Technical Note 1

ICOPP

Improved Contribution of Local Feed to Support 100% Organic Feed Supply to Pigs and Poultry

Fulfilling 100% organic poultry diets: Concentrates

Introduction

The main dietary challenge for poultry producers is ensuring that feed fulfills the nutrient requirements of poultry, in particular with regards to protein and the correct amino acid profile. This is a particular challenge for organic poultry producers as the use of synthetic amino acids is not allowed. There has been a derogation from the EU Organic Regulatory Board to allow organic pig and poultry producers to include up to 5% non-organic feed within their rations to assist in meeting the nutritional requirements of the animals. This derogation was due to finish at the end of December 2014 but has now been extended to 31 December 2017 when it will become compulsory under EU Regulations (EC) no 889/2008 to provide all organic livestock with feed derived from 100% organic origins. This guide analyses the potential of locally produced and novel protein sources as viable, alternative feed sources for the organic poultry industry. See ICOPP Technical Note 2 for information on feeding roughage and foraging from the range.

Nutrient requirements of poultry

Nutrient requirements of poultry are relatively high due to their rapid conversion of feed into food products (eggs and meat). Deficiencies of essential amino acids result in retarded growth, reduced egg size or egg production, and outbreaks of abnormal behaviour such as feather pecking, which also indicates a reduction in animal welfare. If a diet is deficient in certain amino acids, over-consumption of feed may occur in an attempt to resolve the deficiency. This may lead to over-consumption of protein (nitrogen) and higher nitrous oxide (a greenhouse gas) emissions associated with manure leading to negative impacts on the environment. Conversely, if a ration is high in protein, lowered consumption may occur resulting in lower intake of amino acids.

Therefore, it is important to correctly balance protein/ amino acid requirements to ensure productivity, bird welfare and sustainability.

Table 1 illustrates the most limiting amino acids in laying hens and broilers and shows the recommended requirements of layers (at different feed intakes) and broilers at different ages. Methionine (Met) is the most limiting amino acid in poultry production and so supply of Met is of paramount importance. Table 1 also shows the increased protein and amino acid requirements at younger broiler ages due to the rapid development of broilers during their first few weeks. Tailoring feed rations

Table 1. Amino acid requirements as percentage of laying hen/broiler diets (Merck vet manual 2014)

	Layers (brown eggs)		Broilers (weeks old)		
			0-3	3-6	6-8
Feed intake g/b/d	100	120			
Protein %	18.0	15.0	23.0	20.0	18.0
Methionine %	0.36	0.30	0.50	0.38	0.32
Met+Cystine %	0.71	0.59	0.90	0.72	0.60
Arginine %	0.85	0.71	1.25	1.10	1.00
Lysine %	0.84	0.70	1.10	1.00	0.85
Tryptophan %	0.19	0.16	0.20	0.18	0.16
Threonine %	0.57	0.48	0.80	0.74	0.68

for poultry according to their stage of development (e.g. by approaches such as multi-phase feeding) maximises the nutritional value of the diet and provides a more sustainable feeding regime since it prevents over-feeding of protein due to an incorrect amino acid profile.

Lysine is generally the first limiting amino acid in almost all practical diets, so if diets are formulated on a lysine basis, the other amino acid requirements should be met. Lysine requirements vary throughout the production stages of pigs. As pigs mature their amino acid requirements decline.

Protein and methionine contents of feed ingredients

In poultry production a digestible methionine content of 0.3-0.5% is required. Table 2 provides an overview of ingredients with a digestible methionine content of at least 0.3%.

Table 2 Overview of crude protein content (%), digestible methionine content (Dig. Met. (%)), and Dig. Met. content as % of crude protein (CP), sorted by Dig. Met. content (CVB, 2007).

Protein source	Protein (%)	Dig.Met (%)	Dig.Met (% of CP)
Casein	86.8	2.47	2.9
Fish meal CP>680	71.1	1.85	2.6
Fish meal CP630-680	65.7	1.71	2.6
Potato protein ASH<10	79.5	1.68	2.1
Potato protein ASH>10	76.8	1.63	2.1
Fish meal CP580-630	62.9	1.60	2.5
Fish meal CP<580	56.7	1.45	2.5
Maize gluten meal	61.0	1.39	2.3
Sesame seed expeller	44.9	1.13	2.5
Milk powder skimmed	35.0	0.90	2.6
Sunflower seed expeller dehulled	38.3	0.73	1.9
Sunflower seed expeller partly dehulled	28.6	0.54	1.9
Rapeseed expeller	32.4	0.54	1.7
Soybean expeller	43.5	0.51	1.2
Peanut expeller dehulled	45.1	0.47	1.0
Cottons expeller dehulled	41.2	0.45	1.1
Peanut expeller partly dehulled	41.8	0.44	1.0
Soybeans heat treated	35.1	0.41	1.2
Sunflower seed exp. with hulls	21.4	0.40	1.9
Cotton expeller partly dehulled	34.9	0.38	1.1
Whey powder	25.4	0.34	1.4
Maize gluten feed CP>230	24.0	0.34	1.4
Linseed expeller	31.0	0.33	1.1
Cottons expeller with hulls	30.7	0.32	1.1
Rapeseed	19.8	0.32	1.6
Peanut expeller with hulls	31.2	0.31	1.0
Maize gluten feed CP200-230	21.2	0.30	1.4

