein sources for animal production will increase accordingly.

The price level of soybean meal (Chicago Board of Trade) have risen in 2012 to a year average of \$473 compared to \$359, \$331, \$379 in 2009, 2010 and 2011. So far, 2013 prices were even higher in the first 6 months compared to the same period in 2012. Non-gm soybean meal is even higher and a premium of around \$160 at the moment is being paid.

In 2011 a motion was adopted by the European Parliament (Häusling, 2011) taking into account the present situation and the potential risks of this situation to the EU. The motion calls on the commission for several measures to be taken amongst which the following is of special interest to this focus group: "Calls on the Commission to support research into breeding and supply of protein crop seeds in the EU, including their contribution to disease control, and to make proposals for research and development on ways to improve extension services and under the heading of rural development on services training farmers in the use of crop rotation, mixed cropping and technical facilities for on-farm feed production."

Another important driver of the protein crop development is explained in the report by Nowicki et al (2010) that was executed on behalf of the Directorate-General for Agriculture and Rural Development European Commission. The authors identify risk of trade disruptions following

asynchronous authorisations of GM-traits between the producing countries and the EU with forecasts for very high price increases when this disruption would refer to the USA, Brazil and Argentina suppliers simultaneously.

Finally, sustainability is an important driver for alternative sources of protein. There is growing concern about the production systems of soy in part of the production area and the impact that these have on deforestation and soil decline amongst others. This has led not only to initiatives on sustainable soy (like the RTRS soy: www.responsiblesoy.org) and more recently the Danube Soy initiative (www.donausoja.org) but also to a call on alternative protein sources by NGO's (for example www.commodityplatform.org/wp).

Alternative sources of protein for feed

Alternatives to soy bean meal should meet some requirements in order to be or become an option for the compound feed or the animal husbandry industry:

- The protein content should be high. The two main components of compound feed are starch and protein. While starch is largely available from wheat and maize, protein depends heavily on soybean meal. Therefore, alternatives should have a high protein content.
- The protein quality should be high: good digestibility of amino acids and amino acid profile. The digestible amino acid profile of feed (and therefore its constituents) should in total match the dietary requirements of the animals. Partly, indigestibility of proteins is linked to the presence of anti-nutritional factors (ANF's) in feed constituents like protease inhibitors. Other ANF's can also play a role in digestibility of feed (minerals, vitamins) and all grain legumes (including soy) contain these (Mikic, 2009).
- The price level should be low. Animals feed is optimised to minimise the price level under the restriction that it matches the dietary demand by the animals. Thus, alternatives should have prices comparable to those of soybean meal.

The widespread use of soybean meal in the animal compound feed industry and husbandry represents the high value of this product for meat, egg and dairy production. Alternatives should match this quality or have the potential to do so in the future following an appropriate R&D roadmap. Many of the potential alternatives to soybean meal have been listed by Sauvant et al (2004). More recently, non-crop sources like insects, aquatic biomass (algae, duckweed) or products from biorefineries (green leaves) have made their entry as a potential source. Most of the potential alternatives have been reviewed by Krimpen et al (2013) on production, processing and nutritional aspects and much information can be assessed through www.feedipedia.org. More recently, a renewed interest can be witnessed on the concept of single cell protein (methane to protein by bacteria).

European soy bean

Import soybean meal could well be (partly) replaced by European soybeans. This crop is produced on some 400.000 ha (data: Eurostat), mainly in Italy (33%), Romania (18%), Croatia (14%), Austria, Hungary and France (all 9%). For these production circumstances, varieties have been bred. It is not known to what extent these crops are used for food or feed purposes. But competitiveness of these crops to wheat and corn is not very good and yields need to improve, except for the Italian Po-valley

where average yields are more than 3 tons/ha. Breeding programs in Germany, Switzerland and Austria show that potential yields can be as high as 4-5 tons provided enough water is available. Protein quality and content of European soybean is questioned but results from practices show that the quality can match that of the import soy, even though some variations in protein content exist. An important advantage of European soybean would be that in Europe still a crushing capacity remains (although in decline) that is needed to defat the beans. To this remark it should be added that in some areas European soybeans are processed as full-fat beans and are only toasted and not crushed. Most probably, this is the best way forward if volumes do not allow investments in crushing and negative effects of the oil in animal feed are not important. When scaling up, the toasting would probably need to be replaced by crushing. On European soybean much information is available through www.sojainfo.de, www.sojafoerderring.de and www.sojanetz.ch.

