Breeder nutrition and chick quality

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The developing embryo and the hatched chick are completely dependent for their growth and development on nutrients deposited in the egg. Consequently the physiological status of the chick at hatching is greatly influenced by the nutrition of the breeder hen which will influence chick size, vigour and the immune status of the chick.

The financial effects

Nutritional decisions for breeders need to take account of the overall economics of the whole production cycle.

Table 1 shows the changes in hatchery and broiler performance that are required to equalise the effect of a 1% increase in breeder feed cost on the profitability of the whole production cycle.

Only one of these changes is required to have the necessary economic effect; in practice all are likely to move positively making the measurements of any one change difficult.

The calculations are done under typical UK 2003 conditions and they show quite clearly that small improvements in bird performance are required to 'pay' for more expensive breeder feed.

Conversely, apparent savings in breeder feed cost can readily lead to an overall loss if small changes in broiler performances are ignored.

Similar economic analyses have been conducted by Mississippi State University which, based on US integration 2002 costs, demonstrates that a measurable improvement in progeny liveability as a result of hen diet change can be profitable.

The key point is that trying to cut the cost of a breeder feed may easily reduce the profitability of the overall enterprise.

Hatch of total eggs (%)	0.24
42 day liveweight (g)	7.4
42 day FCR	0.0015
42 day mortality (%)	0.07-0.45*

**depending on age of mortality.*
Calculated using input-output values for UK industry 2003 (Kemp and Kenny 2003).

Table 1. The necessary change in hatchery or broiler performance to equalise profitability when breeder feed cost is changed by 1% per tonne (for example from £UK 140.00/tonne to £UK141.40/tonne or £UK138.60/tonne).

Influence of feed allocation

Underfeeding the hen can have an impact on chick quality and this is particularly noticeable in the early production period. Modern hybrid parent flocks commence production at a faster rate than in the past and consequently egg output increases over a shorter time span during the early laying period. Feed allocations during this period have not necessarily increased in line with this egg production trend. Low feed allocation intake by young commercial breeder flocks has been shown to compromise nutrient transfer to the egg, resulting in increased late embryonic death, poorer chick viability and uniformity.

In a recent study by Leeson (2004) broiler breeders were fed different levels of feed through peak production varying from 140 to 175 grams. Although the increased feed allocation increased bodyweight there was no influence on egg size, however chick weight was influenced by feed allocation (Table 2).

Of equal importance is the effect of overfeeding on ovarian development. In experimental studies ad libitum feeding has been the most widely used model for overfeeding which can result in excessive follicular development or Erratic Oviposition and Defective Egg Syndrome (EODES).

Flocks with EODES generally have poor shell quality, a reduced duration of fertility and poor hatchability. It is also known that fewer sperm will survive but it is not clear how the surviving sperm are affected and if they generate a weaker embryo. The same authors also warn that the effect of aggressive feeding two to four weeks after photostimulation reduces productive performance throughout the life of the flock.

Table 2. The effects of breeder feed levels on chick weight.

Peak breeder feed (g/b/d)	30 week breeder chick weight (g)
140	40.3
147	40.0
155	41.5
162	41.7
169	41.8
175	42.0

In this period the bird switches from primarily growth to a reproductive state. The young birds' reproductive hormone system is not mature enough to deal with high nutrient intakes; nutrients are instead metabolised to egg yolk lipid which contributes to excess follicle development.

Research shows that nutrient supply to the broiler breeder is of consequence to chick quality and production performance. This places greater emphasis on the nutritionist providing the correct nutrient density diet and the flock manager to provide appropriate feed intake to the bird coming into lay.

Diluted breeder diets

The use of diluted breeder diets is receiving a lot of attention in Western Europe on the basis of improvements in bird welfare. Experimental work feeding low energy density diets to young parent stock gave a delayed onset of oviduct development, increased early egg size, faster development of the embryo and a higher live weight of day old chicks.

When broiler mortality was above average, low density broiler breeder feeds gave a significant reduction in mortality of offspring. Other experimental work showed improvements in breeder productive performance when diluted diets were fed in the rearing period.

Vitamins

Vitamins are involved in most metabolic processes and are an integral part of foetal development, therefore the consequence of suboptimal levels of these nutrients in commercial diets are known to result in negative responses to both parent and offspring performance.

Vitamins account for about 4% of the cost of a breeder feed, so economising on vitamin inclusion rates is rarely an option.

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The levels of vitamin supplementation recommended by different sources have been summarised in Table 3. Generally there is a shortage of information on vitamin requirements of broiler breeders especially when related to offspring performance. Most of the breeder work is quite dated and since that time breeder performance has changed.

