Poultry feed availability and nutrition in developing countries

Alternative feedstuffs for use in poultry feed formulations

***Velmurugu Ravindran**, Monogastric Research Centre, Institute of Food, Nutrition and Human Health, Massey University, Palmerston North, New Zealand*

Global consumption of poultry products, especially poultry meat, has consistently increased over the years, and this trend is expected to continue. Much of the increase in global demand for poultry products will be in developing countries. Such growth in the poultry industry is having a profound effect on the demand for feed and raw materials. However, it is also becoming clear that the requirements for the four traditional feed ingredients – maize, soybean meal, fishmeal and meat meal – cannot be met, even according to optimistic forecasts. The gap between local supply and demand for these traditional ingredients is expected to widen over the coming decades, providing a compelling reason for exploring the usefulness of locally available, alternative feedstuffs in feed formulations.

A wide range of alternative feedstuffs are available for feeding in all three poultry production systems. The greatest potential for efficiently utilizing these feedstuffs will be in traditional family poultry systems (scavenging and backyard) and the semi-commercial system. In the semi-commercial system, only part of the feed requirement is purchased from commercial compounders, so there is opportunity for on-farm mixing or dilution of purchased feeds with locally available, alternative feedstuffs. In low-input family poultry systems, locally available, alternative feedstuffs can be used to supplement the scavenging feed base.

NON-TRADITIONAL FEEDSTUFFS – THE ISSUES

Alternative feedstuffs are often referred as "non-traditional feedstuffs" because they have not traditionally been used in animal feeding or are not normally used in commercial animal diets. However, it is difficult to draw a clear distinction between traditional and non-traditional feeds. Feedstuffs that may be classified as non-traditional in some regions, may actually be traditional and based on many years of usage in others. Some feedstuffs may have started as non-traditional, but are now being used increasingly in commercial diets. A good example is palm kernel meal, which is a non-traditional feedstuff in Western Africa, but an increasingly normal feedstuff for feed millers in Southeast Asia, especially in pullet and layer diets.

It is widely recognized that in developing African and Asian countries, existing feed resources in many circumstances are either unutilized and wasted or used inefficiently. Most of these alternative feedstuffs have obvious potential, but their use has been negligible owing to constraints imposed by nutritional, technical and socio-economic factors (Table 1). Three major criteria determine the regular use of a feedstuff in commercial diets: i) it must be available in economic quantities, even if its availability is seasonal; ii) the price must be competitive against the main feedstuffs; and iii) its nutritive value must be understood, including its nutrient content, existing variation and nutrient digestibility. In many developing countries, it may be difficult to assess the nutritive value of any feedstuff, owing to the lack or scarcity of appropriate research or analytical facilities. This is a major factor discouraging commercial feed mills from considering the use of alternative ingredients.

There has been keen interest in evaluating alternative feed resources over the years, and a proliferation of published data, especially from developing countries. Lists of alternative feedstuffs that seem to have the greatest potential as substitutes for maize, soybean meal and animal proteins are presented in Tables 2, 3 and 4, respectively. These lists are by no means exhaustive; this information note does not aim to review all the available literature on each individual ingredient, but rather to identify the general issues limiting their use and maximum inclusion levels in commercial poultry diets.

FUTURE PROSPECTS FOR ALTERNATIVE FEEDSTUFFS

The immediate prospects for the use of alternative feedstuffs listed in Tables 2, 3 and 4 will be in semi-commercial poultry units that employ some degree of on-farm feed mixing, and family poultry units. In these sectors, where the objective is economic

TABLE 1

Factors limiting the use of alternative feed ingredients in poultry feed formulations

Nutritional aspects
- Variability (or lack of consistency) in nutrient quality
- Limited information on the availability of nutrients
- High fibre content
- Presence of anti-nutritional factor(s)
- Need for nutrient supplementation (added cost)
Technical aspects
- Seasonal and unreliable supply
- Bulkiness, physical characteristics
- Need for de-hulling and/or processing (drying, detoxification)
- Limited research and development facilities for determining nutrient composition and inclusion levels in poultry diets
Socio-economic aspects
- Competition with use as human food
- Poor prices relative to other arable crops (farmer)
- Cost per unit of energy or limiting amino acids, relative to traditional feedstuffs (feed manufacturer)
- Cost of processing