Other oil seed meals

Other defatted oil meals that are available in Europe are rape seed and sunflower seed meal. For rapeseed meal the protein content is less (30-40%) than that of the benchmark (soybean meal with 45-50%) while it contains high levels of ANF's and high levels of fibre, making the product less attractive compared to the benchmark. Sunflower seed meal contains 30-35% of protein (however with a low level of the essential amino acid lysine) but has high levels of ANF's reducing the maximum inclusion level in animal feed.

Grain legumes

Grain legumes like field peas, chickpeas, field and broad beans and lupins are all to some extent interesting alternatives to soybean meal. Production figures available from Eurostat in 2012 are field pea 520.000, field and broad beans 460.000 ha, lupins 84.000 ha. Not classified dry pulses reached just over 1 million ha in 2012. The grain legumes have high protein content but distinctively lower than the benchmark and contents of methionine and lysine (essential amino acids) are lower compared to the benchmark product. They all have high potential as regards the levels of ANF's some of which have been reduced in level due to breeding and this limits inclusion levels in animal feed. Yield levels of field peas and field and broad beans are high while lupins yield considerably less and are therefore less attractive. Peas, beans and lupins are sensitive to diseases and pests and can only be grown in a wide crop rotation and therefore need much attention from farmers. Of these, beans have more preference by arable farmers because it is more easy to grow with more steady yield levels. From a nutritional point of view, peas are the favourite of the grain legumes. It must be mentioned here that crop rotations for soybean would tend to be the same, even though crop diseases and pest at the moment are restricted compared to the situation with grain legumes.

At the moment the competitiveness of grain legumes in arable crop rotations in Europe is limited and yield increases are needed to replace crops like wheat, barley or corn. As mentioned earlier, this would also be needed for European soybean.

Compared to the benchmark product, the grain legumes are not processed. However bio-refinery of these pulses could have considerable advantages: the protein content would rise (and with it the content of essential amino acids), heat treatment would reduce ANF's and multiple marketable products (starch to ethanol or lactic acid and fibres) could make the business case more feasible. Protein concentrate of peas is a product that contains up to 80% protein and has been tested as a feed product with good results. However, such a processing industry needs to be founded and developed if feasibility would be proved.

Leaf proteins

Protein levels in leaves are low, due to high moisture content, but bio-refineries of green leaves could potentially be producing high protein content products, free of fibres that negatively influence digestibility. At present, alfalfa protein extracts (>50% protein) are commercially available on the market but in restricted areas. With products like grass and sugar beet leaves experimentation is ongoing but economic feasibility is still questionable at the current level of technology and market prices. Feasibility would be enhanced if all co-products of these refineries would have market value (protein, fibres, fatty acids). Sugar beet leaves could be available at 40 tons per ha and if processed at an early stage a protein rich juice could be produced with in total 120 kg of protein per ha. Grass would be interesting because of the protein content of about 200 g per kg dry matter at a dry matter percentage of around 16-17%. In all cases a considerable amount of water needs to be removed to produce an alternative to the benchmark product.

Aquatic biomass

Recently, products like duck weed, macro- and micro-algae have surfaced as potential protein sources for animal feed. Micro-algae can (depending on the species contain 50-70% protein in the dry matter with good methionine and lysine values (Becker, 2007). With dry matter productions reaching 15-20 tons per ha per year, this crop would yield unmatched production levels of protein. However, digestibility figures are not available yet and at present production cost are too high to make bulk markets accessible to algae. Duckweed is also considered as a potential alternative because of the relative high protein content in the dry matter (25-35% but some sources claim even over 40% crude protein content in the dry matter) and with good amino acid profiles. With a yearly dry matter yield level of 15-20 tonnes, this would result in protein production levels as high as 4-8 tonnes per ha per year. With a dry matter content of 6-8% this potential protein source would need processing to produce a credible alternative to soybean meal. However, for cows this product could be a roughage product, much like grass, and thus contribute to protein uptake. Nevertheless, digestibility studies are scarce, so digestibility and ANF's are still to be investigated.

