Canolfan Organig Cymru
Organic Centre Wales

# Making organic poultry feed more sustainable: Dehulling homegrown protein crops

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The Better Organic Business Links (BOBL) project, run by Organic Centre Wales, is a four year project designed to support the primary producer in Wales and grow the market for Welsh organic produce in a sustainable way.

The aim is to develop markets for organic produce whilst driving innovation and promoting sustainable behaviours at all levels within the supply chain, to increase consumer demand and thence markets for organic produce, especially in the home market, and to ensure that the primary producers are aware of market demands. The project provides valuable market information to primary producers and the organic sector in general.

Delivery of the project is divided into five main areas of work:

1. Fostering innovation and improving supply chain linkages
2. Consumer information and image development of organic food and farming in Wales
3. Market development
4. Providing market intelligence to improve the industry's level of understanding of market trends and means of influencing consumer behaviour
5. Addressing key structural problems within the sector.

In all elements of the work, the team are focused on building capacity within the organic sector, to ensure that the project leaves a legacy of processors and primary producers with improved business and environmental skills, able to respond to changing market conditions, consumer demands and climate change.

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## Executive Summary

Organic poultry rations are heavily dependent on imported soya to meet the protein requirements of the birds. However, organic and GM-free soya is becoming increasingly difficult, and therefore expensive, to source and relying so heavily on imports is not in keeping with the organic ethos. One approach to the problem is to improve the nutritive value of homegrown protein crops such as peas and beans, thus allowing them to replace soya to a greater extent than is the case now. One way in which that can be achieved is by removing the seed hulls.

The project looked at the potential contribution that dehulling can make by:

- Examining the nutritional basis for dehulling
- Quantifying the benefits associated with the process
- Exploring how Welsh producers might access dehulling facilities at economic prices.

Analysis of the nutritional composition of entire grani, dehulled seed and the hulls alone were carried out for peas and beans. They confirmed that there is a nutritional benefit to dehulling through increasing the relative proportions of crude protein, key amino acids and starch and decreasing fibre content. Although anti-nutritional factors were not analysed as part of the project, we can assume that their concentrations in the dehulled seed are low because published data show clearly that these compounds are concentrated in the hulls.

The economic value added by dehulling was assessed by entering the nutritional data obtained from the analyses into a 'least cost' ration formulator. This is a computer programme which shows how the user can arrive at a given nutritional target using the cheapest ingredients possible. A value was placed on the dehulled grain by calculating its 'opportunity price', that is the price at which it becomes competitive with alternative ingredients. The opportunity price was calculated in the context of four poultry diets: Turkey starter; turkey grower; broiler finisher; and chicken layer. The largest benefits were seen for broiler and turkey diets, especially the latter which require higher protein levels.

If income could be derived from the separated hulls, the economic benefit of dehulling would be enhanced and peas and beans could potentially be used at higher inclusion rates and in more diets. Possible uses could include ruminant feeding and poultry/ pet litter.

The relatively high cost of purchasing a dehuller and the associated seed cleaning equipment (£14,000 combined) may act as a disincentive for individual farmers to buy the necessary equipment. Options for cost sharing and joint ownership are discussed.

# 1 Introduction

Organic poultry rations are heavily dependent on imported soya to meet the protein requirements of the birds. However, organic and GM-free soya is becoming increasingly difficult, and therefore expensive, to source and relying so heavily on imports is not in keeping with the organic ethos. For a detailed examination of the issues, watch this short film: http://streaming.aber.ac.uk/restricted/departments/ibers/Feed_from_the_Farm.wmv.

One approach to the problem is improve the nutritive value of homegrown protein crops such as peas and beans, thus allowing them to replace soya to greater extent than is the case now. One way in which that can be achieved is by removing the seed hulls.