Potential protein sources from plant origins

Oilseeds

Concentrates derived from oil seeds are well established ingredients in current organic monogastric diets.

Soya bean

Soya bean is covered here as it is often classified as an oilseed although it is a legume that fixes nitrogen to the soil (it therefore has the advantages and disadvantages, including anti-nutritional factors, discussed below in the section on legumes). Soya bean is a very popular source of protein in monogastric diets due to its high nutritional value and protein digestibility. Current feeds often make use of soya bean imported from South America, India and China. European-produced soya bean meal seems to be the most promising alternative to imported soya bean meal, but it is a complex issue as it would displace the cultivation of another crop and the carbon footprint is no lower than imported soya. Production would be likely to be confined to southern parts of Europe as, although soya beans grow in a range of soil types, they require a long growing season and ample sunshine. It is possible that selecting high yielding varieties with an ultra-short growth season could maximise European production.

Oil seed rape

Rape seed expeller has similar digestible methionine content to soya bean expeller (0.54% and 0.51% respectively). However, high concentrations of anti-nutritional factors (ANF), specifically glucosinolates and uric acid, which affect palatability and reduce intake levels, limit inclusion rates of rape in poultry rations to 2.5% in broilers and 5% in laying hens. Rape seed also contains sinapine, which is converted to trimethylamine in the gut, and can impart a fishy taint and rancidity to meat and eggs which is clearly undesirable. However, the development of 'Canola' (oil seed rape low in both glucosinolates and uric acid) provides a more suitable variety for organic poultry diets. From a crop production viewpoint, rape needs to be strategically placed in an organic rotation due to the high risk of attack from insect pests and weeds and, being a relatively hungry crop, it can be difficult to grow with regards to crop-nutrition.

Oil seed rape is now being grown primarily for human purposes and it is expected to become too expensive to produce it for animal feed.

Sunflowers

Sunflower meal does not contain ANF such as those found in soya bean and oil seed rape and the digestible methionine content of sunflower seeds is relatively high (0.4%) making them a promising alternative protein source. Dehulled sunflower seed expeller has increased concentration levels of digestible methionine (0.73%) and crude protein (circa 21% to circa 38%). The recommended inclusion rates for sunflower seeds in poultry diets are 5% for broilers, 10% for layers and 10% for breeders. From a crop production viewpoint, sunflowers are drought tolerant and can be grown on a wide range of well-drained soil types. They are relatively easy to produce under organic conditions, and can be grown quite widely in Europe. However, organic production in Europe seems to be of small and irregular quantities, and because it is produced in southern Europe and needed mainly in northern Europe, transportations costs will be high.

Legumes

Legumes can be extremely useful as they provide an important fertility building role in organic rotations while simultaneously providing livestock with a valuable protein source. However the use of legume proteins is limited by anti-nutritional factors, such as tannins, lectins, protease inhibitors and pyrimid-glycosids that are present in all legumes at varying levels but most particularly in beans. These challenges could be tackled by further breeding and selection.

Peas and beans

Peas and beans are good options due to their high protein content (17-35%) and because organic cultivation is widely practiced across Europe. White-flowering varieties contain a low amount of tannins and are often low in trypsin inhibitor activity (TIA). White-flowering winter peas show fourfold higher TIA than spring types. Therefore, with the right choice of cultivar, peas and beans can be incorporated into broiler diets at inclusion rates of 25% to 30% and into layer diets at rates of 15% to 20%. Regions with suitable climatic conditions (Mediterranean and warm coastal regions) could increase production by implementing an autumn-spring cycle. The protein yield is reasonable, but should be further improved to make it a real alternative for the farmer. Because of the sensitivity of peas and beans to pathogens and pests, however, a rotation period of at least 5 years has to be taken into account.

