Protein accounts for a significant part of total feed cost and affects many aspects of bird performance and profitability. How much protein to use in broiler feeds is a challenging decision that must be made by all producers and their nutritionists.

Protein and amino acid requirements are published by several authorities and can be found in the Ross Breeders Broiler Management Manual. Tables giving the protein and amino acid content of feed ingredients are also widely available. Nutritionists use these data and their understanding of raw material quality, content and price within computerised formulation models to minimize the cost of feed produced to the required specification. This approach can lead to a drive to minimize feed cost without taking account of the effects on broiler performance and profitability.

The challenge for the nutritionist and production manager is not to minimize costs but to maximize profitability. To calculate profitability, feed cost, farm and processing performance need to be analyzed together.

This Ross Tech aims firstly, to demonstrate the effects on profitability of variation in dietary protein content and, secondly, to show how optimal performance of broilers is dependent on good nutrition especially in the starter period.

OPTIMAL PROTEIN LEVEL FOR BROILERS

Birds will grow and perform over a broad range of dietary protein and energy levels. The broiler grower or integrator is interested in the protein level which optimizes profitability under local conditions. It is important to realise that this level depends on local conditions (i.e. climate, raw materials, disease levels) and on economics.

Three major factors influence which level of protein is most appropriate:

GENOTYPE: Rate of response and optimal level of protein may differ between genotypes. The genetic potential of the stock will define the upper limit to growth, body composition and, via energy requirement, feed intake and feed conversion.

ENVIRONMENT: Growth and feed conversion in commercial flocks are less than the genetic potential expressed under ideal conditions. There are many reasons for this and the consequences for nutritional decisions are not fully understood. However it is important to try and understand which factors are limiting performance in commercial flocks so that the potential for response to dietary change is properly identified. The major environmental factors are climate, housing type and condition, stocking density, disease challenge and availability of raw materials.

ECONOMICS: Determining the most appropriate protein level requires an understanding of:

- the payment structure (income from live birds, whole carcasses, portions etc.)
- the cost of inputs (dietary raw materials)
- performance (growth, FCR, livability, yield etc).

The optimum will be different for different operations (e.g. broiler growers, whole bird integration, portioning integration) and will vary over time as costs and incomes change. The profitability of the whole process needs to be optimized rather than a series of steps in which profitability of each step is examined. Simple computerised models can be produced which demonstrate the effects of altering each of the variables and these can be used to predict where profitability is maximized.

THE RESPONSE TO DIETARY PROTEIN LEVEL

Provided a bird is not at the limit of its response, then giving more protein or amino acids (relative to energy level) will increase the growth of body protein, reduce the growth of body fat and lead to a reduced food intake. In production terms we expect a heavier, leaner bird with an improved food conversion. Meat yield, which is strongly correlated with body protein growth, will increase as a proportion of body weight.

Each bird in the flock exhibits such a response. The response shown by the flock is the average of all the individual bird responses and this will generally show a smooth, diminishing response to increases in protein level as more birds reach their individual maximum response (see Figure 1). For economic analysis, the response in performance to protein is best considered to be asymptotic i.e. rising to a maximum plateau value. Excess protein may cause litter problems and hock burn and has been associated with increased susceptibility to conditions such as necrotic enteritis. In addition, excess amino acids must be catabolised and excreted - an energy expensive process. Especially at high temperatures, there are benefits in supplying modern broilers with as well balanced protein as is economically possible. At low levels of protein, feather cover may be reduced.

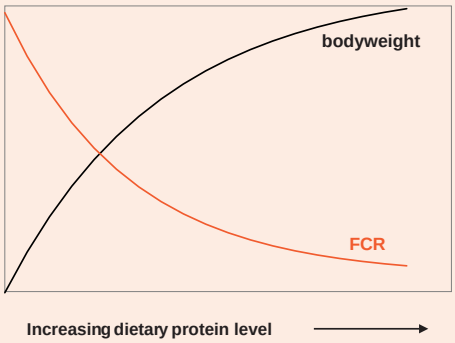


Figure 1. Response of bodyweight and feed conversion to increasing dietary protein level. Breast meat yield increases in a similar way to bodyweight and fatness decreases like feed conversions.

