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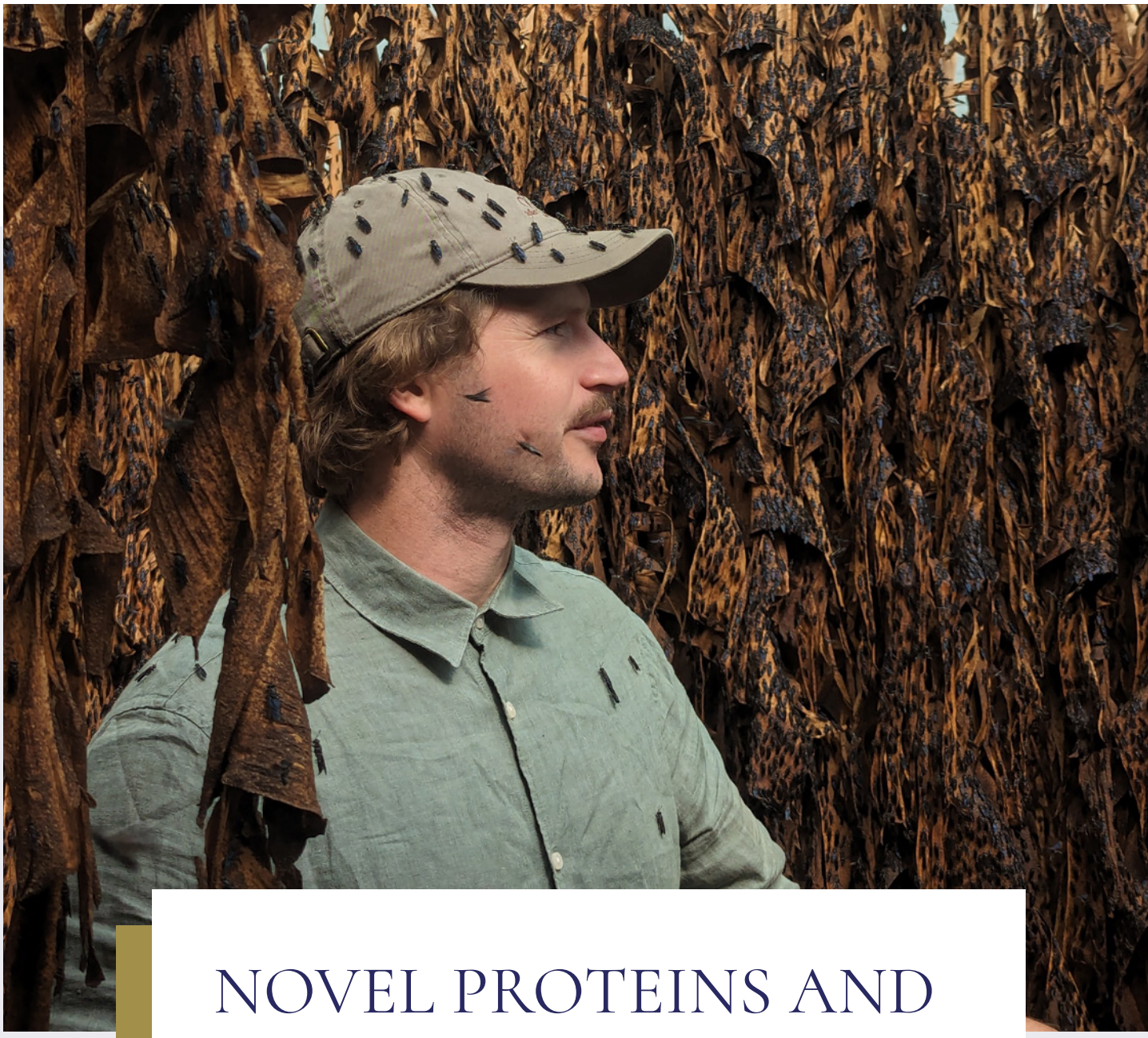


NOVEL PROTEINS AND FEED EFFICIENCIES

A Bitesize Guide

INTRODUCTION

Each year, up to 25 people aged 25-45 are selected as scholars and sponsored by the Nuffield Farming Scholarships Trust to travel, research and report on subjects they are passionate about and which contribute to advancing farming, food, horticulture, forestry and ancillary industries.

These studies bring new thinking, technology or management approaches from across the globe to the UK. While many know of Nuffield Farming scholarships, few people in the industry are aware of the huge knowledge base of global reports, dating back to 2006, that can be accessed via the online Nuffield Farming library.

This Bitesize Guide, supported by the Elizabeth Creak Charitable Trust, Central Region Farmers Trust, Gloucestershire Agricultural House Foundation and the Royal Agricultural Society of England, gives an insight into the practical experiences and research freely available at:

https://www.nuffieldscholar.org/reports

WHAT IS THIS GUIDE, AND HOW SHOULD I USE IT?

This Bitesize Guide on 'Novel proteins and feed efficiencies' is designed to provide a range of ideas to help anyone who is interested in exploring alternatives to mainstream options such as soya.

With an increasing focus on sustainability, soya in particular has come under scrutiny, driving farmers to look for alternative protein sources. This Bitesize Guide covers a wide range of options, including home-grown proteins such as peas, beans and lupins and newer options such as fava beans and insect meal.

This Bitesize Guide brings together research, discussions and ideas from relevant Nuffield Farming reports, all highlighted as 'Talking points' and 'In practice' sections, with 'Putting it into action' sections at the end which includes useful links. The Guide features short, thought-provoking extracts - each one includes a TinyURL link and QR code to access the relevant Nuffield Farming report for more information, case studies and discussions.

TALKING POINT 1:
Pigs and alternative proteins

Michelle Sprent NSch 2013

> ***The pig has good capacity for utilising a wide range of alternative vegetable protein sources. This has been shown with the more recent use of rape seed meal and sunflower meal."***

Ingredients such as peas and beans also show good potential. A collaborative UK project known as 'Green Pig' showed that the use of high levels of peas and beans in diets is possible. These results supported those of earlier studies by Canadian researchers.

While we know we can use peas or beans, there simply aren't enough grown in the UK due to issues with agronomy and lack of economic return for the grower. Products such as lupins might also be interesting in the future but they have similar drawbacks to peas and beans. This situation is changing slowly with new varieties being brought in and increasing interest in home grown proteins.

I have heard and read that soya is being grown in the UK. This may be a possible option for some growers in the future as part of arable rotations. It seems, on paper, that yields can match those of product grown in the US and South America and there is work being done to improve the varieties to suit the UK climate. Figures of up to 2.5t/ha are suggested as possible for the UK (www.soya-uk.com) although yield estimates vary, with quoted yields of between 0.74 up to 3.1t/ha (Farmers Weekly article, 30/12/2010). As a comparison, the USDA figures for the US in 2012 were 2.6t/ha, and the predicted 2014 Brazilian yield was 3.05t/ha.

If home produced soya does become more widespread we need to ensure we understand the nutritional specification, as this is likely to differ to the product grown in the Americas. From a sustainability perspective we should be certain that growing soya in the UK is the most sensible use of the land. Soya production would be in direct competition with other crops and resource and this is an area the experts in arable production need to evaluate carefully.

Scientists from Wageningen University in the Netherlands, along with Plant Research International and Food and Biobased Research, published a report in February 2013 called 'Cultivation processing & nutritional aspects for pigs and poultry of European protein sources as alternatives for imported soya bean products'. This study put together a long list of 62 feed ingredients which contained a wide range of protein sources. It then created a shortlist of potential proteins that may contribute to increased protein production in Europe (see table).

In creating this shortlist they looked at factors such as; whether the protein source would be able to perform well in the climatic conditions of North West Europe; whether cultivation of the product was already commonplace in Europe; and whether in the long term (beyond 2020) the protein source will still be available for feed or is the use limited to food applications.