It would be impossible to review all the literature in this article, however a review of work on fat soluble vitamins, biotin and pantothenic acid have shown that vitamin E has the largest impact on progeny.

The production and economic effects of vitamin E supplementation are best shown by Hossain et al (1998) where a basal corn soya feed was supplemented with 25, 50, 75 and 100mg/kg vitamin E.

Vitamin	Leeson & Summers (1997)	DSM	Ross
A (iu/g)	7	10-14	13
D3 (iu/g)	3	2.5-3.0	3
E (mg/kg)	25	40-80	100
K (mg/kg)	3	2-4	5
Thiamine (mg/kg)	2.2	2-3	3
Riboflavin (mg/kg)	10	8-12	12
Pyridoxine (mg/kg)	2.5	4-6	6
B12 (mg/kg)	0.013	0.02-0.04	0.03
Nicotinic acid (mg/kg)	40	30-60	50
D-pantothenic acid (mg/kg)	14	12-15	12
Biotin (mg/kg)	0.2	0.2-0.4	0.3
Folic acid (mg/kg)	1	1.5-2.5	2

Table 3. Some practical recommendations for vitamin supplementation of breeder feeds (Fisher and Kemp 2001).

Table 4. Impact of dietary breeder vitamin status on bodyweight, enzyme activities, tissue characteristics and immunity of progeny.

Vitamin	Progeny response
A	Increased liver vitamin A in embryonic and chick liver but decreased vitamin E, carotenoids and ascorbic acid. Surai et al. (1998).
Carotenoids	No positive impact on chick growth, organ development or humoral immunity in chicks five weeks post hatching. Haq et al. (1995).
Carotenoids	Transferred from the hen to the yolk but not absorbed well by the embryo and subsequent chick. Haq and Bailey (1996).
Carotenoids and vitamin E	Carotene, vitamin E, and their combination improved lymphocyte proliferation, but only vitamin E improved humoral immunity. Haq et al. (1996).
Vitamin E	Vitamin E levels of 150 and 450mg/kg increased passively transferred antibody levels in chicks to Brucella abortus up to seven days of age. Jackson et al. (1978).
Vitamin E	Increased vitamin E in chicks' yolk sac membrane, liver, brain and lung all of which had reduced susceptibility to peroxidation. Surai et al. (1999).
Vitamin E	Increased progeny antibody titers to sheep red blood cells at hatch. Boa-Amponsem et al. (2001).
Vitamin E and selenium	Increased liver glutathione activity in chicks. Increasing selenium increased selenium dependant glutathione peroxidase in chick liver. Surai (2000).
Vitamin D	Tibial calcium was increased at two weeks post hatching and tibial ash increased at four weeks of age by increased vitamin D3. Ameenudin et al. (1986).
Vitamin K	Chicks from hens fed vitamin K deficient diet had reduced tibial glutamic acid levels at day one and 28 post hatching but tibial glutamic acid was restored by supplementing the chick diet with vitamin K. Lavelle et al. (1994).
Biotin	Foot pad dermatitis and incidence of breast blisters were decreased in some trials in chicks from hens fed biotin fortified diet. Harms et al. (1976).
Biotin	As biotin increased in the hens' diet, yolk and chick plasma also increased. Biotin concentration in chick plasma was poorest from young hens. Whitehead (1984).
Pantothenic acid	Liveability of chicks was best when hens were fed 20mg/kg diet of pantothenic acid. Utno and Klieste (1971).

Adapted from M. Kidd 2002

The effects on hatchability were not significant; however the best hatchability was obtained at 50mg/kg at 52 weeks.

Offspring immune response continued to increase up to 100mg/kg. In the same studies higher final bodyweights at 42 days, improved FCR and reduced mortality were observed in chicks from eggs which had been injected with vitamin E in ovo.

Haq et al., (1996) working with very high levels of vitamin E (134mg/kg versus 412mg/kg) found no growth response to 21 days and an improvement in FCR for the offspring of hens receiving the supplemental feed.

In other studies the combination of selenium and vitamin E to broiler breeders has been shown to increase liver glutathione activity of progeny.

In general it seems to be justified to supplement practical breeder feeds with 100mg/kg vitamin E.

There appear to be mixed reports on the efficacy of vitamin C; some experiments suggest a positive response, but a more recent study failed to detect any benefit on any production parameter.

This lengthy study used corn soya diets supplemented with 75mg/kg stabilised vitamin C which when analysed recovered 49mg/kg which might explain the variability of response.

The influence of increased vitamin levels fed to young parent stock on progeny performance is an area which has received significant commercial interest.