TABLE 2

Alternative energy sources that can replace maize in poultry diets

Feedstuff	Comments
Cereals	
Wheat	Can be used when cost-competitive Limitation: high non-starch polysaccharide contents result in intestinal digesta viscosity problems; can be used without restriction when exogenous carbohydrases are added
Sorghum	Limitation: tannins lower protein and energy digestibility; low-tannin sorghum can completely replace maize
Millets	Can replace 50–65% of maize, depending on millet type Limitations: high fibre contents, presence of tannins
Cereal milling co-products	
Rice bran/polishing	Limitations: high fibre, phytic acid, rancidity; good-quality material can be used at levels of 5–10% in broiler diets and up to 40% in layer diets
Wheat bran/pollard	Limitation: high fibre; can be used at levels less than 5% in broiler diets and up to 15% in layer diets
Roots and tubers	
Cassava root meal	High in starch, excellent energy source Limitations: low protein, powdery texture, needs detoxification to remove the cyanogenic glucosides; can be used at levels of 30–40% in nutritionally balanced, pelleted diets
Cassava peel meal	Limitations: high fibre, very high levels of cyanogenic glucosides, needs processing; carefully prepared meal may be used at 5% level
Sweet potato tuber meal	High in starch, good energy source Limitation: powdery texture; can be used at levels up to 50% in nutritionally balanced, pelleted diets
Taro	Limitations: poor palatability caused by calcium oxalate, needs processing; processed meal can be used at up to 10%
Fruits and fruit co-products	
Banana and plantain meal	Limitation: low palatability due to tannins in the peel; removal of peels improves nutritive value; inclusion must be limited to 10–20%
Breadfruit meal	Good energy source; can be included at up to 30%
Jack seed meal	Limitations: lectins in raw seeds, needs processing; processed meal can be included at up to 30%
Mango seed kernel meal	Limitation: high levels of tannins; processed meal can be used at levels of 5–10%
Date waste	Limitation: high sugar content; use must be restricted to 30% of the diet
Miscellaneous	
Sago meal	Limitation: powdery texture; can be included at up to 25%
Cane molasses	Limitations: high sugar content, wet litter problems; use must be limited to 15% of the diet
Animal fat	Tallow, lard and poultry fat; high-density energy sources that enable the use of low-energy feedstuffs in formulations; can be used at up to 5–8%
Distillers dried grains with solubles (DDGS)	High fat content (10%), good energy source; can be used at up to 25%

TABLE 3

Alternative protein sources that can replace soybean meal in poultry diets

Feedstuff	Comments
Oilseed meals[1]	
Cottonseed meal	Limitations: high fibre, presence of gossypol; low-gossypol meal can be used at levels of 10–15% in broiler diets; limit use in layer diets because of effects on internal quality of eggs
Canola meal	Limitation: glucosinolates; low-glucosinolate meals can be used at up to 30%
Groundnut meal	Limitations: tannins, aflatoxin; good-quality meal can be used at up to 15%
Sunflower meal	Limitation: high fibre Rich in methionine; can be used at up to 15%
Sesame meal	Limitation: high phytate content Good source of methionine; can be used at up to 15%
Palm kernel meal	Limitations: high fibre, poor texture, low palatability; good-quality meal can be used at levels of 5–10% in broiler diets and up to 30% in layer diets
Copra (coconut) meal	Limitations: low protein, mycotoxins; can be used at up to 20%
Rubber seed meal	Limitations: low protein, presence of cyanogenic glucosides, requires processing; can be used at up to 10%
Grain legumes[2]	
Lupins, field peas, chick peas, cowpeas, pigeon peas, faba beans, etc.	Limitations: presence of anti-nutrients, low in methionine; can be used at up to 20–30% when processed and supplemented with methionine; current cultivars contain low levels of anti-nutrients
Green meals	
Leaf meals, aquatic plant meals	Rich in minerals, moderate levels of protein Limitations: high fibre, high moisture content and requires drying; most green meals can be used at levels less than 5%; some, such as duckweed, can be included at higher levels
Distillery co-products	
DGGS	Good source of protein, amino acids and available energy Limitation: variable amino acid availability; good-quality meals can be used at up to 25%

[1] Compared with soybean meal, other oilseed meals have lower contents of available energy, protein and essential amino acids, and require supplementation with synthetic amino acids and energy sources. Suggested inclusion levels are for nutritionally balanced diets.

[2] A range of grain legumes are grown in developing countries. Only selected species are identified here. It must be noted that all raw legumes contain a number of anti-nutritive factors, but most of these can be eliminated by processing.

productivity rather than maximum biological productivity, alternative feedstuffs can make a useful contribution to poultry feeding.