Potential European-grown protein sources

Category	Protein source
Oil seeds	Proteins of deffated soya beans, rape seed and sunflower
Grain legumes	Peas, *Vicia Faba*, lupins 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 oats and quinoa
Insects	e.g. meal worm, housefly and cricket

Source: Wargeningen University

Michelle Sprent

Sustainable pig nutrition: https://qrco.de/bgYj4S

TALKING POINT 2:

Alternative proteins for laying hens

Alistair McBain NSch 2023

> ***My Nuffield project reviewed alternative protein sources, including grain legumes, industry by-products, insect protein and single cell proteins, to determine the most suitable source of protein for helping to drive egg production towards net zero emissions."***

Given that soya contributes so highly to the carbon footprint of an egg, the use of alternative proteins to reduce or remove soya from diets completely is a silver bullet for the poultry industry.

However, the use of alternative proteins is complex, because laying hens have been bred for almost 100 years with selection being carried out with birds fed on soya based diets. Soya is by far the most widely used protein source in layer diets globally.

Grain legumes, particularly faba beans (see p12 and 13), are of particular interest in the UK as a home-grown source of protein. Recent advancements in breeding are bringing varieties that are low in vicine and convicine to market, anti-nutritional compounds which have limited the use of faba bean in laying diets up until now due to effects on performance and mortality. Further investment is needed to breed varieties with increased yields of protein, disease resistance and early maturity to increase the area produced in the UK and Europe.

The use of industry by-products in laying diets is an important part of a circular economy. A key interest is the development of technology to further process DDGS from bioethanol production to increase the protein content. Processed animal proteins can provide a valuable source of protein and are used widely in the US. Regulation change in Europe has allowed its use since 2021, and the UK is expected to follow in 2025. One of the main problems with the use of by-products is their variability in nutritional value. Constant monitoring is required to correctly formulate diets to meet the nutritional requirements of laying hens.

The continued development of novel protein sources such as insect protein fed on low grade food waste, and single cell proteins grown on captured CO_2 from industrial processes have great potential in providing protein sources with a negative carbon footprint, vital for offsetting unavoidable emissions on the road to net zero. Both sectors are working on scaling their technologies, with insect protein expected to be economically viable for livestock feed within five to eight years.

None of the protein sources studied are considered a complete replacement for soya. A combination of alternative protein sources is required to significantly reduce or replace soya completely, resulting in an increase in the cost of the diet. Support is required to cover the cost of using alternative proteins either through investment in finding solutions to reduce the cost of production of the alternatives, i.e plant breeding or scaling insect protein production, or increasing the price paid to egg producers, potentially through differentiated egg brands.

Alistair McBain

> ***A combination of alternative protein sources is required to significantly reduce or replace soya completely."***

From beans to bugs – alternative proteins to drive net zero egg production:
https://qrco.de/bgYj7z

TALKING POINT 3:

Sustainable proteins for ruminants

Iwan Vaughan NSch 2017

> ***Ruminants are seen as being very inefficient in converting dry matter to an end product such as milk or red meat."***

It is important to increase the efficiency of ruminant industries as, in the future, we may come under threat of more efficient man-made protein such as laboratory-produced synthetic meat.

With this in mind we must think which protein feed sources are sustainable for feeding ruminants, especially dairy, in the future.

Soybean meal is a proportion of the purchased protein we bring onto UK dairy farms. This is mainly imported from North and South America. During my time in Mato Grosso, Brazil, I saw the full scale of soybean production with vast areas of land laid down to soybeans. My personal perception of Brazil - before heading out there - was the unsustainable activity of growing crops for export after deforestation. Although deforestation is illegal, it is still evident in the Amazon region in the north of the country. However, the majority of produce coming out of Brazil would be coming from the central and southern states - where scrub had been cleared - rather than from rain forest.

Soya will still be grown across the world and sold as a commodity and it will always be available, but we need to start thinking of restricting imported soya within our diets and finding protein sources with good amino acid profiles closer to home. This may include UK-grown soybean in the future. If we can grow the required protein in the UK there is no point feeding a product with a higher carbon footprint that has been shipped from the other side of the world.

Other pulses within the UK have a similar amino acid (AA) profile to soya. These include field beans and peas. Beans work really well within diets: adding protein and starch, driving microbial protein synthesis and supplying a good AA profile as they are high in lysine. Peas on the other hand are both higher in lysine and methionine than either soya or beans. Both crops work great in an arable rotation, and as both are legumes they fix their own N.

Legumes including red clover are great options for home grown protein. Dr Jon Moorby, from Aberystwyth University, explained how red clover can have a higher true protein content compared to forage such as grass, as enzymes - including polyphenol oxidase - bind to the protein and stop it breaking down after harvest. This means more of the protein in red clover is true protein and available within the rumen.

When I started my Nuffield Farming journey I was interested in developing insect protein for ruminants, thus producing a high quality protein source from waste products. This would be very efficient and tick all the boxes in terms of protein sustainability. After discussing the subject with Dr Aidan Leek NSch (see p24 and p30) and reading his Nuffield Farming report I came to the conclusion that insect protein may be the future; however, at the current time, there are greater opportunities for insect protein within marine and poultry feed.

Insect protein is only currently registered as a feed in the EU for marine, and would currently be too expensive to be considered in ruminant diets. This may change in the future and become a viable option.

Iwan Vaughan

"We need to start thinking of... finding protein sources with good amino acid profiles closer to home."

Sustainable protein feeding for the UK dairy industry:
https://qrco.de/bgYjAF

TALKING POINT 4:

Alternative feed ingredients in the marine sector

Aisla Jones NSch 2021

Fishmeal and fish oil (FMFO) historically made up a large proportion of the diet of carnivorous aquaculture species diets, which rely on marine ingredients to provide essential omega 3 fatty acids, which plant oils may not be able to deliver.

FMFO inclusion has drastically declined over recent decades and in 2021, made up around 25% of Scottish salmon diets. Globally, marine ingredients made up 7% of aquafeed ingredients.

Marine ingredients are increasingly being fully or partly replaced by terrestrial crops and other Ingredients. Some refer to these ingredients as 'alternative' or 'novel' ingredients, although there is no agreed industry definition.

There is growing concern that increasing use of terrestrial ingredients could shift environmental impacts onto land rather than the sea. Of particular concern is the production of soy, especially in Brazil where areas of high conservation value in the Amazon and Cerrado, have been used for soy plantations causing high rates of carbon emissions due to deforestation and land conversion. A range of other plant ingredients are used in aquaculture diets as an oil or protein source such as rapeseed, corn, wheat, sunflower oil and guar meal.

Novel ingredients such as single celled proteins, insects and algae have been hailed as having potential to alleviate the impacts of high-risk marine and terrestrial ingredients. Some algae have high levels of omega 3, making them suitable to replace fish oil while still delivering health benefits to consumers. However, most 'novels' need to achieve scale to be competitive with traditional ingredients and more data is needed to assess trade-offs.

Aisla Jones

> ***"Marine ingredients are increasingly being fully or partly replaced by terrestrial crops and other Ingredients."***

How can retail and supply chains support demand for more sustainable aquaculture feed? https://qrco.de/bgYjCp

In practice: Getting inventive with protein, US and Sri Lanka

Sophie Gregory NSch 2023

Organic protein is one of the most expensive costs and one of the biggest challenges in organic dairy; on our farm it sits just behind rent, so we must stay inventive. As the climate shifts, proteins that might not have suited our area before may now be possible, and we need to stay open minded.

Travel sharpened my thinking. In the US I was lucky enough to meet Ed Zimba and his wife Melanie, who run an organic grass fed dairy with 2,000 cows. The grass fed standard, meaning no grains in the diet, forced them to get genuinely inventive with protein. Their cows were fed a mix of sorghum, male sterile maize, alfalfa and clover silage, yielding roughly 30 litres per cow per day, which is seriously impressive. Ed's huge dedication to building soil that could grow these crops was remarkable. Yes, climate was on their side, but with not a very high rainfall it was not simple to achieve.