# 2 Objectives

- To examine the nutritional basis for dehulling
- To quantify the benefits associated with the process
- To explore how Welsh arable and poultry producers might access dehulling facilities at economic prices

# 3 Project activities

These objectives were achieved through the following:

- A leaflet (Appendix I), based on a literature review and expert opinion, outlining the potential benefits of dehulling protein crops.
- A study tour to see dehulling machines in action at:
  - Alvan Blanch (Malmsbury Wilts), a manufacturer, for detailed information on the dehulling process and technical specifications of the machine.
  - Hammonds End Farm (Harpenden, Herts) to show how a dehuller can be integrated into the farm's grain handling system.
- A video was made of the study tour and made available on the OCW website and YouTube
- Samples of peas and beans (entire and dehulled) were collected during the study tour and analysed for nutritional content. This information was used to determine the opportunity price for dehulled peas and beans using a least cost formulation programme.
- The Welsh Machinery Rings were consulted on arrangements that might facilitate access to dehulling machines at economic cost

# 4 The nutritional case for dehulling

The use of peas is low and field beans rare in organic poultry diets. While they are comparatively rich in protein, they are both low in methionine and cystine (Table 1). One of the reasons for the lower nutrient content of peas and beans is the presence of a fibrous outside hull. The hull also contains anti-nutritive factors such as tannins which reduce digestibility of amino acids (see Box 1). For this reason a limit on inclusion is placed by poultry nutritionists.

The rationale is that if the outside hull was removed, the nutritive value of the remaining seed, and its monetary value would be markedly increased, while the reduction in anti-nutritive factors would allow poultry nutritionists to include more in their diets at the expense of soya.

| Ingredient | Protein (%) | Lysine (%) | Methionine (%) | Meth + Cystine (%) | ME MJ/kg |
|---|---|---|---|---|---|
| Soya 44 | 44 | 2.71 | 0.59 | 1.24 | 11 |
| Sunflower | 33 | 1.16 | 0.74 | 1.29 | 7 |
| Rapemeal | 33.9 | 1.83 | 0.68 | 1.49 | 7 |
| Peas | 20.5 | 1.45 | 0.19 | 0.48 | 11.4 |
| Beans | 25 | 1.58 | 0.18 | 0.49 | 11.85 |
| Fishmeal | 66 | 4.46 | 1.75 | 2.32 | 12.85 |

***Table 1: The protein and ME content of some key ingredients***

**Box1: Anti-nutritional factors in grain legumes**

**Tannins** bind strongly with proteins and other large molecules such as starch, cellulose or minerals. Tannins reduce intake by making the feed less palatable and form indigestible compounds in the gut.

**Trypsin inhibitors** reduce the activity of trypsin, an enzyme involved in protein digestion. This, in turn, reduces growth rate and feed efficiency in poultry. They occur mostly in legumes but are also found in low concentrations in cereals.

**Alkaloids:** There are many types of alkaloids, which are specific to a particular plant species. The one present in lupins, for instance, is quinolizidine. If ingested, they can have a wide range of adverse effects and sometimes cause stock to refuse feed.

**Plant lectins** are found mostly in legume seeds or beans and have a specific affinity for sugar molecules. As well as causing red blood cells to clump together (a process known as agglutination), lectins may bind to cells in the gut lining. This reduces the action of some digestive enzymes which, in turn, decreases the absorption of nutrients and ultimately slows growth.

# 5 The dehulling process

The process of dehulling is an entirely physical one. The machine (Figure 1) consists of a series of rotating tubes which fling the seed against a metal ring. The initial impact cracks the hull, which is scrubbed off the seed as it goes round the ring at high velocity. Once the hulls have been removed, the grain is passed through a seed cleaning system which separates the output into three fractions: the dehulled seed; the hulls; and any grains that are left entire. This last can be fed back into the machine. For further information watch this short film: (http://www.youtube.com/watch?v=3_dJAjuIvsM).

Two variables are important to ensure an efficient process:

- *The speed of the dehuller,* that is the velocity with which the grain is flung against the metal ring: Too slow and the hull will not crack; too fast and the seed shatters. Manufacturers issue guidelines for each crop, but a period of trial and error is usually required to fine tune it once it is installed.
- *The rate at which grain is fed in to the machine*: If you go too fast, the system becomes flooded. This slows the dehuller down which makes it less efficient.