PROTEIN LEVELS – AN EXPERIMENTAL TEST

Advice on the protein and amino acid levels for Ross broilers is published in the Ross Breeders Broiler Management Manual. Different specifications are given for different production scenarios (e.g. as hatched to 1800g, sexed males to > 2500g). In making these recommendations it is not possible to take account of the wide variations in conditions, biological, physical and economic, that exist in different countries and companies. The recommendations are based on genetic potential, field experience, published research and feeding trials. Feed formulation to meet the recommended specifications can only be made by a nutritionist who understands local conditions.

Ross Breeders have recently carried out some trials to examine the effects of varying available amino acid levels. In this Ross Tech also referred to as protein. The trials were carried out in small pen facilities in the UK under what is regarded to be good UK-type conditions (i.e. closed housing, litter, pelleted feed). Broiler performance in the trial facility is generally equal to or better than the current performance objectives for Ross broilers.

Practical Starter (0-10days), Grower (10-28days) and Finisher (28-49days) diets were formulated to meet the available amino acid and other nutrient standards as described in the Ross Breeders Broiler Management Manual, 1999 (Appendix 2, Table 31). Ingredients included wheat, soyabean meal, fishmeal etc. and neither growth promoters nor coccidiostats were used. These feeds are described as 'Manual'. Feeds deviating from these available amino acid standards by -20, -10, +10 and +20 percent were then formulated from the same ingredients keeping all non-protein nutrients constant. The levels of 5 available amino acids, LYS, MET, MET+CYS, THR and TRP were controlled in exact ratios, the minimum levels of the other essential amino acids were ensured by adjusting the crude protein levels.

EFFECTS OF REDUCING PROTEIN LEVEL

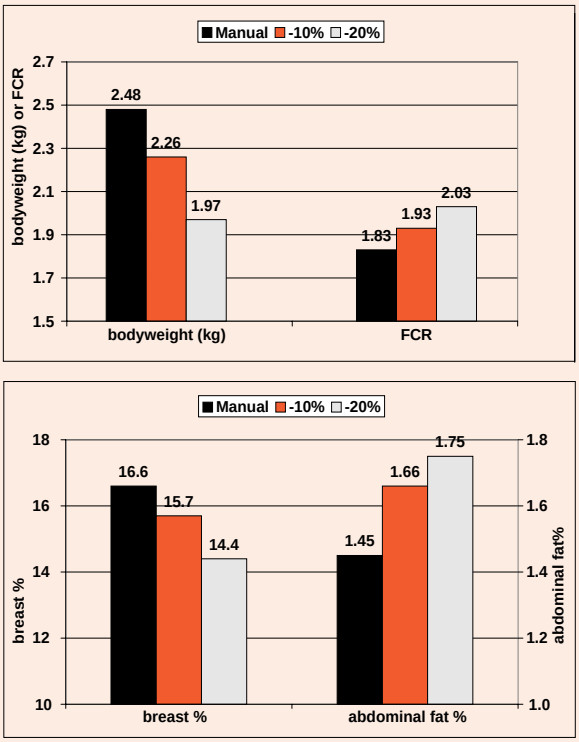


Figure 2. The effect of reducing protein levels below the Ross manual level for Starter, Grower and Finisher on performance of Ross 308 broilers at 42 days of age. Data are for the average of males and females penned separately.

The figure shows the effects of reducing protein levels from current manual recommendations by 10% and 20% in Ross 308 broilers. As expected reducing the protein level results in a lower bodyweight, worse feed conversion, lower breast meat yield and higher fat content. The reduction in performance from this and similar experiments is seen to be linear and is similar across a range of ages (35, 42 and 49 days). This allows the effect of a 10% reduction in protein levels on growth, feed conversion, meat and abdominal fat yield to be estimated (see Table 1). Table 1 shows that reducing protein levels by 10% of manual levels will reduce bodyweight by 9.6%, reduce breast meat yield by 6.2%, increase feed conversion by 5.5% and increase abdominal fat percentage by 8.5% in Ross 308 males. Similar reductions in performance are seen for Ross 308 females and Ross 508.