Before the use of these feedstuffs can be considered in the modern commercial poultry sector, most – if not all – of the limitations identified in Tables 2, 3 and 4 must be resolved. A number of other possibilities are available for improving the feeding value and increasing the inclusion levels of many of these alternative feedstuffs: i) formulation of diets based on digestible amino acids, rather than total amino acids; ii) use of crystalline amino acids to balance amino acid specifications; and iii) supplementation with commercial exogenous enzymes to improve nutrient and energy

TABLE 4

Alternative animal protein sources for use in poultry diets

Feedstuff	Comments
Dried fish silage	A way of turning waste fish into quality animal protein supplement; can completely replace fishmeal Limitation: requires drying
Blood meal	High protein content Limitations: extremely deficient in isoleucine, poor palatability; can be included at no more than 5%
Hydrolysed feather meal	High protein content Limitations: deficient in several essential amino acids, low availability of amino acids; can be included at no more than 5%
Poultry by-product meal	Feeding value similar to that of meat meal; recommended inclusion level of 5%
Skimmed milk powder	Reject milk powder; good-quality protein; can be included at up to 5%
Novel sources: insects, fly larvae, earthworms, termites, bees, snails, etc.	Good protein sources; can replace 50% of fishmeal in formulations; useful supplements for family poultry Limitation: no commercial production and harvesting systems

availability. The effect of supplemental enzymes on alternative feedstuffs is twofold: first, they eliminate or reduce the action of anti-nutritive factors; and second, they increase digestibility and improve nutritive value

The greatest potential for using alternative feedstuffs is in the feeding of layers, irrespective of the production system. Owing to physiological differences, pullets and layers are more tolerant to high fibre, poor-quality feedstuffs and nutritional challenges than fast-growing meat birds are. Some of these feedstuffs can be included at high levels, but have negative effects on egg production. Rice bran and palm kernel meal are good examples of this tolerance; both can be used at maximum levels of only 10 percent in broiler diets, but may be safely incorporated into pullet and layer diets at levels of up to 30 percent.

SUPPLEMENTARY FEEDING STRATEGIES FOR FAMILY POULTRY

The scavenging area for family poultry is usually limited and often over-scavenged. The quantity and quality of the feed base for family poultry are also very variable, depending particularly on the season, but also on rainfall and agricultural activities. The supply of protein, minerals and vitamins is often high during the rainy season, owing to the abundance of insects and green materials, but becomes critical during the dry season. On the other hand, most of the materials available are deficient in energy throughout most of the year, because the feed base is generally high in fibre. Overall, feed consumed by family poultry can be considered deficient in all major nutrients – energy, protein, calcium and phosphorus. It is therefore recognized that scavenging alone will not provide enough feed to support the needs for growth or egg production, and that body weights and egg numbers can be markedly improved by the provision of supplementary feed. Small amounts of strategically administered supplements are likely to increase production and minimize mortality. Several of the alternative feedstuffs identified in this information note can play an important role as supplementary feeds.

Unlike the intensive poultry production system, the family poultry system lends itself well to the inclusion of locally available, alternative feedstuffs. Most of these feedstuffs are available only seasonally, in limited quantities and in specific locations, but can easily be accommodated within the family poultry system. Many of these materials are dusty in nature, and could be wasted if offered in dry form. To avoid wastage, these materials are therefore best offered as wet mash.

Energy supplements

The main feature of the traditional poultry system is that it does not directly compete with humans for the same food. However, where possible, it is advisable to offer small amounts of grains such as millets, maize and sorghum as energy supplements. Attention must therefore be paid to available cereal by-products. In most households and locations, several by-products from cereal milling are available for animal feeding, including bran, hulls and screenings. Despite their high fibre contents, these can be valuable sources of energy.

Small and damaged tubers and roots of cassava, sweet potatoes and yams, which are unfit for human consumption, are available in many areas and could be processed into a high-energy animal feed. The most practical method is to slice, sun-dry and pound or grind them into a meal. Cassava peels (which constitute 10 percent of the tuber weight) are not used for human consumption, and represent an economical feed for family poultry. However, they contain high levels of cyanide and must be processed to eliminate this toxic factor prior to feeding; simple sun-drying is adequate for this. Residues from the production of fermented cassava products can also be useful energy supplements.

A number of locally available fruit by-products can be used to provide energy. A good example is banana peels, which can be collected from local markets, sun-dried and milled into a meal. Proper drying is important to avoid spoilage and bacterial growth. A similar meal can be prepared from mango seed kernel, which has to be boiled prior to drying. On their own, both these meals have poor palatability and have to be offered in a mixture with other feedstuffs.

In areas where breweries or fruit processing operations are located, by-products may be collected and offered to poultry in wet form. These materials are good sources of supplemental energy.

Protein supplements

Green materials

Green materials are the cheapest sources of protein available to family poultry. A wide range of materials are available, including herbs, fodder leaves (e.g., leucaena, calliandra, sesbania), leaves from cultivated plants (e.g., cassava) and aquatic plants (e.g., azolla, water hyacinth, duckweed). These can be grown in small plots around the household. Where lagoons are available, the cultivation of aquatic plants should be promoted. The advantage of green materials is their high dry matter yields, which can be harvested and fed directly to poultry in fresh form. Not only are these materials good sources of protein, but they are also rich in pigments, vitamins and minerals.

Industrial by-products

By-products from local industries such as oil mills (palm kernel meal, sesame meal, coconut meal, rubber seed meal) and fibres (cotton, kapok) represent good sources of protein. Some of these materials are already used to supplement the feeding of family poultry.