Lupins

Sweet lupin seeds (low-alkaloid varieties) containing approximately 37% protein and lacking in TIA can make a valuable contribution to poultry rations on-farm since high temperature cooking to eliminate anti-nutritional factors is not needed. However the ratio between digestible methionine and digestible lysine is lower in lupins than in soya bean meal. Sweet lupins are acceptable at up to 10% inclusion rate in the diet of broilers and 20% for layers.

Sainfoin

Sainfoin seeds are a promising, highly palatable, protein source for poultry when compared with soya bean. Sainfoin seeds with hulls intact and dehulled contain 27.9% and 38.8% crude protein respectively. Sainfoin thrives on free draining, alkaline and calcareous soils (pH6.2 or above). It is not suitable for production on moisture-retentive or acidic ground.

Cereals

Organic cereals are generally the main bulk ingredient of poultry feed. Cereals, in general, are relatively low in methionine, lysine and threonine and so cereal-based feeds require the inclusion of amino acid rich ingredients such as soya and other pulses to balance the diet. However, oats have a crude protein content of 12-15% and are a very robust crop that complements organic farming practices. Oat crops are well adapted to cultivation in North-West and Eastern Europe. The amino acid composition of oats is superior to that of other cereals due to their containing a higher amount of limiting amino acids like methionine, lysine and threonine. With breeding and selection the amino acid content of cereals could potentially be increased.

Intercropping of legumes and cereals

Intercropping is the mixed growing of two crops in order to obtain advantages that are not achieved with the growing of the single crops. Research in The Netherlands and Denmark shows that there are many opportunities, but it is important to use the best mix (species and ratio between species), optimise the growing (how much of which manure), and breed and select the best breeds. Currently, a mixture of wheat and faba beans seems to be most promising. Wheat has a higher methionine content when grown with a legume. This could best be combined with a legume with a higher lysine content. However, more research is necessary on differences between breeds and how to optimise growing circumstances.

Protein sources from animal origin

Table 2 shows that the highest levels of digestible methionine are found predominantly in products from animal origin, e.g. casein (2.47%), fish meal (1.85%), and milk powder (0.9%). However, most of the potential poultry feed ingredients listed below, with the exception of fishmeal, are still very much at trial stages despite having good potential for future use in organic poultry feed. Unlike ruminant feed, it is allowed to include animal protein sources in diets of monogastrics. However, in feed mills that produce both cattle and poultry diets, animal protein cannot be processed due to the unavoidable risk of contamination of cattle feed. Subsequently, animal protein sources, while potentially viable, are not expected to provide an overall solution for 100% organic poultry diets.

Fishmeal and fish oil

Fishmeal and fish oil either as a by-product of fish for human consumption or from sustainable fisheries can be used in organic poultry feeds. It is an excellent source of protein, it supplies high levels of lysine and methionine and contains useful minerals such as calcium and phosphorous. Its preferred use is in starter rations at a rate of around 2.5% where it helps to balance the amino acid requirements. However, an objection against this is that chickens naturally are not fish-eaters.

Mussel meal

Mussel meal is an alternative protein source option that can replace fish meal while still maintaining laying hen performance. The meat of blue mussels contains 60% crude protein and 1.56% methionine. However there is only experimental production, which has limited availability and is too expensive to be of current practical importance.

Larvae meal

Larvae meal could also be a promising methionine source in the future. House fly pupae meal has a crude protein content of circa 63.1% DM and a fat content of circa 15.5% DM, similar to that of fishmeal. Currently, however, legislation prohibits the use of insect meal in animal feed.

Earthworm meal

Earthworm meal has a crude protein content ranging from circa 58% DM to circa 71% DM, depending on species, and an amino acid profile similar to that of fishmeal. The development of organic vermiculture (earthworm farming) systems is a realistic option and is thought to be possible all-year round throughout Europe. It is a potentially sustainable method of protein production for organic poultry, where any waste products can be collected and recycled to land. The contaminant content of the feedstock would need to be closely monitored for high levels of heavy metals and dioxins but if managed correctly the process should have minimal environmental impacts.

Algae

Algae could make a useful addition to poultry diets because their amino acid profile compares favourably with that of most feed proteins with several species containing more methionine per 100g protein than soya bean (Becker, 2007). This suggests that algae may make a good substitute for soya bean in poultry rations. However, it is necessary to process them to make the amino acid content available for intake in the chicken's digestive tract and the metabolisable contents are not currently known. From experiments in The Netherlands and UK it is known that chickens are willing to eat it dry and mixed through their feed. An experiment with wet algae showed that while hens will eat it, a part of it is wasted resulting in wet litter and dirty hens. The challenge would be to produce the algae in a way that can be certified organic and that would result in a reasonably priced protein source.