One of the first farms I visited in America was the Fry family in Maryland. Ed, the father, walked me through his alfalfa fields and for a moment I thought I had found the magic bullet for organic dairying, six cuts of silage a year from one crop. It turned out to be lucerne by another name, and the real lesson was that the right crop in the right conditions matters most.

Many conventional and organic herds use lucerne as a large part of the diet because it delivers home grown protein and improves soil. The Fry diet had changed little since going organic, the difference was management. Short, precise harvest intervals lifted forage quality and put better milk in the tank. With summer heat, cows grazed in the cooler parts of the day and were buffer fed year-round, a simple adaptation to climate. Ed was a businessman, and with 800 cows and close access to organic processing he secured a strong premium for his milk. It was the first time I had seen farmers negotiate directly with a processor on a long-term basis, in this case five years.

In Sri Lanka, protein was coming in very varied forms but was easily accessible. Coconut by-products, rice hulls, maize and molasses made up a nut often fed to dairy cows. They were also feeding sorghum type forages, which thrived in their climate.

Melanie and Ed Zimba

> ***"As the climate shifts, proteins that might not have suited our area before may now be possible."***

What is the future for organic dairy? https://qrco.de/bgYjEq

In practice: Getting inventive with protein, UK

Sophie Gregory NSch 2023

Closer to home on our organic dairy unit, we have grown, milled and fed peas with barley, and we have bought in oats and palm kernel this year. We have tried peas and barley wholecrop, triticale and lupin wholecrop, and wheat and beans too.

Clover is a no brainer for any system, reducing inputs on conventional or fixing nitrogen on organic. SFI has encouraged farmers who might not have tried it to test different mixes to fit the herbal ley element. Because organic protein is so expensive, over the past few years we have really tightened up our silage management: clean faces, reducing waste, and taking silage at the right time, even making a few more cuts to increase quality. Building a good relationship with contractors helps so you are higher up the list when the weather looks favourable.

There are standout innovators in the UK organic space, such as Will Armitage (see p16 and p19), who has seen success growing sugar beet to support winter milk production, and Matt Senior, who is always trialling new whole crop and protein ideas. We need people like this to test the boundaries and bring back practical ideas the rest of us can use.

UK-grown wheat and beans

Another area we have looked at is what we feed over winter in the wagon. I know this is not an option for everyone, and it does not always feel organic in spirit, but sustainable also means a sustainable bottom line, and that means reducing costs. There are a lot more options available than I realised, including from specialist organic suppliers like Rob Daykin. He has still not got me to buy a load of soya, but we have had good success with wheat feed and palm kernel alongside our own grown crops. It is all about doing the maths.

Sophie Gregory

> ***"There are a lot more options available than I realised."***

What is the future for organic dairy? https://qrco.de/bgYjEq

TALKING POINT 5:
Faba beans

Alistair McBain NSch 2023

Faba beans, although significantly lower in protein content than soyabean meal at 26% versus 46% for hi-pro soyabean meal, are the most attractive alternative grain legume. In the UK, Faba beans have a higher protein content (26%) and yield compared to peas, at 22% protein. The average protein yield per hectare based on the Processors and Growers Research Organisation PGRO descriptive list is 1,144kg of protein/ha for faba beans and 838kg of protein/ha for peas.

The use of faba beans is currently limited by several factors. One of the main factors is the nutritional profile. Faba beans are high in lysine but low in the main limiting amino acid in egg production methionine. Adding faba bean to diets therefore requires an increased requirement for synthetic methionine along with other sulphur containing amino acids such as tryptophan and arginine. This reduces the cost competitiveness of faba beans compared to soyabean meal, which as of June 2024 is around 10% more expensive per kg of protein. However, relative costs will vary depending on market conditions.

Antinutritional factors, mainly the presence of vicine and convicine, also limit the use of faba beans in poultry diets. These compounds cause favism, a condition that causes hemolytic anaemia, which can be fatal in both humans and animals. High levels can reduce feed intake, growth rates and egg production.

Work at the Swedish University of Agricultural Sciences identifying the genetic marker responsible for vicine/convicine production and a new faster breeding process means there is a wave of new low vicine/convicine varieties currently coming to market.

Tannins are another anti nutritional factor that cause problems when feeding faba beans by interfering with protein digestibility and mineral absorption. They are concentrated mainly in the hull of the bean, therefore levels of tannin can be reduced by dehulling.

Other attributes that plant breeders are basing their variety selections on include:

- **Yield** - in the past 60 years faba bean yield has tripled globally.
- **Higher protein -** the protein % of faba beans is highly influenced by genetics and less so by the environment compared to cereal crops. Dr Fred Stoddart from the University of Helsinki noted that 20% of the protein content of a faba bean is set by its environment, and the other 80% by genetics, whereas 80% of the protein content in wheat is attributed to the environment, leaving 20% to genetics. The global average protein content of faba is 29%. The average protein content of varieties grown in the UK is lower at 26%. With current plant breeding techniques it is possible to reach a protein content of 35% in theory, and Dr Stoddart suggested this could be higher with the implementation of gene editing.

- **Disease resistance** - there are many pests and diseases that make growing faba beans more challenging than cereal crops. The number one enemy across the world is chocolate spot, which can cause yield losses of up to 50%. Other diseases that are a problem in certain areas are ascotyta, downy mildew and root rot.

- **Drought tolerance** - drought is one of the major limiting factors which affects the yield of both faba beans and peas. Dr Stoddart noted that the average yield across Finland in the past few years was 2.2t/ha, whereas the most successful producers are achieving yields of up to 6t/ha. The main difference attributed to this yield difference is access to water/irrigation.

- **Earliness of maturity** - one of the main factors deterring production, especially in northern Britain, is earliness of maturity. Breeders are working on reducing the growing period to allow earlier harvests, when conditions are drier. This earliness of maturity was of particular concern for growers I visited in Alberta, where sowing dates can be as late as May with the first frosts arriving in September. Varieties that are used in Canada are more suited to their extremes in temperature, typically reaching +30°C in the summer to -30°C in the winter with no long spring or autumns to soften the change. These varieties are not commonly grown in the UK and Europe.

NB. A lot of research is being carried out to develop lupin as source of protein in Canada and Europe. Lupins have a protein content ranging from 29% to 42%, with 6% to 10% oil. The rest of the plant is mostly cell walls, which makes lupin very high in fibre. This limits its use in poultry diets and confines the crop's use mainly to dairy.

Nitrogen fixing nodules in faba bean roots

From beans to bugs – alternative proteins to drive net zero egg production:
https://qrco.de/bgYj7z

In practice: Intercropping, Canada and France

Andrew Howard NSch 2015

Intercropping or companion cropping, where two or more crops are grown together, can impact on crop nutrition, For example, it can result in a higher grain nitrogen % (and protein) in wheat when intercropped with a legume (could be due to lower yields in some cases).

Farms that have crops and livestock have the easiest options for integrating intercropping into their system. If an attempted full season intercrop does go wrong due to weeds or weather, then a livestock farmer can cut and bale or ensile the crop and still make use of the biomass. Livestock farmers can also make use of undersown crops, living mulches or cover crops by grazing or taking a fodder crop before or after the main cash crop. They are able to spread and lower the risks of intercropping.

Mapleton Organics in Ontario were growing peas and oats together for their dairy which was a very cheap and easy mixture to grow.

Malpeton Organics' peas and oats mix

Christian Abadie in Southern France used to need all his 100ha to feed his 60 dairy cows but now only needs 20ha because he has improved his soil through no-till and companion cropping. He tries to have two if not three crops per year. Next year he is growing maize, sunflower and vetch together as he thinks it will make the perfect ration combination. He is going to use taller varieties of sunflowers so they don't get shaded out by the maize. He also ensiles pea/triticale as a whole crop.