Work conducted at Aviagen Ltd has shown chicks derived from 31 week old parent stock fed elevated levels of vitamins showed improved growth to 11 days and reduced mortality compared to chicks derived from 42 and 45 week old parents.

Similar responses have been found in the field where chicks derived from young parents fed increased levels of vitamins have benefited in terms of viability and liveability. Perhaps this supports the need for further work exploring the vitamin requirements of the breeder in the early production period.

Whitehead (1991) proposes that a basis for making recommendations is to feed vitamin levels that maximise the resulting level in the egg.

For vitamins with active transport mechanisms (thiamine, riboflavin, biotin, cobalamin, retinol and cholecalciferol) these levels reflect the saturation of binding proteins.

Levels derived in this way include 10mg/kg for riboflavin and 250 microgram/kg for biotin. Whitehead (1991) contrasts this level of riboflavin with the conventional requirement (4mg/kg in this case) but the higher figure – the upper limit to nutritionally useful range – may be a better guide to good commercial practice.

Vitamins and chick immunity

Reference has already been made to the effect of vitamin E on chick health and immune function, while other vitamins have been researched none show the same degree of effect as vitamin E.

Table 4 summarises work investigating the effect of different vitamins fed to breeders and consequent impact on progeny health.

Recent work by Rebel et al (2004) investigated the effects of several elevated levels of vitamins and trace elements fed to breeders and broilers on the immune system of birds infected with malabsorption syndrome.

Broilers derived from breeders fed elevated vitamins and mineral levels had increased numbers of leukocytes at day old which indicated stimulation of the immune system (see Table 5).

Major minerals

Calcium, phosphorus, sodium, potassium, magnesium and chloride are involved in shell formation hence general improvements in shell quality lead

Table 5. Blood cell count of the broiler derived from parents fed high or low vitamin and mineral levels (Rebel et al 2004).

	Breeder low vitamins/ minerals	Breeder high vitamins/ minerals
Heterophil	5.3	3.8
Lymphocyte	4.6[a]	21.4[b]
Monocyte	1.1	5.3
Basophil	0.0[a]	5.4[b]

	Growth	Liveability	Immune function	Skeletal
Fluoride				X
Phosphorus				X
Selenium		X		
Selenomethionine	X		X	
Zinc	X		X	X
Zinc and methionine		X		
Adapted from M. Kidd 2002				

Table 6. Summary of minerals fed to breeders shown to have an effect on progeny performance.

to better egg and chick quality. Variations in maternal phosphorus supply have been shown to influence bone ash of young but not older progeny.

Broiler performance was not affected by these treatments so the practical significance of this work is not clear but the use of relatively low phosphorus levels in breeder diets, while benefiting egg shell quality, may not lead to the best possible bone integrity in the early stages of growth.

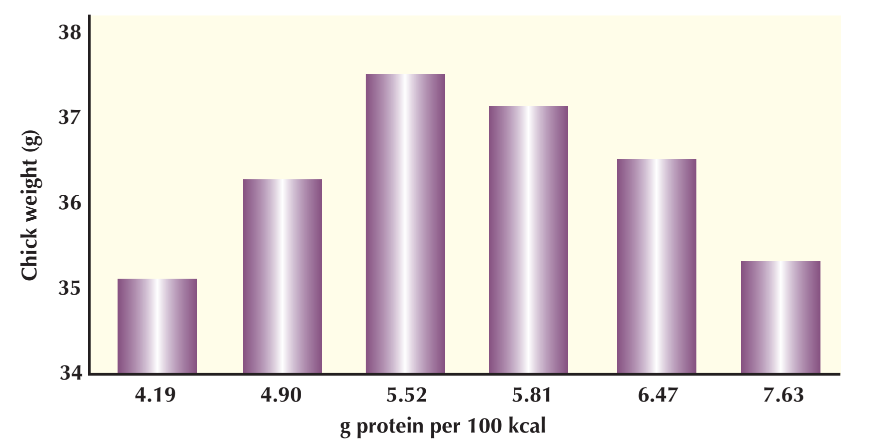

Fig. 1. The effect of protein-to-energy ratio in the breeder feed on chick weight at hatch (Spratt and Leeson 1987).

Trace minerals

Most interest in this field has centred on the use of chelated minerals which have been shown to increase deposition in the egg and transfer to the tissues of the hen and the embryo.

Most recent work has focused on the antioxidant status of breeders, embryos, offspring and the role of selenium.

Surai (2000) has shown the role of Selenomethionine on both vitamin E and glutathione peroxidase levels in eggs, embryos and chicks up to 10 days of age.