Concentration of protein sources by further processing

Further processing of ingredients, thereby reducing the level of anti-nutritional factors (ANFs) and increasing the protein content to levels of 65% or higher, would help to fulfil the need for high quality methionine-rich proteins for poultry feed.

The concentration process currently used for soya beans could be used for other oilseeds such as rapeseed (Canola) and sunflower seed to increase their crude protein levels from circa 23% to 50-70%. The methionine content of dehulled sunflower seed can be further increased to 0.84% when the crude fibre content is reduced from 16.7% to 6.4%. Rapeseed concentrate contains 57% crude protein and a digestible methionine + cysteine content of 1.55%.

Most legumes contain carbohydrates, particularly starch, instead of oil as in soya beans, as the energy source for the growing seedling. Dry fractionation (milling followed by air classification) concentrates the protein content of legumes. Three fractions are obtained: fractions enriched in fibres, starch and proteins. The enriched protein fractions can then be collected for utilising in diets. Common figures for peas and faba beans indicate an enrichment to about 60-70% of protein and a digestible methionine plus cysteine content of 1.19%. However, while these techniques are technically possible, there is no commercial party seeing enough profit in it yet and it is only produced in small quantities for experiments. Large scale application is not expected in the near future.

Peas are high in lysine, and the digestible lysine content of pea protein concentrate can be 5.5%, exceeding the required value for poultry. Therefore, the use of pea protein concentrate in poultry diets should be regulated with lysine content in mind.

Other nutritional considerations

The organic regulations dictate that roughage, fresh or dried fodder, or silage be added to the daily ration for poultry. Energy requirements of organic laying hens differ compared with those of hens in conventional systems, due to differences in ambient temperature and as a consequence of foraging in the open air run, whereas digestible methionine requirements are more consistent across systems. Laying hens are able to adjust their feed intake level to match their energy requirements. Therefore, digestible methionine + cysteine concentration of the diet can be reduced in case of high feed intake levels (e.g. during winter).

Ranging birds obtain nutrients from pasture, seeds, insects and other small invertebrates. However, there is only substantial feed available in the case of small flocks in mobile housing. For example, with 3000 hens in a department and 4 square metres range area per hen available, only a very limited number of hens of this flock would reach a substantial level of protein intake from the range area. Access to a grass-clover covered pasture could substantially contribute to the protein supply of poultry. Broilers are able to obtain 7% of the recommended amount of protein by the intake of grass-clover from the pasture. Laying hens are able to consume considerable amounts of fresh grass, which might contribute to 12 –13% of the total dry matter intake. It is estimated that hens could obtain circa 5 -10 % of their nutritional demands from foraging.

It is also possible to harvest grass-clover and bring it inside to the chickens. A Dutch farmer harvested 50 tonnes of 5 hectares of dry matter of grass with red and white clover in 2014. He had it processed into pellets which he feeds to his chickens. He calculated that he will be able to feed them year-round 5% of grass-clover with a protein content of 17%.

Nutrient contents and digestibility of organic cultivated ingredients can differ from that of ingredients which are conventionally cultivated. Studies have shown that the crude protein content of some important organic protein-rich ingredients (sunflower seed expeller, rape seed expeller, soya bean meal expeller and sesame seed expeller) is considerably lower compared to conventional variants. Therefore, nutritionists should take the crude protein content of the organic ingredients into account, whereafter they have to recalculate the digestible methionine content, based on the determined crude protein content of those ingredients.

Conclusions

If we take into account the same numbers of organic poultry to be fed into the future as we have now, and if we continue to feed them with concentrates, then several options are available to fulfil the requirement of 100% ingredients of locally produced organic origin in organic poultry concentrate diets. However if the practical, economic and environmental foot print issues are taken into account, then the list of current viable options is quite small. Within the category of plant ingredients, oilseeds and in particular European-produced soya bean meal seem to be the most promising long term alternative to imported soya bean meal. Sunflower seed and rapeseed have potential as widely available protein crops due to the high value of extracted oil for other markets. Within the category of legumes, peas, beans and sainfoin seeds seem to be a viable option because of their relatively high digestible methionine content, and their good availability. Reducing the protein and energy concentration of poultry diets, and with it the amino acid concentration, thereby increasing feed intake, is another option to help fulfill the requirement of 100% organic diets.

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Also see ICOPP Technical Note 2 for information on feeding roughage and foraging from the range.

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