Sarah Singla in the south of France grows lucerne for silage. She plants the lucerne with a companion of beans, vetch and peas. Using this mix gives a better first cut in the spring. She is also going to plant peas and vetch with her winter wheat; take a first cut of silage in the spring then let the wheat grow on. In Switzerland it used to be traditional to grow vetch/peas and oats as a good forage together.

Andrew Howard

The potential for companion cropping and intercropping on UK arable farms:
https://qrco.de/bgYjOL

In practice: Intercropping, UK

Gordon Whiteford NSch 2015

> ***Intercropping or companion cropping is where two or more crops are grown at the same time on the same land area. This makes use of natural synergies between plants, adding diversity to the soil."***

This is something we are doing on my home farm in Morayshire. In 2015 spring wheat (60%) and peas (40%) were sown together as a companion crop. This crop was then taken through to harvest and stored in its mixed form, having yielded over 5t/ha with no inputs.

The synergy of two crops mitigates any fungicide requirements, while peas are contributing nitrogen to the soil and the wheat helps hold the peas up. The improvement in the soil was evident, with a 300-400% increase in the number of earthworms in one year. This crop was then added to the home-mixed hen feed at 10% and the hens produced extremely well.

Furthermore, it saved on purchased soya, contributing to the value of the wheat/pea mix so that it was worth £142/t; this can be compared to a wheat price of around £100/t [prices at the time of writing the report in 2015].

Hens at the home farm

> ***Spring wheat (60%) and peas (40%) were sown together as a companion crop."***

Gordon Whiteford

Improving bird welfare on free-range systems:
https://qrco.de/bgYjQf

In practice: Home-grown concentrate, Denmark

Wil Armitage NSch 2013

I went to visit a number of good farms in Denmark with Kenneth Sobye, the product manager for Limagrain. We saw some some very high tech conventional farms, but one stood out and that was an organic farm with 130 cows yielding 9,500 litres and growing all their own feed - maize, lucerne, grass and rye plus the concentrate mix.

Hans's home grown concentrate was a mix of spring wheat, lupins and peas growing in a single stand that he combined and then heat-treated through a home-made drying system which comprised essentially a long auger that turned very slowly with a fire built around it. This cooked the feed and so reduced the protein deamination in the rumen - meaning he had more bypass protein for the small intestine to digest.

His aim was to achieve 180°C for 24 minutes. Unfortunately he could only spare me a little time in his fields so I did not see this in operation, but his crops looked fantastic. He was running a five year rotation on his arable block of rye undersown with lucerne, then lucerne for two years, maize and then spring wheat, lupins and peas.

Triticale, lupins and peas

Wil Armitage

Sustainable milk production: The vital role of soil for feed integrity:
https://qrco.de/bgYjUT

TALKING POINT 6:

An alternative view on protein for dairy cows

Iwan Vaughan NSch 2017

> ***Through extensive travel and information-gathering it is clear the UK has a long way to go to reduce overall protein feeding and become more efficient in terms of rumen N utilisation."***

We currently over feed crude protein in ruminants, especially dairy. Targeting lower crude protein diets while targeting higher microbial protein production in the rumen is far more efficient and environmentally efficient to start before looking for alternative protein sources.

From the information I gathered in the States it is clear that running a low N base diet can be effective in producing high yields. In the UK diets are predominantly based on grazed grass or perennial grass silage, which are high in N, and low in fermentable carbohydrates. The Americans see our cows as thin hat racks, with no rumen fill exactly for this reason. We can make the excuse that the States has different and better quality forages. However, we just need to understand our forages better and feed accordingly to maximise microbial protein yield.

Microbial protein synthesis needs to be the driver for metabolisable protein supply to the small intestine. The rumen needs to be fed rumen-degradable protein when required to achieve this. If rumen energy and rumen ammonia are as close in synchrony as can be possible, supplementation of bypass protein needs to be considered. When asking Prof. van Amburgh from Cornell University what is missing currently in UK ruminant diets, he replied: "The UK don't use enough rumen-protected soybean meal."

Although we in the UK are trying to reduce imported soya bean meal intake, we can add rumen bypass protein in the form of protected soybean meal to match metabolisable protein (MP) requirement on top of the microbial protein which has been supplied from the rumen. Although the feedstuff would be more expensive, we can reduce total protein cost and be more efficient in the N we use. As an alternative to protected soybean meal we could supplement formaldehyde-treated rapeseed meal: this could be more cost effective and produced from UK- or EU-sourced rapeseed meal.

Once the rumen and MP supply have been balanced we can then look at amino acids (AA) and supplementing where required. Most UK diets will be deficient in methionine and, depending on yield aspirations, should be supplemented accordingly with metabolisable energy (ME) supply. It will be crucial going forward to formulate diet on AA supply and shortfall to realise the potential of the cows we are feeding.

Feeding high crude protein (CP) grass or grass silage could mean there is enough CP. However, increasing bypass protein and supplementing AA can increase performance. With reduced use of CP on farm in the UK I have seen an initial saving of 0.3-0.5p/litre on feed costs. This equates to £4,000/year for every 1,000,000 litres sold; and this does not include benefits of higher health status and reproductive performance which will increase yield and dilute feed costs down further.

Iwan Vaughan on his Nuffield travels

> ***"From the information I gathered in the States it is clear that running a low N base diet can be effective in producing high yields."***

Sustainable protein feeding for the UK dairy industry:
https://qrco.de/bgYjAF

In practice: Home-grown protein for dairy cows, Sweden

Wil Armitage NSch 2013

Olaf Jansen is a farmer and botanist I visited in Sweden in June 2013. He farmed 800ha organically, 1,100ha of forest and had 340 dairy cows.

Cows	Litres	Butterfat %	Protein %	Calving intervals
230 Holsteins	10,700	3.91	3.21	13 months
110 Swedish Reds	9,200	4.03	3.34	11 months

He grew all his own food and was adamant that plant diversity and crop rotation were key to the success of his business. Olaf used a seven year rotation:

Year	Crop	Seed mix
Year 1	Wholecrop	80kg/ha spring beans and 160 kg/ha wheat undersown with a ley mix which was sown at 45 kg/ha: 25% lucerne 10% red clover 5% white clover 35% timothy 15% rye fescue 5% meadow fescue 5% ryegrass
Year 2	Silage x 3 cuts	
Year 3	Silage x 2 cuts	
Year 4	Winter OSR	
Year 5	Winter Wheat/triticale	
Year 6	Field beans + wheat combined	
Year 7	Oats or triticale	

His forage quality was good, averaging 16% protein. He then made his own concentrate at 21% rotein that he mixed with his forage to end with an overall protein of 17.5% - he felt that was the optimum for his cows, given the amount of milk they were producing.

He ground all his own feed through a disc mill and with whole OSR going into the meal mix he had a meal with an ME of 15 and an oil of 73g/kg.

His cows looked really well with great skins – they were bright and alert when I saw them, and grazing in a mixed sward with the same ley mix as above. He was not concerned with any potential bloat problems.

As he had been a botanist and studied for many years, it was very useful speaking with him. Olaf believed diversity held the key to agriculture's future with the synergies that could be achieved between crops and sound rotation.

Sustainable milk production: The vital role of soil for feed integrity:
https://qrco.de/bgYjUT

TALKING POINT 7:

Market demand - insects for animal feed and petfood

Dr Olivia L. Champion NSch 2022

> ***In the UK, supermarkets are putting increasing pressure on feed producers to eliminate soya from poultry diets, and feed mills and poultry producers are looking for consistent, sustainable, soya-free ingredients; soya currently costs around £350/t."***

Assuming insect ingredients contain the same crude protein content as soya (50%) then the price of insect meal must be comparable with soya to be competitive. Currently, insect meal is selling for around £3,500/t. As pressure increases, some of the premium supermarkets may be prepared to pay a premium to eliminate soya (e.g. Waitrose and M&S) whereas other supermarkets will probably stick to conventional soya diets. This is unless the carbon footprint of feed ingredients is accounted for in the cost.