With peas and beans you can realistically expect a throughput of 1.5 tonnes/ hour. The combined cost of the machine and the seed cleaning equipment is approximately £14,000 new.


***Figure 1: Impact dehuller (Credit Alvan Blanch)***

# 6 Quantifying the benefits of dehulling

The benefits of dehulling were assessed by analysing the nutrient content of the dehulled seed, the separated hulls and the entire grain for each of peas and beans. This information was used to determine the contribution the processed grain could make to a ‘least cost’ poultry ration (section 6.2).

## *6.1 Nutritional analysis*

The results of the analyses are shown in Table 2. Due to the high cost of amino acid analysis, only lysine and methionine were analysed directly. The cystine, threonine, tryptophane and arginine values were calculated by using published figures which establish the relative proportions of the different amino acids in peas and beans. Similarly, the ME has been calculated using the equation based on protein, oil, sugar and starch, originally developed for wheat. This will introduce a small error into the data, but it is unlikely to have a significant impact on the conclusions.

Another potential source of error could arise because only a small amount of material is used in the analysis which may not be representative of the whole batch of material. This could, for example, explain the very high starch figure (66%) for dehulled peas which implies that about two thirds of the pea was hull; this is clearly not the case. When entering in the nutrient values in the least cost formulation system, a judgement based on experience and other published data has had to be used to arrive at logical comparisons.

| | **Peas** | | | **Beans** | | |
|---|---|---|---|---|---|---|
| **Nutrient %** | **Entire** | **Dehulled** | **Hulls only** | **Entire** | **Dehulled** | **Hulls only** |
| Crude protein | 19.7 | 20.2 | 19 | 27.4 | 29.9 | 11.9 |
| Crude fibre | 4.8 | 2.5 | 14 | 10 | 5.4 | 42.1 |
| Moisture | 15.8 | 15.8 | 14.2 | 15.1 | 14.5 | 13.6 |
| Oil (B ) | 1.98 | 1.9 | 2.21 | 1.55 | 1.57 | 0.83 |
| Lysine | 1.57 | 1.78 | 1.3 | 1.46 | 1.92 | 0.4 |
| Methionine | 0.2 | 0.24 | 0.2 | 0.16 | 0.22 | 0.03 |
| Sugar | 3.28 | 2.55 | 3.91 | 2.85 | 2.7 | 2.2 |
| Starch | 45.8 | 66** | 28.5 | 29.6 | 33.6 | 5.9 |
| M.E. MJ/kg (calculated) | 11.81 | 12.5 | 8.97 | 10.09 | 11.14 | 3.4 |
| Meth.+ Cyst. (calculated) | 0.48 | 0.59 | 0.4 | 0.49 | 0.58 | 0.12 |
| Threonine(calculated) | 0.75 | 0.92 | 0.62 | 0.87 | 1.04 | 0.22 |
| Tryptophane(calculated) | 0.19 | 0.23 | 0.16 | 0.2 | 0.24 | 0.05 |
| Arginine(calculated) | 1.76 | 2.16 | 1.46 | 2.3 | 2.74 | 0.57 |

** presumed error in starch value and estimated for ME equation

***Table 2. Nutrient analysis of the various ingredients***

## *6.2 Least cost formulations*

### *6.2.1 The principles*

The aim of least cost rationing is to meet the nutritional requirements of the animal for the lowest possible cost, using specialist computer software. The first step is to programme in the dietary requirements of the birds. This will vary according to species (chickens, turkeys, ducks etc), enterprise (layer or table birds) and the stage of development (starter, grower, finisher, layer). Table 3 gives some examples. For this reason, the value of dehulled peas and beans will vary according to the diet it is being offered in.

