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Matching poultry production with available feed resources: issues and constraints

D.J. FARRELL

The University of Queensland, St. Lucia, Qld 4072, Australia
E-mail: d.farrell@uq.edu.au

Corn and soyabeans may not be available in many countries particularly those which do not have sufficient foreign currency or the capacity to grow them. This paper outlines strategies that may be important under these circumstances. Alternative feedstuffs and various feeding systems may be used to support poultry production. Alternative ingredients such as rice bran, pearl millet, cottonseed meal and grain legumes are discussed. Evidence is presented showing that amino acid requirements of layers and broilers may be too generous particularly in countries where climate, management and disease can impose production constraints. The ability of finishing broilers to perform well on very low-energy diets allows the inclusion of alternative feeds and by-products into formulations. Very low protein diets based on cereals and free amino acids can be used for layers without loss of performance. Self-selection of feedstuffs may be an important strategy in reducing feed costs of broilers and layers. The concept of matching production with available feed resources may compromise broiler growth and egg production, but in many countries this may be the most economical choice. Countries in the humid tropics usually have reduced poultry performance. The effects of high temperature and humidity are difficult to overcome. The vexed questions of the escalation in the price of fossil fuel and the outbreak of avian influenza, both seemingly without a solution, are clouds hanging over an otherwise buoyant industry.

Keywords: alternative feeds; low protein diets; self-selection; amino acid specifications; oil, environment

Introduction

Not every country has access to soyabeans and corn, generally accepted as the basis for pig and poultry diets. Some countries may not have the financial resources to import these

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feedstuffs; others may not have the land or climate to grow them. Those who do import them may be in a precarious position when difficult economic circumstances arise such that their industry collapses (Hutagalung, 2000). The FAO predicts that in the next 30 years developing countries will treble their cereal imports and their meat imports will rise five-fold.

The human population will increase to seven billion in the next 10-15 years. The impact of extra food to feed these people (mainly in developing countries) and the additional feed predicted to support our livestock growth will total 525 million mt/year needing 167 million ha of additional arable land which is not now available (Farrell, 2000), makes the future uncertain. The rapid increase in the price of oil has helped to push up the cost of conventional feedstuffs and affect other activities, ranging from transport to chicken processing. Leng (2002) has demonstrated unequivocally that fossil fuel supply is a key factor in future agricultural production and reserves are declining. Predicted use of corn in the US to produce ethanol will exceed 50 million mt in 2005 (Lyons and Bannerman, 2001). Banning of animal by-products in poultry diets by the European Union has removed a large source of animal protein from the market place and will place more pressure on the demand for soyabeans and other plant protein meals.

The main purpose of this paper is to discuss alternative ways of feeding our poultry, how we can alter the composition of poultry diets, and to emphasise that maximum bird performance for meat or egg production may not always be the most economical. There is also the issue of environmental responsibility and the recognition that it is no longer acceptable to discharge waste from poultry houses and abattoirs into waterways, as well as the need to minimise nitrogen and phosphorus in poultry excreta. It is against this background that we will examine ways by which we can match poultry production with available feed resources.

Alternative feed resources

This topic has been reviewed many times, and only a few selected feedstuffs and by-products will be examined briefly here. Many can be used in modest amounts (5-7%) without loss of performance, and this point is sometimes overlooked.

RICE BY-PRODUCTS

There are over 50 million mt of rice bran produced each year. Not all is used in the feed industry. The high oil content may lead to rancidity and adulteration with hulls may reduce energy content and acceptability. A rapid method to quantify rice hull content of bran has been developed (Tangendjaja and Lowry, 1985). High levels of phytic acid phosphorous (P) can be reduced by the addition of a feed phytase and increasing P availability (Farrell and Martin, 1998). Levels of 10%, 20% and 25% rice bran can be used in broiler starter, finisher and layer diets respectively with no significant decline in production (Farrell, 1994). Rice bran does not have a fixed apparent metabolisable (AME) energy value; it increases as birds age due in part to a higher digestibility of the oil component. AME can be predicted from age of bird (Farrell, 1994).

BROKEN RICE

Normally unsuitable for human consumption, this is a valuable poultry feed ingredient with a high AME of about 13.5 MJ/kg but protein content is only 70 g/kg.