Aside from the high cost of insect meal, if edible insect producers are marketing products as a protein replacement, it must be available on a sufficient scale with reliable supply (20-50,000t/year). However, production of insects is still predominantly small scale. If demand for insect protein for animal feed grows then there will be competition for the edible insects that are produced with large feed companies able to rapidly buy up all the edible insect stock, causing difficulty for smaller companies that don't have the buying power.

The final piece of the 'insect ingredients for livestock feed' jigsaw was to meet with feed mills and livestock farmers using, or interested in using, edible insect products including Humphreys Feed and Pullets and St Ewes. At present, insect-based protein replacement products (which may include added functionality) are valued at around £3,500/tonne, which is not economical for farmers or feed mills. However, edible insects are used on Kipster farms in Netherlands for layer flocks as part of their strategy to reduce carbon emissions and they produce the most sustainable egg!

Pet food is the most accessible market into which insect ingredients can be sold as it is less price sensitive and not subject to the same regulations as the human food chain. All the insect farms that I spoke to are selling predominantly into the pet food market and many small companies have set up, producing insect pet products such as dog treats.

However, as bigger companies, such as Pets Corner, move into the insect pet food market the demand for insects is creating problems for the smaller companies. This is already happening with one UK-based insect dog treat producer that I spoke with. The founder of the company told me that dried mealworms can be sourced from China, but with the rising costs of shipping and the sharp increase in the product itself they are beginning to look elsewhere for supply. Their current supply costs £5,500 per tonne, which has risen greatly due to increased shipping costs and a major supply shortage.

Olivia Champion

Can carbon neutral insects be farmed profitably? https://qrco.de/bgYjc4

In practice: EnterraProtein, Canada

Charlie Steer NSch 2019

Food waste can provide the feedstock for another interesting addition to the bioeconomy - insect agriculture, aka fly farming. Enterra began in 2007 with the aim of solving two global problems: the need for finding new, sustainable sources of protein for animal feed and addressing the high prevalence of food waste.

The Enterra team's solution to these problems came in the form of a beneficial, non-invasive insect species called the Black Soldier Fly (BSF) and by developing techniques to replicate the natural BSF lifecycle. Unlike AD, where the feedstock is both pre- and post-consumer, Enterra use only preconsumer waste food to feed the fly larvae. This recycled food is collected from local farms, grocery stores and food production facilities and contains a mix of fruits, vegetables, and grains.

The BSF larvae grow rapidly under controlled conditions, efficiently converting the nutrients in the recycled food into protein and fat. The larvae are then dried and processed into three products:

- **EnterraGrubs** – a feed supplement for poultry, wild birds, and other insectivorous animals.
- **EnterraProtein** – made from de-fatted larvae. This it is an excellent source of digestible protein and can be easily blended into commercial feed pellets for fish, poultry and pets.
- **EnterraOil** – the fat component extracted from the larvae can also be blended into feed pellets or used as a pellet coating for enhanced flavouring.

The manure from the larvae is also collected and EnterraFrass is a fertiliser made from the 'frass' (manure) of the BSF larvae. To convert food waste into the products listed above, Enterra's flies consume 130 tonnes of Alberta's food waste each day. This is de-packaged, if required, then blended into a smoothie which is fed into a vertical farming system on just four acres in an industrial area on the outskirts of the city.

A Canadian AD plant I visited, owned by Buck Ross, and Enterra both provide a solution that adds value to waste streams otherwise destined for landfill. The interesting part of the operations is that co-locating the fly farm, which requires energy as an input, with AD could provide a neat, and very circular set of food waste processing options. Food can be sorted into pre- and post-consumer: pre-consumer destined for the fly farm operation, post-consumer to the AD processor. Energy from the AD, both electrical and heat can be diverted into the fly farming operation, the cycle can be added to, and the value-added increased.

Charlie Steer

The circular farm: https://qrco.de/bgYjeq

TALKING POINT 8:

The nutritional composition of insect larvae

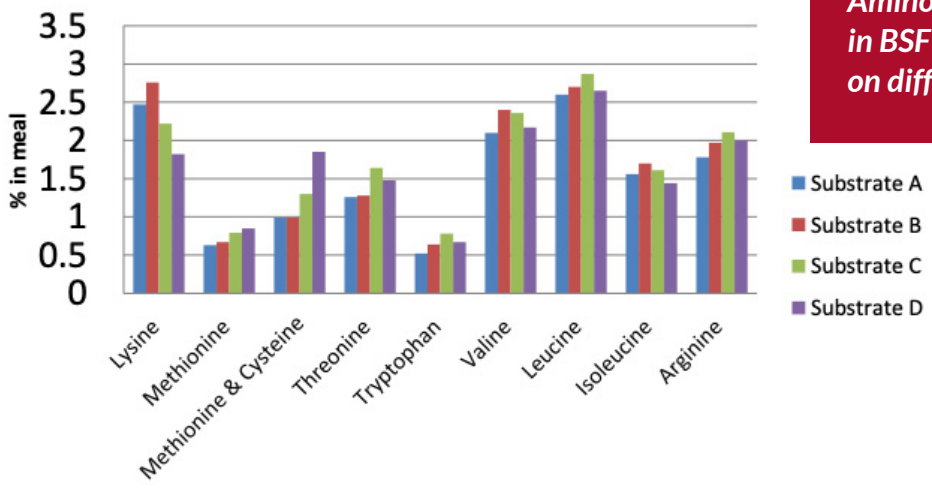
Dr Aidan Leek, NSch 2015

> ***The phrase 'you are what you eat' really seems to apply to insect larvae. Certainly in the case of BSF, the substrate they are grown on appears to determine their amino acid composition, mineral uptake, and fatty acid profile. Some data on this was shared with by Enviroflight in Ohio"***

Protein and amino acid concentration

Variations on the amino acid profile were observed with the use of different substrates. This will have quite an impact on the way nutritionists would formulate with insect meals. For nutritionists it will be important to know the substrate used and the amino acid profile that it will generate.

Consistency of the substitute material will also be important to maintain consistency of the protein quality, i.e. the amino acid profile, in the final product. The variation in amino acid profile will be challenging for the feed industry to know the nutritional value of the insect material that is received, as it is not commonplace for routine direct measurement of amino acid levels in feedstuffs. Normally, amino acids are a calculation from an assessment of crude protein by wet chemistry or Near Infra Red (NIR) spectroscopy.

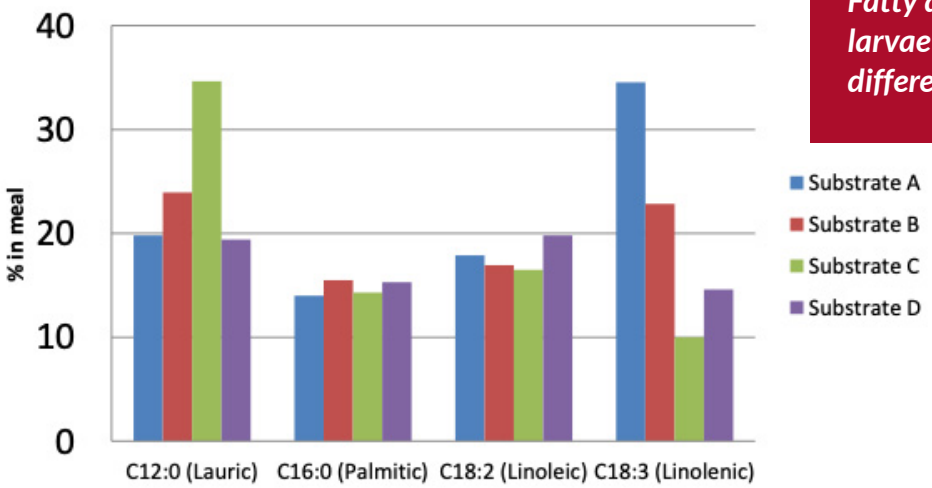


Amino acid concentration in BSF larvae meal reared on different substrates

Source: Enviroflight

Oil and fatty acid concentration

Where insect fats are being used in feed, the variation in fatty acid profile will also be important to understand. This is particularly relevant where functional values are being ascribed to particular fatty acids, rather than just an energy source e.g. high lauric acid for intestinal health or high omega 3 or 6 for product enrichment. The energy level of insect meals will be affected by the oil level in both full-fat meals or defatted meals. Estimates on energy vary between 14.2MJ and 17.9MJ in the literature.