TABLE 1. PREDICTED EFFECT OF REDUCING AMINO ACID LEVELS BY 10% IN ROSS 308 AND ROSS 508 BROILERS RELATIVE TO MANUAL RECOMMENDATIONS IN PERCENT (35,42 AND 49 DAYS)

	Ross 308		Ross 508	
	Male	**Female**	**Male**	**Female**
Bodyweight	-9.6	-7.5	-7.7	-3.1
FCR	+5.5	+6.1	+5.8	+3.2
Breast meat yield	-6.2	-7.2	-4.8	-2.6
Abdominal fat	+8.5	+6.9	+12.1	+5.9

Conclusions

Reducing protein level from the level recommended in the Ross Breeders Broiler Management Manual will reduce the performance on the farm and in the processing plant.

EFFECTS OF INCREASING PROTEIN LEVEL

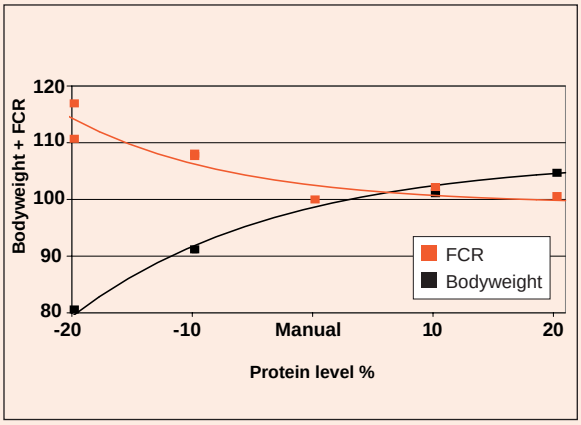
Broilers fed higher levels of protein than recommended in the manual are expected to improve in the major production traits. However, the rate of response is lower than that seen when protein is below recommended levels. Depending on the production system and costs in individual operations profitability may be improved.

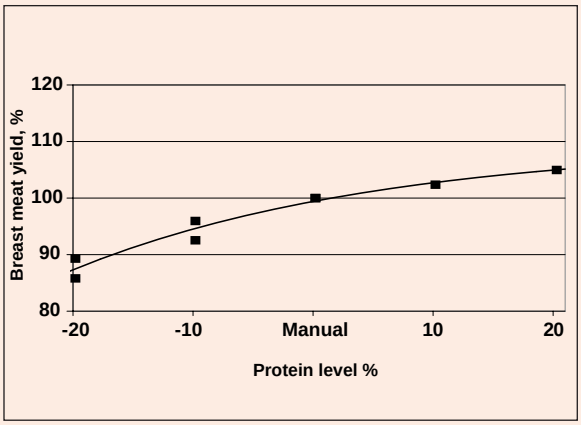
In the trial described above Ross 308 broilers received increased protein levels, which resulted in performance shown in Figure 3. Live weight, feed conversion, breast meat yield and abdominal fat continued to respond beyond the recommended protein levels and seem to reach a plateau as expected. Males and females respond in a similar way although males tend to show a larger response. The response of eviscerated yield in these trials appears to be linear. This is unlikely to be seen in the field but indicates a positive response to increased dietary protein levels.