PEARL MILLET

The replacement of corn with alternative cereals especially in climates and conditions unsuitable for corn production poses a challenge. Millet grows under hot conditions and utilises soil moisture better than corn growing in drier areas of Asia and Africa. This grain has not been fully exploited partly because it is susceptible to rust. A rust-resistant hybrid cultivar has now been developed and this has superior amino acid balance to corn and similar in AME (Davis *et al.*, 2003). These workers demonstrated that inclusion of 500g of this cultivar /kg resulted in no loss of performance of broilers. Singh *et al.* (2000a) analysed two Australian cultivars which gave crude protein contents of 137 and 118 g/kg and AMEs of 15 and 13.5 MJ/kg. In an experiment with layers, Singh *et al.* (2000b) showed that inclusion of up to 600 kg millet/kg gave excellent egg production with an FCR of 2.0.

PROTEIN MEALS

Coconut (CM) and palm kernel meal (PKM) contain residual oil of 80-100 g/kg, but are high in crude fibre (>150 g/kg) and have protein contents of 180 -200 g/kg. Both contain mannans and galctomannans which have antinutritional properties (Sundu and Dingle, 2003). A recent experiment carried out at The National Research Institute in Papua New Guinea (PNG) (J. Pandi and P. Kohun, 2003, personal communication) showed that it was possible to dilute a broiler-finisher diet with 400g coconut meal/kg without loss of performance (*Table 1*).

Table 1 Dilution (%) of a broiler finisher diet (BF) with coconut meal (CM) on broiler performance from 21-53 days of age. Values followed by the same letter are not different (p < 0.05).

Diet (%)	Protein (%)	Intake (kg)	Weight gain (kg)	Final weight (kg)	FCR	Cost (k/kg)
BF 1000	23.3	4.20	1.665a	2.191a	2.53ab	6.18a
BF 80 + 20 CM	20.1	4.02	1.681a	2.208a	2.40a	5.12b
BF 60 + 40 CM	19.6	4.03	1.645a	2.168a	2.45a	4.39c
BF 40 + 60 CM	18.9	3.39	1.300b	1.823a	2.61b	3.81d
BF 20 + 80 CM	19.3	2.48	0.702c	1.226a	3.55c	3.85d
LSD		0.169	0.102	0.104	0.157	0.227

The lower than expected performance reflects the effects of the harsh tropical climate of PNG and emphasises that by matching production with available resources, growth rate may be reduced but may give a higher profitability as seen for 200g and 400g inclusions of CM (*Table 1*).

COTTONSEED MEAL (CSM)

This is available in large quantities in many countries but is largely under utilised. Inclusion rate of around 5% is normal in commercial practice due in part to gossypol which can be neutralised with soluble iron compounds in the ratio of < 2:1. Perez-Maldonadao *et al.* (2001) has done substantial work on CSM and demonstrated that CSM (47.5% CP) when formulated on a digestible amino acid basis can be included in broiler diets at up to 200g and 300/kg in broiler starter and finisher diets without a significant loss in broiler performance. He also reported low digestibility values for lysine of 0.56 and of 0.65 for threonine. In a semi-commercial experiment, Perez-Maldonado and Barram (2003) demonstrated that broiler chickens had similar growth and FCR when compared with birds on a control diet when CSM was included at 200 g/kg and grown to 43 days. It is clear that once amino acid digestibility has been taken into account, an AME of 10 MJ/kg allocated, and gossypol neutralised, inclusion of CSM can be at least 200 g/kg of starter and finisher diets.

Experiments (Perez-Maldonado, 2002) with cottonseed meal in the diets of brown egg and white egg hybrid layers from 18 to 57 weeks of age resulted in excellent production (90%) when CSM was included at 120g and 200 g/kg and with no effect on inclusion level. A concern was that when eggs were stored at 10ºC for six weeks, yolk mottling was observed in almost 30% of eggs from hens on diets with 200 g CSM/ kg and much higher than at 120 g/ kg. Also there was a suggestion that there were fishy flavours with a 'prawny' odour from some eggs. This suggests that CSM should be restricted to 100g/ kg in layer diets.

GRAIN LEGUME SEEDS

A summary of our experiments indicates that in commercial practice, there is a safe upper limit of inclusion in broiler starter and finisher diets of 300 g/kg for field peas, 200g faba beans/kg, 100g chick peas and 100g for sweet lupin seeds/kg diet. However sweet lupins can increase gut viscosity if used at higher levels but without reducing bird performance (Farrell *et al.*, 1999a). We have also found that with the exception of faba beans, the other three grain legumes can support excellent egg production when included at 350 g/kg (*Table 2*).

Table 2 Results of measurements (± SEM) made over 40 weeks on groups of 50 cages (2 birds/cage) on diets containing 250 g grain legume/kg (Perez-Maldonado *et al.*, 1999).