Fatty acid profile of BSF larvae fat reared on different substrates

Source: Enviroflight

Dr Aidan Leek on his Nuffield travels in China

> ***"The phrase 'you are what you eat' really seems to apply to insect larvae."***

The future for insect bioconversion products in poultry feed:
https://qrco.de/bgYjjk

TALKING POINT 9:
Insect protein for broilers

George Roach NSch 2023

> ***When looking at whether insect protein has any real-world potential to offer the UK broiler industry, the insect industry faces significant challenges."***

Insect agriculture is still in its infancy with global production being, at best, 0.05% of soya output. This problem is multiplied by the fact that the cost of insect meal is over 10 times greater than soya in Europe and that it cannot currently legally be fed to birds in a practical way in the UK.

However, this does not mean that I believe the concept of insects as feed is redundant. The fact remains that insects will convert almost anything into protein. That the industry is in its infancy is a benefit. There are still substantial improvements to be made, and the cost of production will come down. When looking at labour vs automation, I believe the best solutions are the half and half solutions offered by the likes of Insect Engineers redesigning existing mushroom farming conveyor belts or Entroprot's bioreactor. These options could greatly reduce the labour requirements without overengineering the solution, something that will likely suit farmers!

There is huge potential for insect agriculture. If it is adopted by the waste processing industry, the principal return may be the gate fee on the waste. On top of that as insects speed up the process of transforming the waste compared with composting, the firms would benefit from increased through-put through existing facilities. Further, they could extract insect oil from the dried larvae which can be used as biodiesel, and they will also have the frass (the solid matter from insect manure) that can be used as a fertilizer instead of compost. Plus, at the end they would also have produced a by-product of protein meal which might, depending on the substrate and possibly changes in regulations, also provide a valuable byproduct.

Whether or not the benefit will be seen by broiler producers remains to be seen. Insect meal production will likely be dominated by specialist multinational companies as is becoming more common in agriculture more generally, limiting the chance for farmers to capture the benefits on farm. However, I feel there will be a place for both large and small scale production with the broiler industry offering a potential template as insect agriculture grows. Companies specialising in genetics, breeding, production and centralised processing would help the industry reach the economies of scale it so desperately needs.

Insect farming could form an integral part of a mixed farm subject to legislation change and reduced cost of production. Insects can be grown using farm waste and bioproducts, and by adoption of basic processing in the form of drying they can then be used as supplementary feed to poultry or pigs in the same way that whole wheat is often incorporated into a poultry ration on farm currently. They would then also provide fertiliser in the form of frass for use on farm. This is a truly circular system and where, in my opinion, the industry should go. Whether or not it will is yet to be seen.

George Roach

> ***"The fact remains that insects will convert almost anything into protein."***

There is a buzz around insect protein in the broiler industry, does the idea have legs? https://qrco.de/bgYjlr

TALKING POINT 10:
Insects and UK regulatory issues

David Tavernor NSch 2024

In the UK, insects may only be reared on approved substrates, which generally exclude low-cost organic waste streams, such as food waste or animal by-products. Instead, black soldier fly (BSF) farmers must rely on expensive pre-consumer food waste, dramatically increasing production costs.

Not only does this restriction diminish one of the key advantages of BSF farming: the ability to valorise waste streams that would otherwise go to landfills. But it significantly increases the cost. One tonne of defatted insect protein would cost anywhere between £1,000 and £2,500 on feedstock alone. Quite the price for a waste product and makes soy protein look very enticing indeed.

Insects are currently identified as livestock, so cannot technically be fed un-approved feedstocks, even if the BSF is solely used as a waste processing agent. However, we have a special exemption for feeding animal by products to maggots used for fishing bait. Further clarification is needed on this if we are to give ourselves the tools to approach food waste problems in the UK.

On the product side, UK Transmissible Spongiform Encephalopathies (TSE) related laws state processed animal protein (PAP), including insects, can only be used in aquaculture feed, with prohibitions on its use in poultry, pig, ruminants, etc. This limitation significantly narrows the potential customer base and reduces demand for BSF protein. An interesting loophole in the UK legislation currently permits feeding of live insects to livestock, regarding that they are not processed.

Globally, more permissive regulatory environments have allowed the BSF industry to thrive:

- **European Union:** Insect PAP is approved for poultry, pig, and aqua feeds, providing a broader market base.
- **Africa:** Countries like Kenya and South Africa have fewer restrictions on feedstock usage, enabling BSF farmers to use organic waste streams effectively. These regions also have growing markets for frass as a soil improver.
- **North America:** The USA and Canada have adopted a more flexible approach, permitting a wider variety of feedstock inputs and encouraging innovation in product applications.

The UK's regulatory stance contrasts sharply with these regions, leaving its industry at a competitive disadvantage.

David Tavernor

Building a black soldier fly industry in the UK: https://qrco.de/bgYjoD

TALKING POINT 11:

Single cell proteins

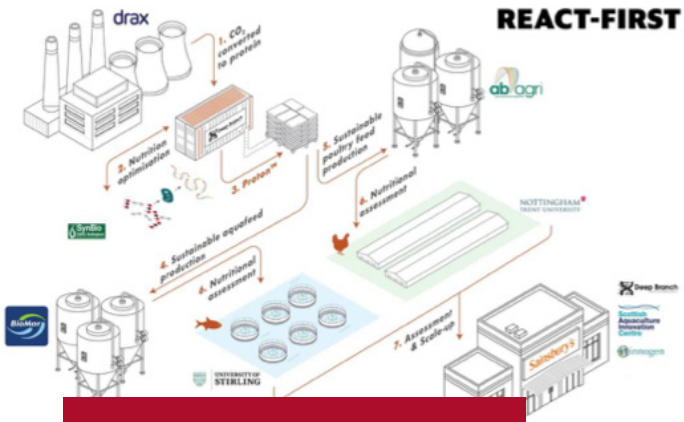
Alistair McBain NSch 2023

Single cell proteins are derived from the biomass of microorganisms (bacteria, algae and yeast), which are cultivated in controlled environments. They are grown on various substrates, from crop residues, industrial by-products, specially designed growing media and even CO_2. As well as being used in animal feed, single cell proteins are also being developed to produce meat analogues.

One of the major opportunities in the production of single cell proteins is the use of CO_2 as the growing media. This was seen on a visit to the University of Kentucky's Centre of Applied Energy Research. They have a project underway to develop a method of growing algae by capturing CO_2 from coal fired power stations in the US, to help them meet carbon reduction targets. The algae fed from the CO_2 from the power stations would be harvested and biorefined into several different products, including biodiesel, bioplastics and protein. One issue that the researchers have faced was that the algae required a specific temperature range to grow. This temperature was only achieved during summer, which meant that scaling the algae production up was not feasible for power stations who require a year-round solution to capture CO_2.