The programme has a database that includes the nutritional value of a number of common ingredients and their costs per tonne. It uses this information to arrive at the target it has been set by the cheapest possible route

| | Turkey -Starter | Turkey - Grower | Broiler - Finisher | Chicken - Layer |
|---|---|---|---|---|
| Crude protein% | 26.5 | 22 | 22.5 | 17 |
| Lysine % | 1.4 | 1 | 1.1 | 0.8 |
| Methionine% | 0.48 | 0.4 | 0.43 | 0.38 |
| ME (MJ/kg) | 11.7 | 12.2 | 12.7 | 11.8 |
| Calcium % | 1.3 | 1.05 | 0.85 | 4 |

***Table 3 Some poultry diet specifications***

### *6.2.2 Calculating opportunity prices for dehulled peas and beans*

It therefore follows that the inclusion or otherwise of peas and beans will depend not only on the nutritional content but also how their cost compares with that of other ingredients that are effectively competing for a place in the ration (We used spot prices for November 2012, quoted in Table 4). Initially the value of dehulled peas and beans were given a very high value i.e. £7777, to ensure that they did not come into the initial formulation. The programme then calculates the price at which rejected ingredients become competitive and come into the formulation. This is known as **the opportunity price**

| Ingredient | Cost (£/ tonne) |
|---|---|
| Wheat | 318 |
| Soya 44 | 559 |
| Sunflower | 330 |
| Fish meal* | 1095 |
| Maize | 298 |
| Mz Gluten 60** | 730 |
| Mon.Ca. phos. | 485 |
| Limestone | 50 |
| Sod.Bicarb. | 280 |
| Salt | 130 |

* Fish meal, as a non agricultural ingredient can be used in organic poultry diets without restriction

** The Maize Gluten 60% protein can be included up to 5% of the non mineral ingredients

***Table 4 Ingredient costs***

We entered values for the nutrient content of dehulled, entire and hull fractions obtained from the analyses (Table 2) into the programme. It calculated the opportunity prices (Table 5) for each of the four rations.

| | Turkey starter | Turkey grower | Broiler finisher | Chicken layer |
|---|---|---|---|---|
| Peas entire | 391 | 439 | 274 | 307 |
| Peas dehulled | 440 | 514 | 383 | 359 |
| Pea hulls | 270 | 223 | Nil | 149 |
| | | | | |
| Beans entire | 343 | 395 | 101 | 221 |
| Beans dehulled | 414 | 514 | 255 | 302 |
| Bean Hulls | Nil | nil | nil | Nil |

***Table 5: Opportunity prices of dehulled peas and beans in various rations***

### *6.2.3 Putting a value on dehulling*

Table 5 shows considerable variation between dehulled and entire pea and bean opportunity prices, depending on the diet. We assessed the proportion (by weight) of hull to seed by directly measuring the proportion of each fraction. This was between 15 and 20% and we have calculated the benefits at the extremes of this range (Table 6 for peas, Table 7 for beans). The analysis shows that dehulling the peas or the beans significantly increases the value of the seed remaining. The largest increase is seen if the peas or beans were planned for use with broilers. However the dehulled peas and beans were most valuable if used in turkey diets which are higher in protein than broiler diets

The economic analysis would be more favourable if income could be derived from the separated hulls. The hulls have no attraction in poultry diets because of their low ME and the presence of anti-nutritive factors. However these are of little significance in ruminant diets. The pea hulls look particularly attractive with 19% crude protein and the bean hulls with nearly 12% crude protein are of value. In the costing above no income has been attributed to bean hulls and little to pea hulls. They do therefore represent a major opportunity to add value to the dehulling exercise. Ways of using them in ruminant feeding, particularly direct to animals on farm is an obvious opportunity. Another opportunity is for use as poultry litter to replace wood shavings which are becoming increasingly expensive.

| | **Turkey starter** | **Turkey grower** | **Broiler finisher** | **Chicken layer** |
|---|---|---|---|---|
| ***Assuming 15% of the pea is hull*** | | | | |
| Value of 100 tonnes of peas | 39100 | 43900 | 27400 | 30700 |
| Value of 85 tonnes of dehulled | 37400 | 43690 | 32555 | 30515 |
| Value of 15 tonnes of hulls | 4050 | 3345 | 0 | 2235 |
| Total dehulled+hulls | 41450 | 47035 | 32555 | 32750 |
| Difference from entire peas | 2350 | 3135 | 5155 | 2050 |
| Added value per tonne of pea | 23.5 | 31.35 | 51.55 | 20.5 |
| ***Assuming 20% of the pea is hull*** | | | | |
| Value of 100 tonnes of peas | 39100 | 43900 | 27400 | 30700 |
| Value of 80 tonnes of dehulled | 35200 | 41120 | 30640 | 28720 |
| Value of 20 tonnes of hulls | 5400 | 4460 | 0 | 2980 |
| Total dehulled+hulls | 40600 | 45580 | 30640 | 31700 |
| Difference from entire peas | 1500 | 1680 | 3240 | 1000 |
| Added value per tonne of pea | 15 | 16.8 | 32.4 | 10 |