Treatments	Hen-day egg production (%)	Egg weight (g)	Egg mass (g/d)	Feed intake (g/d)	Feed conversion (g/g)
Chick peas	82.4 ab[1]	56.9 a	46.7 a	115.4 bc	2.60 a
	(1.21)	(0.28)	(0.74)	(0.97)	(0.072)
Field peas	84.1 a	55.9 b	46.9 a	116.3 b	2.59 a
	(0.74)	(0.33)	(0.52)	(0.81)	(0.033)
Sweet lupins	84.0 a	55.9 b	46.8 a	118.9 a	2.64 a
	(0.76)	(0.3)	(0.47)	(1.01)	(0.032)
Faba beans	80.7 b	53.7 c	43.2 b	113.3 c	2.80 b
	(1.05)	(0.33)	(0.61)	(0.89)	(0.063)
LSD (P=0.05)	2.68	0.86	1.65	2.57	0.148

[1]Values with different superscript are significantly different (P<0.05)

There are many examples of useful by-products and legume seeds that can be used in poultry diets when balanced for deficient nutrients. Some have antinutritional factors but this does not necessarily mean that they may not be used in poultry diets but can be included in low amounts.

RAW SOYABEANS

It is expensive to heat-treat full-fat soybeans to destroy protease inhibitors. In many cases this may not be necessary especially if the variety has been selected for low levels of some or all of these. Perez-Maldonado *et al.* (2003) found that a variety of soyabean (Kti) selected for low Kunitz inhibitor gave better growth rate when included in starter chicken diets at 70, 120 and 170 g/kg than untreated soyabeans, but it did not match that on the control diet. However in layer diets, inclusion of the Kit variety and untreated soybeans (70 and 110 g/kg) gave similar hen-day egg production but a slightly lower egg mass than the control diet. For laying hens, expensive treatment of soyabean is not necessary and may not warrant the substantial expense of extrusion or other treatments.

Low protein diets

There are several good reasons why poultry should be fed on low-protein diets. Nitrogen excretion will be reduced, and protein is both scarce and costly. More synthetic amino acids are becoming commercially available at competitive prices. This will mean that diets can be formulated with little or no protein concentrates. We have been experimenting with such diets, some of which had no added protein but the deficit was made up of free amino acid following analyses of ingredients and adjusting for their digestibility (Farrell *et al.*,1998). Further studies have shown that it is possible to construct diets without including a protein source (*Table 3*).

Diets 3 and 4 were similar except diet 4 had glutamic acid added as a source of non-protein nitrogen but without any effect. All diets gave similar production except that nitrogen excretion was lower on all diets compared to the control. These findings are important because soyabean meal may be unavailable or too expensive in some low-income countries. The availability of most synthetic amino acids, realistically priced, is just a matter of time.

Table 3 Results of feeding laying hens (n=40) on diets with cereals and cereal by-products with no added protein or cereals with 40g soybean meal and 20 g sunflower meal/kg, or a control diet with 17% CP from 25 weeks to 45 weeks of age.

Diet	Control Major ingredients (g/kg)[1]	2	3	4	5	SEM
Wheat	(conventional ingredients)	757	487	477	500	
Sorghum			300	300	300	
Rice pollard		40	53	51		
Millrun		60				
Rice hulls			24	25	7	
Soybean meal					20	
Sunflower meal					40	
Glutamic acid				8.5		
Crude protein (g/kg)	175	145	137	139	142	
Layer performance (n = 40) over 16 weeks						
Hen-day production (%)	86	89	86	86	89	1.90
Egg weight (g)	61.9	61.1	61.0	60.8	60.6	1.86
Egg mass (g/d)	53.4	54.4	52.2	53.0	54.0	1.36
Feed intake (g/d)	126[a2]	123[a]	117[b]	117[a]	122[a]	2.39
Feed efficiency (g/g)	2.40[a]	2.27[b]	2.25[b]	2.26[b]	2.28[b]	0.0553
N excretion (g/kg)	61.7[a]	49.0[a]	48.0[b]	44.1[b]	47.7[b]	2.56

[1]all diets were supplemented with minerals and vitamins and free amino acids where appropriate.
[2]values with different superscripts are significantly different (p<0.5)

Nutrient specifications

It is recognised that in many low income, resource-poor countries, particularly those in the tropics, it is not possible to obtain bird performance observed in many western countries. Climate, chick size and disease status may also be unfavourable, yet nutritionists insist on using nutrient requirements (*e.g.* NRC 1994,) which may over-specify in these circumstances. Even under favourable conditions, these requirements may be too high. We have researched this in broiler and layer trials (Farrell *et al.*, 1999b). Broilers when grown to 42 d, growth rate and FCR were not different (p>0.05) when diets were as low as 91% of recommended amino acid requirements, even when diets were also formulated on a digestible amino acid basis. When we formulated layer diets on a total lysine (73 g/kg) and digestible lysine (64 g/kg) amino acid basis to 97% and 90% of specification, and using the ideal balance of amino acids, production was not affected (*Table 4*).