An alternative option for capturing CO_2 is currently being researched and trialled at Nottingham Trent University in partnership with Drax power station, biotech company Deep Branch and other industry partners. Deep Branch has developed a process that uses microbes to convert CO_2 into protein. Nottingham Trent will trial the effect of the protein on the performance of broiler chickens. It is hoped that the trial will start during 2024.

The carbon foot print of single cell proteins varies between products depending on their production process and should be assessed on an individual basis. One of the most exciting factors of the use of single cell proteins is their ability to utilise waste CO_2 from industrial processes, potentially providing a negative CFP. Due to the high moisture content of the production process, drying is required to produce a stable product, but this adds cost and carbon to the process.



React First project illustration

Source: Nottingham Trent University

From beans to bugs – alternative proteins to drive net zero egg production:
https://qrco.de/bgYj7z

In practice: The varied diet of the Danish free range hen

Dr Aidan Leek NSch 2015

Around 22% of egg production in Denmark is under organic rules. Although it allows for a higher rate holding size that under UK rules, the rules surrounding feed are the same. Organic sector demand has largely driven interest on the use of insects in poultry diets and there is other advanced thinking in Denmark on alternative, sustainable feed materials.

Another example is the use of forage in laying hens. What is unusual is the smell of silage that hits your nose when you enter an organic laying house in Denmark. It is common place for hens to be fed an ensiled mix to complement a nutrient-adjusted layer compound diet. This mix can be either high energy (whole crop cereals) or high protein (pea, bean, alfalfa mix). Even some root crops are used e.g. carrots. The silage is either delivered from the clamp or from wrapped bales. It is then dropped into a robotic dispensing system that chops and spreads the forage over the scratch or veranda areas three to four times per day.

On the farms I visited, forage intake was around 40g/bird/day in addition to 120g of pelleted feed. Structural fibre is recognised as a benefit to the birds' digestive system. Levels of production were excellent and the bird clearly performed well on this system, still achieving 94% production at 39 weeks.

Forage feeding system in Denmark

The future for insect bioconversion products in poultry feed:
https://qrco.de/bgYjjk

Putting it into practice: Recommendations for the egg sector, but applicable more widely

Alistair McBain NSch 2023

1. Currently the use of South American soya bean meal and oil makes up around 60% of the carbon footprint of an egg. The use of alternative proteins will play a major role in driving the egg production sector towards net zero.

2. Currently none of the alternative proteins studied were considered complete replacements for soyabean meal. A combination of alternatives is required to replace soya. This makes the feed production process more complex.

3. Egg producers need to evaluate available alternative protein sources. This will vary by country. Accurate testing is often required to establish the nutritional quality of the protein source. Care must be taken to formulate a balanced diet. Synthetic amino acids will play a large role in balancing the amino acid profile in reduced and no soya diets.

4. Novel protein sources, such as insect protein and single cell proteins, have the most potential in terms of net zero egg production. Their potential use in a circular economy, whether upcycling of food waste, or the capture of CO_2 from power stations, gives the potential of a negative carbon footprint. However, these are not commercially viable in most production situations.

5. Recent advancements in breeding are bringing faba beans to market with lower levels of vicine and convicine, considered a major anti nutritional factor to poultry.

6. It is hoped that regulatory changes in the UK in 2025 will allow the use of processed animal proteins to be used in poultry and pig rations. The same set of regulations are expected to allow the use of insect protein meal.

From beans to bugs – alternative proteins to drive net zero egg production:
https://qrco.de/bgYj7z

Putting it into action: Recommendations for the wider sector

Alistair McBain NSch 2023

1. Retailers should look to incentivise the use of alternative proteins, to allow their use to be financially viable for producers. This will assist retailers in their drive to reduce their scope 3 emissions.

2. Carbon accounting methods must be standardised in their method of calculating the carbon footprint of food production to allow comparisons to be made.

3. The method of allocating the carbon footprint of industry by-products should be weighted more towards the primary product to encourage the use of by-products as part of a carbon reduction plan.

4. Investment in the breeding of faba beans and other protein crops is relatively low in the UK due to the relatively small area of protein crops grown. More government and industry investment is required to further develop these crops, making them better suited for our changing climate and for the nutritional requirements of livestock. An increased supply of UK grown protein crops will reduce our reliance on imports from other countries, strengthen food security and limit the impact of global market fluctuations on producers and ultimately consumers.

From beans to bugs – alternative proteins to drive net zero egg production:
https://qrco.de/bgYj7z

Think ahead: Resources for further information

There are a range of organisations and establishments who can help with assessing the benefits (and drawbacks) of novel proteins and feed efficiencies.

This list (which is not exhaustive or in any particular order) may be able to provide help and support in terms of researching alternative proteins and assessing their role and impact in feed efficiencies.

Processors and Growers Research Organisation (PGRO)
As the UK's centre of excellence for peas and beans, the PGRO has a track record of providing authoritative, up to date information (including practical agronomy guides) and research. A non-statutory levy body, it is supported by grower members, the UK trade and outside funding for research work carried out on its own and in partnership with other organisations.
https://www.pgro.org/

Nitrogen Efficient Plants for Climate Smart Arable Cropping Systems (The NCS Project)
This farmer-led research programme involves 17 industry and research partners and over 200 farmers. PulsePEP is the farmer-led community for the NCS Project and is free to join. Its aims include reducing carbon emissions, increasing pulses and legumes in arable rotations and reducing imported soya meal, with potential cost savings of over £1bn/year.
https://ncsproject.co.uk/

VALPRO Path Knowledge Point
This is a central online hub for exploring innovative practices in land-based protein production, consolidating project experiences and insights. Designed for a broad range of stakeholders, it presents key concepts and the results. It engages experts and provides accessible content, allowing knowledge transfer and accelerating adoption of new plant-protein innovations.
https://valpropath.eu/

Innovative Farmers
Innovative Farmers is a not-for-profit membership network, for farmers and growers who are running on-farm trials to test innovative new practices. This farmer-led research allows them to collect robust data which is relevant to the real-world farming environment and easily transferable to their businesses.
https://www.innovativefarmers.org/

The British On-Farm Innovation Network (BOFIN)
BOFIN was founded in 2020 on the belief that farmers should be at the forefront of agricultural innovation – helping to shape research and development for the future of the industry. The BOFIN model is based around a 'Knowledge Cluster' which engages farmers and shares learning and insight from its projects. Joining BOFIN is free and includes membership of its Knowledge Clusters.
https://bofin.org.uk/

Soya UK
A commercial seed merchant, Soya UK deals in a range of crops including soya, white, blue and yellow lupins, mammoth millet, spring triticale and wholecrop mixtures. It is also involved in seed production, crop trading and exporting, as well as farming in its own right. Its website offers a range of information booklets and videos.
https://soya-uk.com/

ADOPT
ADOPT (Accelerating Development of Practices and Technologies) is a funding competition designed to support farmer-led, on-farm trials and experiments. Funded by the Defra and delivered by Innovate UK, it aims to generate, test, and demonstrate innovative solutions to challenges in agriculture, horticulture, and forestry. The full ADOPT Grant to support projects with costs of between £50,000 to £100,000.
https://www.farmpep.net/adopt/front

Innovation for Agriculture
Helping farmers put innovation into practice, Innovation for Agriculture connects farmers with farming research. It works with leading agricultural researchers, businesses, landowners, and farmers to develop the knowledge and technologies that will make modern farming more sustainable, resilient, and productive. Through practical and interactive workshops, farm walks, and on-farm demonstrations, we help farmers to put this knowledge into practice.
https://www.i4agri.org/

UK Agri-Tech Centre
An independent organisation, it aims to deliver solutions to agriculture's most complex challenges by accelerating innovation through expert insight, advanced facilities and strategic support. In collaboration with farmers, the agri-food industry and some of the best research institutions and most innovative companies in the world, it provides leadership and guidance to progress change.
https://ukagritechcentre.com/