The economic benefits of using Selenomethionine compared with sodium selenite have been examined in a number of unpublished field trials in the UK. Hatchability improvements ranged between 0.5-2.0 chicks per 100 eggs and in another trial 0.3-0.7 chicks per 100 fertile eggs. Few of these tests involve a proper assessment of subsequent broiler performance although comments about chick quality are generally positive.

In one of the commercial trials mentioned an improvement of 0.5% in mortality and cull rate at 10 days was observed when organic selenium replaced sodium selenite.

Research has indicated that the improvements in chick immunity as a result of mineral fortification of hen diets may result in improved liveability.

Flinchum et al. (1989) demonstrated that leghorn breeders fed supplemental zinc methionine to a zinc adequate diet had progeny with improved survival to an E. coli challenge. Similar improvements to progeny liveability were seen with breeders fed supplemental zinc and manganese amino acid complexes.

Table 6 is a summary of those minerals which, when fed to breeders, have an effect on progeny performance.

Nutrient levels in the breeder diet

There is clear evidence that a high protein to energy ratio depresses hatchability, and probably chick performance. The experiment by Whitehead et al. (1985) shows the effect of excess protein where the higher protein level reduced reproductive performance, producing 3.1 fewer chicks per 100 fertile eggs.

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Chick quality was also reduced so that the difference in saleable chicks was 4.0 per 100 fertile eggs.

The effect of energy protein ratio in the breeder feed is shown in Fig. 1. This emphasises both the effects of excess and inadequate protein, and also indicates that the optimum level is quite steeply defined.

According to this trial the optimum protein level is at 5.52g protein per 100kcal which converts to an optimum of 15.18% protein for a diet containing 2,750cal/kg of feed.

The protein level of the diet and its ratio to energy is important not only for parent performance but also for chick quality.

The effect of feed ingredients

There is evidence of improved breeder performance when maize is compared to wheat as the main cereal in breeder feeds. From a survey of many depleted commercial flocks overall hatch of fertile eggs in the UK based on wheat diets and Brazil based on maize diets is 83.3 and 86.2 per 100 eggs respectively.

Other management factors may contribute to this difference in hatchability other than cereal source; male management is very good in Brazil and the resulting high fertility may also contribute something to this difference.

Unpublished commercial development trials from the Netherlands and Aviagen Ltd grandparent flocks (see Table 7) support this observation.

	Advantage of maize over wheat based feed
Mortality during lay (%)	-1.7
Total eggs (per hen housed)	+3.8
Hatching eggs (per hen housed)	+4.8
Hatching/total eggs (%)	+0.9
Hatch of set eggs (%)	+0.6
Hatch of fertile eggs (%)	+1.1
Second quality chicks	-0.1

Based on a comparison of two commercial houses each containing 6500 female grandparent breeders. Data to 58 weeks (Ross Breeders, unpublished data, 1998).

Table 7. Commercial comparison of breeder feeds based on wheat or maize (400g/kg).

The most likely benefit of maize is probably in shell quality and thickness. From the same data average poorer shells with specific gravity of <1.08 accounted for 26.1% of eggs from wheat fed hens and 17.1% from maize fed.

Studies of hatching losses showed less late dead embryos (>18 days) and less bacterial contamination. These two responses are expected with eggs of better shell quality.

Evidence about fat levels and sources is conflicting but there is no question that this is an important consideration. Added fat levels should be kept low in breeder feed (1-3%) and preference given to unsaturated vegetable oils rather than saturated animal fats. Work from Mississippi State University compared maize oil and poultry fat and generally supported the use of more unsaturated fat (see Table 8).

Table 8. Experiments comparing fat sources and/or levels for broiler breeders.

Reference	Fats compared
Brake (1990)	PF
Brake et al. (1989)	PF
Denbow & Hulet (1995)	SBO, PF, FO
Peebles et al. (1999a, b)	CO, PF, LA
Peebles et al. (2000a)	PF, CO, LA
Peebles et al. (2000b)	PF, CO, LA

Fats: PF – poultry fat; SBO – soybean oil; FO – fish oil; CO – corn oil; LA – lard

Maize oil increased 21 day bodyweight over that of poultry fat and improved slaughter weight of broilers in comparison to equal levels of poultry fat and lard.

Summary

Over and undersupply of nutrients into and through lay can have a very significant impact on breeder production and quality of progeny. This places greater emphasis on the nutritionist providing the correct nutrient density diet and the flock manager to provide appropriate feed allocation in lay.

Addition of micronutrients to the breeder has been shown to be beneficial to progeny quality especially in the early production period. Use of specific dietary ingredients such as maize can affect breeder performance and progeny quality. Both on economic grounds and on biological grounds, high quality nutrition of breeders is well justified. ■

References are available from the authors on request