Table 4 Egg production, egg weight, egg mass, feed intake and feed conversion ratio, and specific gravity are given for each of the four diets specified at 97% and 90% of requirements on a total and digestible amino acid basis.

	Total		Digestible		Probability
	97%	90%	97%	90%	
Egg production (%)	90.9	87.3	89.8	89.0	0.24
Feed intake (g/d)	106.8	105.9	108.5	107.6	0.53
Egg weight (g)	61.5	61.3	61.7	61.5	0.94
Egg mass (g/d)	55.8	53.5	55.4	55.8	0.25
Feed conversion ratio (g/g)	1.92	2.00	1.98	1.99	0.24
Specific gravity	1.087	1.088	1.088	1.087	0.64
Weight change (kg)	0.204	0.187	0.186	0.520	0.70
Ingredient cost ($/tonne)	253	243	247	227	
Feed cost/kg eggs (¢)	48.6	48.6	48.9	45.1	

Results in *Table 4* show that layer performance was not different (p>0.05) on any of the diets. These results are important because, when lowering nutrient specifications, more of the poorer quality feedstuffs can be brought into the formulation and this allows producers to match their production with available feed resources without compromising performance greatly. This also applies to broiler diets.

Leeson *et al.* (1992) demonstrated the remarkable capacity of broilers aged 35 days to increase feed intake in response to diet dilution (*i.e.* reducing AME content) without altering substantially body weight and breast meat yield. This allows a high inclusion of low-quality feedstuffs for the last week of growth (*Table 5*). Again this allows the formulator a wide range of ingredient choices which would not normally be available in conventional finisher formulations when diets as low as 8 MJ AME can give satisfactory performance.

Table 5 Effect of reducing the energy content of broiler finisher diets by dilution (Leeson *et al.*, 1992).

Diet AME	Growth rate (g/bird)		Breast weight (g)	
(MJ/kg)	42-49 d	35-49 d	42 d	49d
13.4	625	1275	323	421
12.1	581	1225	326	436
10.7	571	1182	330	409
9.4	599	1209	328	428
8.1	629	1209	322	412
6.7	620	1199	318	414

Self-selection

The concept of allowing poultry to select their feed has appeal. First, the chemical composition and/or nutrient availability of unusual feedstuffs may be uncertain or not known. By allowing birds to choose between ingredients on offer, they can balance their diet by selecting them in various quantities. Second, hens may vary their nutrient needs depending on production and may do so on a day-to-day basis. By offering them a complete layer feed, and a cheap whole grain source, they may select more of the grain and less of the formulated feed according to their needs with considerable saving. Emmans (1977) demonstrated this when hens were given barley and a complete diet to select from, about 16% of their intake was barley. Self selection in layers has been shown to work particularly well under warm conditions (Scott and Balnave, 1989). Broiler chickens can also select their diet from feed choices. Rose *et al.* (1986) found that broilers (3-7 weeks) preferred the formulated diet in pelleted form and the grain whole, when given this choice. In self-selection, growth rate is often slightly less than when given a formulated feed only, but FCR is often lower.

Removing premixes

Skinner *et al.* (1992) have shown that it is possible to eliminate the mineral and vitamin premix during the last week of broiler growth (42-49) days without affecting bird performance. Even withdrawal of the premix at 35 days did not affect growth rate or FCR. This would reduce the cost of a tonne of feed by up to 3% and even more in many developing countries that have to import premixes. The logistics of this are often problematical unless there is need to introduce a 'withdrawal' diet during the final week of broiler growth as there sometimes is.

Priority for ingredients used in poultry diets

As poultry age, their ability to digest feedstuffs increases. This fact has been long recognised when comparisons have been made of AME values of the same ingredients when fed to young and old birds, they often increase (Johnson, 1987). Also, energy constraints for diets of layers are less rigid than for broilers and these can be reduced to below 11 MJ/AME kg without influencing substantially egg output. There is opportunity therefore to establish a priority scheme of feedstuffs in which the high-quality ingredients have highest priority in broiler starter diets, next in broiler finisher diets, followed by layer diets, pullet rearing diets and finally broiler-breeder diets. These priorities may change during the growing or production cycle. This sort of arrangement will allow much better use of available resources and make better use of the nutrients that they contain.