Insects

Insects are a well-known source of protein. In the dry matter crude protein level can be higher than 50% and the animals grow fast on organic waste materials (Huis et al, 2013). Wang et al (2005) reported good amino acid digestibility of field crickets fed to poultry, but still much knowledge is yet to be collected to judge the real potential of insects as protein sources for animal feed. If grown on waste material, insect protein could be price competitive, but at high production levels, the question will arise whether or not insect feed needs to be produced in an efficient way beyond organic waste sources. And then, the incorporation of an extra trophic level in the production of animal feed based on insects, could result in drawbacks that could affect their potential as an alternative source of protein. Also, little is known about processing cost of insects, so much R&D is needed.

Sustainability remarks

The replacement of soybean meal by other protein sources does not automatically imply that a sustainability gain is realised. This requires additional attention. For instance, the enlargement of the

production of European soy or grain legumes will be realised at the expense of wheat and corn in most countries. So some extent this could be counteracted by increases of yield level, but to a larger extent it will imply import or reduced exports of wheat and corn from outside the EU. In sustainability studies, this aspect needs to be taken into account.

Often the production of aquatic biomass is considered as not competing with the food value chains. However, aquatic biomass needs sunlight to be produced and that sunlight could also be used for other purposes (human food production). If explained in this way, a sustainability issue could still arise.

Implementation remarks

When considering alternatives to soy import, it is necessary to consider the impacts on the whole value chain. The larger the impact the larger the challenge of the transition. Also, it is important to consider the transition road of the benchmark to the alternative(s). The soy bean meal value chain is illustrated in Figure 1. The blue marked boxes present activities outside the EU (the America’s) while the purple marked boxes are EU activities. The orange marked activity is more and more being done in the America’s while at the same time the EU processing capacity is steadily decreasing. The production of European protein, based on soy or grain legumes, will not much distort the feed value chain. Note however that the breeding activities directed at EU varieties need to be build up commercially. Also note that these alternatives are not very competitive at present in European arable production compared to wheat, barley or maize. A difference between grain legumes and European soy can be noted at the processing activity: soy bean processing capacity is still available in the EU at present.

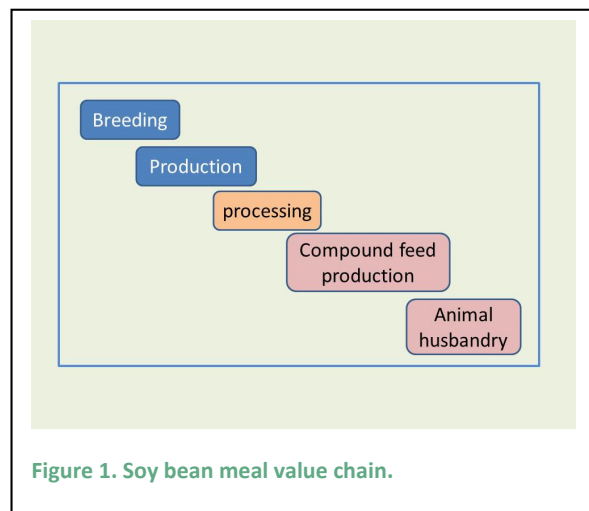


Figure 1. Soy bean meal value chain.

Some other potential protein sources like aquatic biomass or leaf proteins are high in moisture content and/or need to be processed without any delays after harvest. This would make them more local and less adequate for integration with the value chains at present. This would require more energy on the implementation side before these resources would lead to significant alternatives to soybean meal. The transition of the benchmark value chain to the alternatives should also be considered as mentioned before. The mainstream feed value chain needs substantial amounts of price and quality competitive alternatives and it will take time and efforts to build up a supply chain large enough to meet these demands. Therefore, a transition needs a wide industry commitment to be successful.

Conclusion

The main conclusion at this point in the EIP focus group process would be that for all alternatives intensive R&D roadmaps would be needed. Additionally, implementation issues should be taken into account and sustainability gains should not be taken for granted.

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