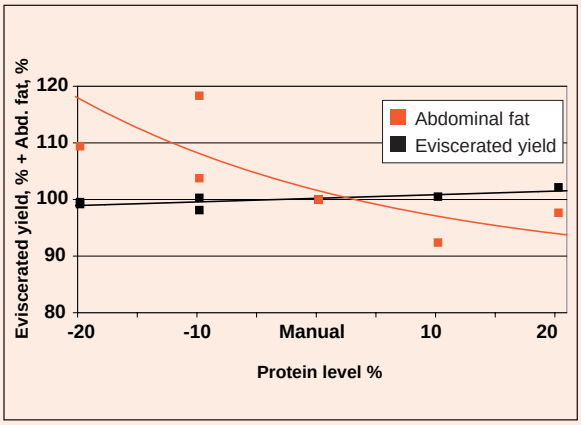
Conclusions

Increasing protein level above the level recommended in the Ross Breeders Broiler Management Manual will improve liveweight, feed conversion and processing yield. As expected the response reaches a plateau.

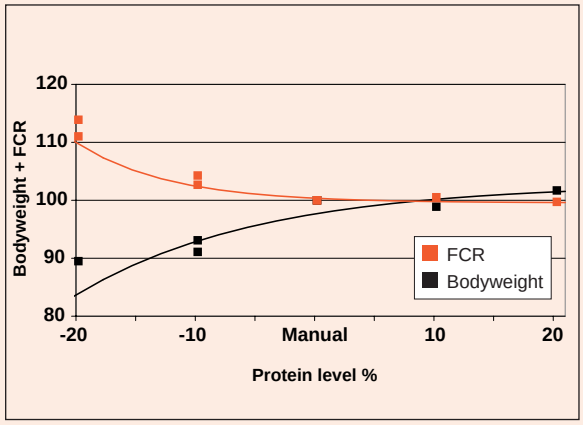
ROSS 308 MALES

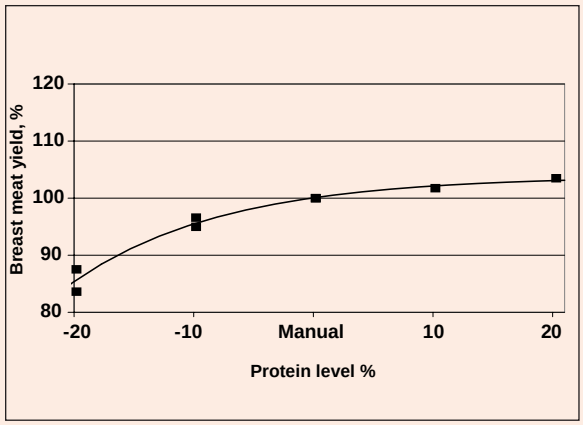






ROSS 308 FEMALES





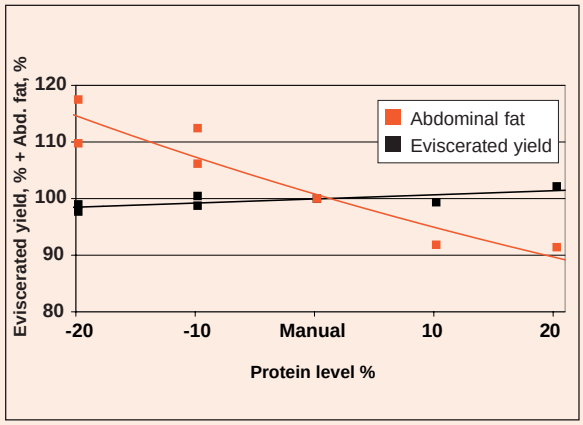


Figure 3. The response of Ross 308 broilers to dietary protein at 42-days of age indexed to performance on manual feeds. The fitted asymptotic curves have the formula (y = k0 + k1 * (1-exp(k3*digestible lysine))). The response curve for eviscertated yield is linear. The x-axis is expressed as dietary protein level deviated from the recommended level.

PROFITABILITY

Reducing the protein level in the diet makes feed less expensive but also causes a reduction in performance. Increasing protein in the diet will improve performance but make the diet more expensive. Profitability depends on the cost of feed and the income generated from the sale of broilers, carcasses and/or portions. The optimal diet will be different for each production operation depending on genotype, environment and economics as described above.

The consequences of changing diets can be predicted by a spreadsheet model, which calculates profitability from costs and incomes in a broiler operation.