Matching poultry production with available feed resources

The main purpose of this paper has been to identify areas where not only savings can be made through reduced feed costs but also to emphasise that many countries have no longer the luxury of importing feed ingredients, particularly corn and soyabeans. The concept goes much further than just the feeding of poultry. There can no longer be reliance on the importation of grand-parent stock to produce high-performing layers and broilers. Many government authorities have in the past considered developing their own strain of poultry breeding stock. With the exception of countries like China and Vietnam, almost all have shelved the idea. This was partly because they lacked the genetic resources to match the performance of imported breeds and partly because of outside pressure not to do so. Similarly, there has been heavy reliance on imported technologies that relate to disease prevention, bird health, poultry equipment and growth promotants to name just a few. The prospect of developing a stable and sustainable poultry industry that depends on matching poultry production with available resources, although daunting, must be done. This initiative should be taken by government agencies and there is great opportunity to establish a new industry along different lines than previously. According to Hutagalung (1998), nearly 70% of all poultry farms and 50% of feed manufacturers had ceased production in Indonesia, the hardest hit of all countries as a result of foreign currency difficulties. The industry there has slowly recovered only to be hit recently by a serious outbreak of avian influenza.

Major issues

The first issue that may over ride other considerations is our inability to control disease outbreaks in a world shortly to reach a population of seven billion people and with unprecedent bird numbers. The virulent avian flu virus, at time of writing, has already infected 34 people and killed 27 in East Asia and South Asia and may trigger a human pandemic. There is little evidence to suggest that the disease is under control despite the culling of 100 million birds in the region. It has spread to pigs and other animals. Some maintain that it will never be eradicated completely in Asia.

The effect of the rapid increase in the cost of oil has yet to have a serious impact on world economies. Leng (2002) showed that in highly mechanised countries 1 MJ of energy was needed to produce 2.91 MJ grain. In non -mechanised countries it produced 12.5 MJ grain. For every 10% increase in fuel prices there is a 0.5% increase in the cost of meat to the consumer; for poultry meat and eggs, this is about 1c in the dollar. Given the recent rise in oil price from $15 to beyond $50/a barrel, high inflation must follow if this price is sustained

Concluding remarks

The concept of maximising growth rate of meat birds and laying hens must be matched with economic considerations. There has been undue focus on growth rate, feed efficiency and egg numbers and comparing these bench-marks with those observed in some western countries. This is a luxury that is no longer affordable and in the humid tropics, maximum performance is unlikely to be achieved, irrespective of level of inputs, because of environmental constraints.

The recognition that production conditions in many countries do not allow poultry to reach their full genetic potential, allows the use of diets formulated to lower nutrient specifications than would otherwise be possible. This means that a wider range of ingredients can be used in these formulations.

Creswell (2004) compared performance of broilers in trials conducted in several countries against standard values for the strain of bird used (*Table 6*). Those countries in the humid tropics had generally poorer all-round performance compared to that in more temperate climates and with higher feed costs. New Zealand with arguably the most favourable climate for broiler production gave values that were consistently well above the standard. Although Creswell (2004) maintained that broiler production in these countries could match that in temperate climates, this is unlikely given the high temperature and high humidity, both difficult to reduce significantly.

This paper highlights some short-term and long-term approaches to diet formulation, use of key alternative ingredients, especially rice bran and some oil seed meals, the better use of nutrients in existing feeding stuffs and the long-term possibility of a much greater reliance on free amino acids.

Table 6 Broiler performance in seven countries when compared with the standard for the same strain of bird (2.1kg liveweight at 37.5 days with feed : gain of 1.637) adjustment is made to each trial for deviations from these standards (Creswell, 2004).

Country	No of trials	Days	Variation from FCR (Points)	Cost of Variation ($/million birds)[1]
Thailand	4	41.7	15.1	95 000
		(0.58)[2]	(5.9)	
Philippines	3	43.6	24.6	155 000
		(1.3)	(5.8)	
Taiwan	4	38.6	19.0	90 000
		(0.78)	(5.8)	
Indonesia	1	41.2	26.3	166 000
Malaysia	3	41.2	21.3	134 000
		(1.3)	(0)	
New Zealand	3	33.2	-6.2	-39 000
		(0.90)	(0)	
Australia	5	38.0	15.1	19 000
		(0.43)	(2.7)	

[1]Feed at $300/tonne
[2]Standard error of the mean

Although the economic crisis, starting in 1997, dealt a shattering blow to many countries in South East Asia, and in the short-term has caused great hardship, as Hutagalung (1998) has stated succinctly "... the economic crisis has taught Indonesia and other countries a very costly lesson for being complacent and placing too heavy a dependence on imported raw materials". In other words such countries must now match their livestock production with available resources. This goes far beyond providing poultry with cost-effective diets.

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