Monitor Farm Scotland
Scotland's Monitor Farm initiative has pioneered new ways of working, experimented with new ideas and measured the inputs and outputs of host farms to improve their productivity and profitability. The current programme launched in November 2022 running to 2026 and features nine farms. The programme is managed by Quality Meat Scotland with support from AHDB and is fully funded by £2 million secured from the Scottish Government's Knowledge Transfer and Innovation Fund.
https://www.monitorfarms.co.uk/

AHDB Strategic Farms
AHDB's Strategic Farms, part of its Farm Excellence platform, deliver sector-specific improvements, with a focus on technical performance (as opposed to the whole-farm business performance focus of AHDB's Monitor Farms). The network of strategic farms across the UK encompasses arable, dairy, and beef and sheep, with meeting topics being based on demand from those who attend.
https://ahdb.org.uk/farm-excellence-strategy

Innovate UK Business Connect
Innovate UK Business Connect is part of UKRI (UK Research and Innovation, the UK's national funding body for science and research. It has a specific focus on agrifoods as well as many other sectors. It provides expertise, opportunities for funding and builds communities around emerging innovations. Its networks span business, government, funders and research.
https://iuk-business-connect.org.uk/

Scottish Government Knowledge Transfer and Innovation Fund
This provides funding for projects which aim to deliver innovative on-the-ground improvements in agricultural competitiveness, resource efficiency, environmental performance and sustainability. Funding support will meet the running costs of operational groups seeking to implement innovative projects in these areas.
https://www.ruralpayments.org/topics/all-schemes/knowledge-transfer-and-innovation-fund/

Farming Connect (Wales) – Try-out Fund

The Try-out fund has been developed to address specific local problems or opportunities in Wales with the aim of improving efficiencies and profitability within agricultural businesses while protecting the environment. It is only open for applications for a short window each year, with maximum funding of £5,000 to put towards an on-farm trial to try-out ideas and bring them to life.

https://businesswales.gov.wales/farmingconnect/our-farms/try-out-fund-bringing-your-idea-life

Innovation visits – CAFRE, Northern Ireland

This provides farmers with the opportunity to visit farm businesses in other parts of the UK or Europe to learn about new innovations being used in other countries but not yet in Northern Ireland. Each visit has a specific theme, and visits are organised and led by a CAFRE adviser or technologist. The main costs of trip are met through the Sustainable Agriculture Programme.

https://www.cafre.ac.uk/business-support/knowledge-transfer-programmes/innovation-visits/

Nuffield Farming Scholarships Trust - Scholarships

NFST aims to inspire passion in people and develop their potential to lead positive change in farming and food. It awards about 25 life-changing scholarships each year that unlock individual potential and broaden horizons through study and travel overseas, with a view to developing the farming and agricultural industries. More than 1,000 Nuffield Farming Scholars have completed their studies and travel.

https://www.nuffieldscholar.org/

Nuffield Farming Scholarship Trust - Next-Gen Scholars

The Next-Gen Scholarships are focussed on young people aged 18-24 as part of Nuffield Farming Scholarships Trust's initiative to develop young talent. They aim to help young people establish themselves in agriculture, using the Nuffield Farming network to link successful applicants directly to farmers.

https://www.nuffieldscholar.org/scholarships/nuffield-farming-next-gen-scholarship

Think ahead: Academic resources

Universities, research centres and other academic institutions can be a useful point of contact if you are considering growing, producing or using novel proteins for feed. They may be able offer a research project with an undergraduate or postgraduate student, or help with other queries. Again, this list is not in any order and is not comprehensive:

Rothamsted Research
Rothamsted Research is a world-leading, non-profit research centre that focuses on strategic agricultural science to the benefit of farmers and society worldwide. This includes being part of the £13.8m 'AgZero+' five-year research programme. This aims to support the UK's transition towards home-grown food production that is sustainable, carbon-neutral and has a positive effect on nature. It has also published a scientific paper on the potential for soya production in the UK.
https://www.rothamsted.ac.uk/

Harper Adams
Harper Adams says it is the University for food production and technology, animal health and wellbeing, and their contribution to sustainable, living environments for our planet's inhabitants. It has departments, curricula, and research specialisms in a wide variety of subjects, including technology, science, environment, engineering, entomology, plant science, animal wellbeing, veterinary science, sustainability, digital, data science and policy.
https://www.harper-adams.ac.uk/research/905/at-harper-adams-university/

SRUC
SRUC has a focus on education, research, and consultancy (through SAC Consulting). Working in partnership, it focuses on solving the 'wicked challenges' facing the planet, including climate change, biodiversity and access to nutritious food and clean water. Its Challenge Centres focus on critical areas to generate solutions and share research that delivers impact that brings about change.
https://www.sruc.ac.uk/research/challenge-centres/

Royal Agricultural University
The RAU's approach to research is formulated around collaborations between scientists, farmers and innovators. Located in a largely rural area, it leverages collaborations, and develops innovative research projects, embracing farmer-science and farmer-led innovation networks. Its six research clusters include sustainability, regeneration and biodiversity in agriculture, livestock health and welfare and food policy, quality and security.
https://www.rau.ac.uk/research/research-at-rau

University of Reading School of Agriculture, Policy and Development

Reading has expertise spanning agriculture, animal science, international development, environmental management, food marketing and consumer behaviour. Its animal sciences work is focussed on increasing the sustainability of animal production, while its crop science research is tackling issues such as sustainable intensification of crop production, breeding for climate resilience, and horticultural growing technologies and systems.
https://www.reading.ac.uk/apd/

Newcastle University

Newcastle's agricultural research strengths are in production systems and food systems. Its work focuses on enhancing productivity and sustainability in livestock and arable agriculture and addressing sustainable development issues in relation to food. Its researchers are looking at areas including precision agriculture, robotics, and new production systems such as vertical farms.
https://www.ncl.ac.uk/nes/our-research/agriculture/

The James Hutton Institute

Using the latest advancements in robotics, drones, sensors, and gene editing, the Dundee- and Aberdeen-based JHI delivers precision solutions to the challenges facing modern farming. Its focus on big data and visualisation means it can decode large-scale biological data, unlocking new insights into sustainability, biodiversity, and global food security, and making data accessible, meaningful, and impactful.
https://www.hutton.ac.uk/scientific-services/research-collaborations/

SPONSORS

Central Region Farmers Trust

Central Region Farmers Trust's mission is to provide funding for education that benefits agriculture and horticulture in the central region. It strives to support farmers in adopting sustainable farming practices and enhancing their skills for a thriving agricultural sector.

www.centralregionfarmerstrust.org

Gloucestershire Agricultural House Foundation

Helping Agriculture in Gloucestershire by supporting the education, development and needs of people in the industry.

Elizabeth Creak Charitable Trust

The Elizabeth Creak Charitable Trust is a grant giving body that invests in people who will advance healthy, fair and sustainable UK food production. Grants finance projects that help farmers innovate to survive and thrive while scholarships support and encourage individuals to innovate sustainable practices in farming.

www.elizabethcreak.co.uk

Royal Agricultural Society of England (RASE)

The Royal Agricultural Society of England (RASE) is an independent charity and membership organisation dedicated to supporting the progression of knowledge and innovation within the agricultural community.

www.rase.org.uk

IN SUMMARY

This Bitesize Guide, from the Nuffield Farming Scholarships Trust and RASE, provides a snapshot of the breadth and depth of reports available at

https://www.nuffieldscholar.org/reports

The website also features reports from global Nuffield Farming Scholars, including Australia, New Zealand, USA and Brazil. The reports are a rich source of inspiration, case studies and thought-provoking recommendations for farming, food, horticulture, forestry and ancillary industries.

Please get in touch at info@rase.org.uk if you have questions, comments or feedback.

RASE

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