Ross Breeders have developed such a model (see Figure 4 for the flow of information used in the model) to estimate the economic effects of altering performance by means of changes to genotype or bird management.

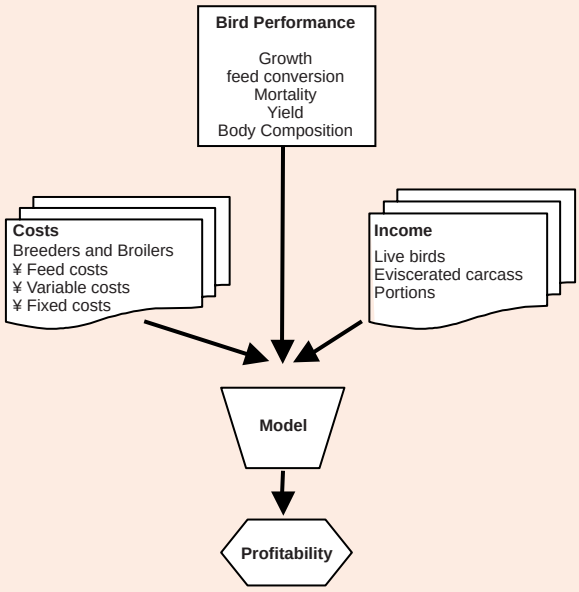


Figure 4. Information flow in the Ross Breeders Economic Model

The change in profitability (margin) due to altering the protein level in the diet is calculated for four production situations; broiler growing, broiler integration with no portioning, 50% portioning and 100% portioning.

Figure 5 shows the effect of changing protein level within each production situation. Profitability for each production situation is shown relative to the level of protein recommended in the manual, which is expressed as 100. It is not possible to compare absolute profitability between situations using figure 5. Profitability depends on local costs and circumstances and should be examined for each operation.

Figure 5 shows very clearly how dietary protein level influences the profitability. Reducing the protein level in the diet makes the feed cheaper. But farm and processing performance is reduced even more resulting in lower profitability. Increasing the protein level makes the feed more expensive but due to diminishing response in performance profitability reaches a maximum and then begins to fall.

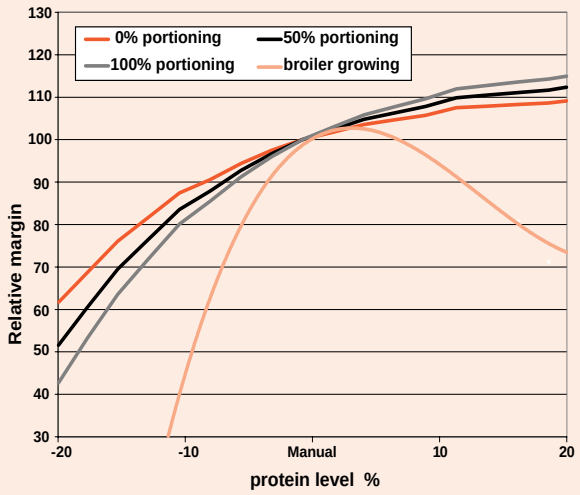


Figure 5. Estimated effect on profitability of deviating dietary protein levels from the recommended level. Calculated using the Ross Economic Model as described in the text. Assuming 600000 birds/week as hatched, age 42 days, turn round 47 days, Jan-June 2000 European raw material costs and whole bird/portion incomes.

Broiler growing appears to be relatively more sensitive to changes in protein level than integrated operations. This is a result of the combined effects of liveweight, FCR and feed cost which determine the profitability in a broiler growing operation. Integrated operations are affected by processing performance and resulting incomes, which seem to be relatively less sensitive to changes in protein level. (See Figure 3.)

These data suggest that margins in integrated operations do not reach a maximum in the range analyzed although there is a diminishing return above the recommended protein level. The continuing increase in profitability at higher levels of protein is driven by the increased yields seen with high levels of protein in these trials.

Profitability for integrated operations with high levels of portioning is more sensitive to dietary protein level. This is due to the greater responsiveness of high value portions compared to eviscerated carcase.