Animal and fish by-products

In areas where there are fishing and meat processing operations, there is good potential for using offal for poultry feeding, in either fresh form or after processing. For example, the edible flesh of most types of fish represents only 40 percent of their total weight, leaving 60 percent for use as a protein feed resource. Scrap fish and fish wastes or residues (heads and offal) can be dried and processed into a meal, or be preserved as silage. The technique for making fish silage is simple, but the producer requires training.

Meals from insects

Insects can be used to produce cheaper proteins from non-food animals. Insects are part of the natural diet of poultry, and scavenging poultry consume a wide variety, including grasshoppers, crickets, termites, aphids, scale insects, beetles, caterpillars, pupa, flies, fleas, bees, wasps and ants. Insects are rich in protein, with reported protein contents ranging from 40 to 75 percent. These novel protein sources can be collected from surrounding areas. There is also opportunity for the production of insects using waste materials.

Insect larva: The biological digestion of animal wastes by the larval stage of flies (especially house and soldier flies), and the harvest and use of larvae and pupae is a cheap way of supplying high-protein materials to family poultry. Insect larva can be produced from kitchen and animal wastes. The materials are left to decompose in a protected area, where insects come and lay their eggs. Guidelines on the medium- to large-scale production of fly pupae using animal wastes describe how light is used to induce the migration of larvae out of the waste, through a screen and into a lower compartment, where they pupate and are harvested.

Termites: Termites are not only collected from nature, but can also be grown near the family unit and harvested. Termites have a unique ability to digest fibre, and the production of termites should be linked to the recycling of wood and paper wastes. A simple method of rearing termites on crop residues for family poultry supplementation is practised in some African countries. This involves the use of inverted clay pots containing termites and filled with moistened fibrous material. The pots must be protected against excessive heat and desiccation, and the termite larvae can be harvested after three to four weeks.

Meals from small animals

Earthworms: Earthworms are a natural food source for poultry kept under free-range systems and, live or dried, are highly palatable to poultry. Worm cultivation for fishing is common in many countries. Earthworms can also easily be produced and harvested for feeding family poultry, based on the biodegradation of animal manure. Techniques for the culture of earthworms (referred to as vermiculture) are well established and can be modified to suit small-scale production systems. Successful culture of earthworms requires: i) a food source; ii) adequate moisture (more than 50 percent water content); iii) adequate aeration; and iv) protection from excessive heat. A kilogram of earthworms consumes and digests 0.5 to 1.0 kg of waste a day. Because worms are top feeders, most of them will be found in the top 10 to 20 cm of the manure and can easily be harvested. Alternatively, the chickens can be let into the area to harvest the worms themselves. Under suitable growing conditions, up to 30 000 worms per square metre of surface area may be harvested.

Snails: The African giant snail is a major garden pest, which is particularly abundant during the wet season. The collection and use of snails as animal feed is therefore also of interest in the context of pest control. The bodies of snails contain hydrocyanic acid, presumably accumulated from the ingestion of cyanide-containing materials, but this toxic factor can be completely eliminated by cooking.

Mineral and vitamin supplements

Scavenging birds have far greater opportunity to balance their own micronutrient requirements. In the scavenging situation, minerals and vitamins are often provided from organic and non-organic materials pecked from the environment by the birds. Important sources of minerals and vitamins include snail shells, insects, fruits and fresh green materials.

REFERENCES

El Boushy, A.R.Y. & van der Poel, A.F.B. 1994. *Poultry feed from waste: Processing and use*. London, Chapman and Hall.

Ensminger, M.E., Oldfield, J.E. & Heinemann, W.W. 1990. *Feeds & nutrition*. Clovis, California, USA, Ensminger Publishing.

FAO. Feed Resources Information System, Animal Health and Production Division.

Kellems, R.O. & Church, D.C. 2010. *Livestock feeds and feeding.* Boston, Massachusetts, USA, Prentice Hall.

Ravindran, V. & Blair, R. 1991. Feed resources for poultry production in Asia and the Pacific. I. Energy sources. *World's Poultry Science Journal*, 47: 213–231.

Ravindran, V. & Blair, R. 1992. Feed resources for poultry production in Asia and the Pacific. II. Plant protein sources. *World's Poultry Science Journal*, 48: 205–231.

Ravindran, V. & Blair, R. 1993. Feed resources for poultry production in Asia and the Pacific. III. Animal protein sources. *World's Poultry Science Journal*, 49: 219–235.

Ravindran, V. & Bryden, W.L. 1999. Amino acid availability in poultry – in vitro and in vivo measurements. *Australian Journal of Agricultural Research*, 50: 889–908.

Sonaiya, E.B. 1995. Feed resources for smallholder poultry in Nigeria. *World Animal Review*, 82:25-33.