***Table 6: The added value from dehulling peas***

| | Turkey starter | Turkey grower | Broiler finisher | Chicken layer |
|---|---|---|---|---|
| ***Assuming 15% of the bean is hull*** | | | | |
| Value of 100 tonnes of beans | 34300 | 39500 | 10100 | 22100 |
| Value of 85 tonnes of dehulled | 35190 | 43690 | 21675 | 25670 |
| Value of 15 tonnes of hulls | 0 | 0 | 0 | 0 |
| Total dehulled+hulls | 35190 | 43690 | 21675 | 25670 |
| Difference from entire beans | 890 | 4190 | 11575 | 3570 |
| Added value per tonne of bean | 8.9 | 41.9 | 115.75 | 35.7 |
| ***Assuming 20% of the bean is hull*** | | | | |
| Value of 100 tonnes of beans | 34300 | 39500 | 10100 | 22100 |
| Value of 80 tonnes of dehulled | 33120 | 41120 | 20400 | 24160 |
| Value of 20 tonnes of hulls | 0 | 0 | 0 | 0 |
| Total dehulled+hulls | 33120 | 41120 | 20400 | 24160 |
| Difference from entire beans | -1180 | 1620 | 10300 | 2060 |
| Added value per tonne of bean | -11.8 | 16.2 | 103 | 20.6 |

***Table 7: The added value from dehulling beans***

# 7 Access to machinery

The relatively high cost of purchasing a dehuller, and the associated seed cleaning equipment may act as disincentive for individual farmers to buy the necessary equipment. However, there are options for producers to share the costs.

One possibility is for an individual to buy the machine, and to process grain for others in the area at an agreed price per tonne. The purchaser would take responsibility for operation and maintenance of the machine, and therefore would need be confident that the others in the group would commit to a certain level of usage. He or she will have to charge relatively high rates per tonne to achieve a return on his capital and to cover the risk of not having sufficient business to pay for it. From the point of view of the other producers there is also the risk that the single purchaser could sell the machine at any time, if there was insufficient work, thus leaving everyone high and dry.

Another option is cooperative ownership, which is more complex, but shares the risk among a greater number of producers. Given that everyone in the group has a stake in the machine, and is therefore more likely to use it. The group sets up a company in which all participants are shareholders. The company buys the equipment and then leases it to share holders on a prorata basis, at a price that cover running costs, spares and repairs. The machines could also be hired out to non-members on a cost per- tonne basis.

The latter option is effectively a machinery syndicate. These are highly successful on the continent but have a somewhat chequered history in the UK. Most of the problems arose because there was no clear agreement among members on responsibility for maintenance, invoicing or priority of use. One solution is to involve an independent third party, such as a machinery ring, to take on all these roles. It involves and extra cost, but could be very important in insuring the project runs smoothly and to the benefit of all involved.

For more information contact Graham Perkins, PMR Limited, 01437 761321 gperkins@pmr.org.uk'

## 8 Conclusions

The situation with regard to protein rich organic ingredients is becoming more serious each year. The main problem is that organic soya is becoming increasingly hard to source because more and more GM soya is being grown.

While there are still a lot of unanswered questions, this project has demonstrated that the dehulling of peas and beans is a promising way for the organic movement to meet the nutritional challenges it faces. To take it further, practical ways in which the crops can be grown, dehulled and utilised need to be devised and pilot tested. Ways of utilising the hulls to gain maximum income are an important aspect of this work

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