The model uses costs, incomes and procedures typical of UK and Europe as an example. In order to determine the optimal value for individual companies the costs, incomes and procedures for that company should be used.

One major difference, which would result in a more pronounced curve with an obvious optimum, would be where protein is relatively more 'expensive' than in Europe. Such conditions exist for example in the USA and South America. Where protein is relatively more expensive than energy there is likely to be a more rapid decline in profitability above recommended levels. This is caused by the increasing cost of producing high protein diets while yield has reached its plateau.

Conclusion:
Reducing protein from the recommended level reduces profitability in all production systems.

Increasing protein level improves profitability for integrated operations but shows diminishing returns.

USING A HIGHER PROTEIN LEVEL IN BROILER STARTER FEEDS

As potential growth rate increases, the need for broiler chicks to have the best possible start becomes more important. The trials described above which examined the effects of altering protein levels in the diet also investigated varying the protein level in the Starter ration on performance.

Three comparisons were made:

1. The protein levels recommended for Starter, Grower and Finisher in the manual were compared with an enhanced Starter (i.e. Manual, Manual, Manual vs +10%, Manual, Manual).
2. Protein level reduced by 10% throughout was compared with manual Starter (i.e. -10%, -10%, -10% vs Manual, -10%, -10%).
3. Protein level reduced by 20% throughout was compared with -10% Starter (i.e. -20%, -20%, -20% vs -10%, -20%, -20%).

The results of the trials are shown in table 3. The trials suggest:

- Reducing protein level throughout reduces performance and profitability as described previously.
- Enhancing the Starter above manual improved meat yield but not liveweight and feed conversion.
- When diets are reduced by 10% below manual improving the Starter ration increases growth but not meat yield.
- When diets are reduced by 20% below manual improving the Starter increases liveweight and meat yield.

These results suggest that current recommendations will give good performance for a broad range of production systems. However, there may be opportunity to optimize feed cost and performance in particular systems. For example, where feed cost has been minimized, growth rate may be improved by increasing protein level only in the Starter. Further benefit is likely to be obtained by increasing protein level in the Grower and Finisher as described previously. Or where meat yield is the major requirement, there may be response to increased protein in the Starter ration without the need to increase protein level throughout. Each of these scenarios should be examined carefully since the optimum approach depends on local costs, incomes and procedures.

Conclusion:
Increasing protein level in the Starter is likely to improve aspects of broiler performance depending on the current local situation.

TABLE 3. EFFECT OF INCREASING PROTEIN LEVEL IN THE STARTER DIETS ONLY IN ROSS 308 BROILERS RELATIVE TO BASE DIETS IN PERCENT (42 DAYS)

Comparison											
Starter	**Base diet**	**Live weight**		**FCR**		**EPEF**		**Eviscerated yield, %**		**Breast meat yield, %**	
		Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
+10,M,M	M,M,M	- 2.4	-	+ 4.0	-	- 4.5	-	+ 0.7	-	+ 3.7	-
M,-10,-10	-10,-10,-10	+ 5.4	+ 2.7	- 0.6	+ 1.8	+ 6.5	+ 1.2	- 0.1	- 1.2	- 0.3	- 1.1
-10,-20,-20	-20,-20,-20	+ 8.4	+ 6.9	- 1.7	-3.1	+ 8.8	+ 12.3	- 0.6	+ 0.6	+ 4.2	+ 5.8

EFFECT OF PROTEIN LEVEL ON BROILER UNIFORMITY

Broiler growers and processors require flocks with low variability (i.e. uniform flocks) to ensure that the maximum numbers of birds can be used for the required end product. Broiler uniformity was assessed in the trials described previously by weighing samples of birds during the trial. Uniformity was measured by the coefficient of variation (CV, standard deviation/mean in %).

Figure 6 shows the response of uniformity to dietary protein level. As protein levels are increased from 20% below recommendations to the manual level there is an improvement in CV to the expected level of 10%. The response is greater in males than in females. Low levels of dietary protein are clearly associated with poor uniformity.

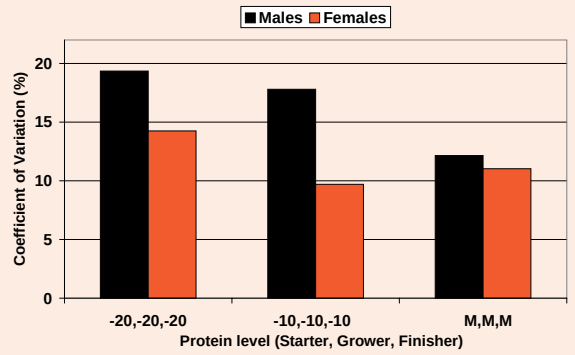


Figure 6. The response of broiler uniformity (CV in %) to dietary protein level. Data for Ross 308 broilers using samples of 50 birds for each point.

The effect of improving protein level in the Starter ration only is shown in Figure 7. Broilers fed 20% and 10% lower levels of protein were compared with birds fed Starter containing 10% more protein. In male birds especially, the use of the enhanced Starter gave a clear improvement in bird uniformity.

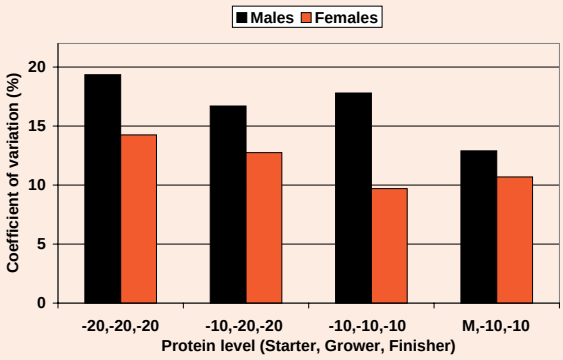


Figure 7. The effect of an enhanced Starter diet on broiler uniformity. Data refers to Ross 308 birds reared in the experiments described previously.

Broilers fed reduced levels of protein show poor uniformity possibly because an increasing proportion of the flock fails to achieve their potential growth. Improvements in the Starter ration allow a greater number of chicks to achieve good growth and appetite over the brooding period after which they are better able to cope with poorer quality rations.

Conclusion:

In situations where variability is important or a problem, increasing the protein level in the Starter or all rations should be considered.

OPTIMISATION OF PROTEIN LEVELS

The experiments described in this Ross Tech show that the modern broiler is capable of responding to changes in dietary protein level and that these changes can have effects on the profitability of broiler growing and processing operations. Although the results discussed were generated in small pen facilities, there is evidence that similar responses are seen in the field. In scaling up results such as these care must be taken to ensure that other limits to performance (e.g. stocking density, temperature etc.) do not prevent the improved performance being seen. Where there is a need to increase broiler performance, improved nutrition should be seen as part of a package of changes designed to increase performance of the bird. Nutrition will only improve performance when other management factors are not limiting.

The economic analysis shows that the whole production process must be examined to determine the optimal protein level to maximize profits. Reducing feed costs may make the cost side of the equation look good but the resulting loss in growth, FCR and yield will have negative effects on profitability. As costs and incomes change and in different types of operation, the optimum protein level to maximize profit will change. A simple computerised model of inputs and outputs can help indicate where profit is likely to be maximized. Such an approach can be used to indicate where profit and performance are optimized for individual organizations.

FUTURE DEVELOPMENTS

Protein levels have conventionally been set in discussion between nutritionists and production managers. Computerised models are used to formulate diets from available raw materials. However, these models fail to take account of the effects of dietary changes on performance and consequently profitability. Models, which translate the effects of dietary changes on performance of the broiler and therefore profitability, may become available. Such models would enhance decision making and lead to better profitability in the broiler industry.

This Ross Tech has shown the economic effects of variation in dietary protein content on broiler performance and profitability and, secondly, shown how optimal performance of broilers is dependent on good nutrition throughout the growing period and especially in the Starter period.