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Feeding schedules for broiler chickens

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The traditional feeding programmes and nutrient requirements of broilers, as established by the NRC, are usually based upon age and fixed growing duration. This is despite the fact that broiler growth pattern characteristics have changed enormously over last decade. Such classical approaches have been questioned as to their effectiveness, and it has been argued the NRC recommendations are no longer applicable to the present methods of production, and need to be re-evaluated. The short comings of traditional or classical fixed duration of feeding phases have led many investigators to suggest and introduce alternative feeding programmes in replacement, including alternative, phase, sequential, choice, dual and subsequent feeding. The effectiveness and shortcomings of such methods are analysed in this review.

Keywords: broilers; phase; sequential; choice; restricted; feeding programme

Introduction

Broilers require fewer nutrients as they grow older due to changes in growth and maintenance requirements. In addition, poultry consume more feed as they grow heavier. Thus to balance and meet their nutrient requirements, the composition of diet has to change accordingly. As such, it is common practice in the poultry industry to reduce dietary protein (amino acid) content and increase energy whilst keeping other nutrients constant throughout the feeding programme as the broiler gets older.

Strategies through which these changes are implemented vary. The classical (traditional) feeding programmes, and notably that of National Research Council (NRC), usually define the nutrient requirements of broiler chickens based upon age within three fixed periods (phases) namely starter, grower and finisher. These broad periods, defined by the NRC (1994) have been used for decades although the production needs that it was originally designed for has altered dramatically. According to Pope and Emmert (2002) the NRC programme does not correspond with the grow-out periods typically used in modern production practices and, thus, are now difficult to apply to commercial poultry nutrition programmes. In a recent survey of the nutritional management of broilers, the South-eastern Poultry and Egg Federation identified the need to determine the optimum time and nutritional level in phased diets as a high priority research area (as quoted by Saleh *et al.*, 1997a).

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Theoretical basis for alternate to NRC

The NRC (1994) phases, as described above, provides a single set of recommendations that includes males and females, requirements segregated into three fixed periods: starter (0-3 weeks), grower (3-6 weeks) and finisher; (6-8 weeks of age). Although easy to follow, these periods do not adhere to the ever-evolving system of broiler chickens. Broilers have come a long way from early commercial production in 1960s, when it took 60 days with a feed efficiency of 3.5 for a broiler to reach 2 kg weight. Broilers now reach the same body weight at half of that time and may attain 1.5 feed efficiency ratio (Zubair and Leeson, 1999).

Just as the time required to reach market weights has been reduced, the length of time various diets are fed have changed (Saleh *et al.*, 1996). Another point underlying the criticism of the NRC phasing is that the birds need diurnal changes, while the length of period NRC suggests are too long for the birds to adjust (Nasril, 2003). Because the bird's needs change gradually with age, each diet can only be optimally balanced for a particular time point (Watkins *et al.*, 1993). Additionally, it can be argued that a fixed duration plan does not take into consideration other variables, such as sex and breed. Some investigators have gone even further, suggesting that any feeding plan has to take into consideration the nutritional requirement changes during the 24 hours schedule (Forbes and Shariatmadari, 1994).

As result of such shortcomings of these traditional feeding systems, many different approaches have been introduced in recent years. Alternate (subsequent), sequential, dual, phase, and or choice feeding compromise different types of feeding presentation and phasing that have been claimed to have merit.

The proponents of these newly methods argue that their programme can benefit both the environment, by reducing the nitrogen excretion (Roush *et al.*, 2004), and the birds, by reducing metabolic disorders such as SDS, ascites and leg weakness (Bizeray *et al.*, 2002). It is also claimed that some of non-NRC feeding plan could be more beneficial to birds kept at high environmental temperatures (Pope and Emmert, 2002).

Feeding time period

The logic of applying a fixed period for traditional dietary phased feeding programmes has been challenged by researchers at University of Arkansas (Saleh *et al.*, 1996; Saleh *et al.*, 1997a;b, and Watkins *et al.*, 1993). They argued that, because the cost of feed generally declines as the protein is reduced, the optimum time for changing diets has economic importance and that the traditional methods do not meet the needs of modern poultry production. They reasoned that, due to genetic improvements, the time required to reach market weight has been reduced, and thus the time span for each phase has to be reconsidered and rearranged based on final slaughter weight.

As a result, these researchers have introduced new phased periods for typical starter (3135 ME and 21.2% crude protein), grower (3195 ME and 20.2% CP) and finisher diets (3250 ME and 17.70% CP) in order to assess the duration required for each diet if the birds are to reach 1, 2 or 3 kg respectively. Saleh *et al.* (1996) recommended allowing a 14 day period for starter, with 7 days for the grower phase and 7 days for the finisher period for birds to reach 1 kg at 28 days of age. Saleh *et al.* (1997a) assessed the length of different durations of feeding for birds grown to 42 days of age, and reported better performance when birds were allowed 14 days for starter, followed by 21 days in the grower diet and 7 days for finisher. For a 56 day production period, 14 days of starter and no less than 42 days for finisher diet were recommended by Saleh *et al.* (1997b).

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Watkins *et al.* (1993), when analysing the effect of changing amino acids, found that mixed sex broiler chickens grown to 40 or 45 days of age may be moved from the starter to the grower diet as early as 7 days of age with no loss of live performance. This is equivalent to a starter feed allocation of approximately 0.113 kg (0.25 lb). The growth response to changing from starter to grower diet was not significantly influenced by amino acid concentrations ranging from 100 to 120% of recommended levels. Male breast meat yield was influenced by dietary amino acid level when moved from a starter to a grower diet at 0, 7, or 14 days, but not when the change was made at 21 days. They concluded that the economic impact of moving from starter diets to less expensive grower diets may be considerable.

It is clear from the above studies that the timing of introducing different feeds can influence the response of broilers to dietary components, especially when the feeding schedule is based on final body weight. However there is no clear pattern to conclude that a shorter starter and grower period is beneficial in all circumstances, but that it rather depends on slaughtering weight.

Phase feeding

Phase feeding is described by Pope *et al.* (2002) as a strategy to change the diet several times (including, but not exclusively, the traditional fixed three times) in the course of the broiler's life. This is done in order to better match nutritional requirements to the specific nutritional need, with the aim of improving feed efficiency. An advanced strategy called 'continuous multi-phase feeding' has been developed by Nasril (2003), which involves using a strategy to match feed composition to the broilers nutritional requirements on a daily basis throughout the growth period.

These researchers have argued that, under the standard three stage feeding system, birds are either under-fed or over-fed for most of each period. Thus, the shorter the duration of feeding period and the more types of feed employed, the closer the diet will be to bird requirement, leading to better performance.

The advantage of multi-phase feeding is considered to be improved feed efficiency and reduced diet cost (Pope and Emmert, 2001), although the total operational cost involved was not included in this analysis. However, multi-phase feeding of broilers does not always result in improved performance. Warren and Emmert (2000) split the traditional broiler starter period into three weekly phases (0-7, 7-14 and 14-21 days) and reported no significant differences in weight gain, feed intake, and feed efficiency. Pope *et al.* (2002) studied phase feeding in broilers with diets switched every other day from 42 to 60 days of age, and found no difference in weight gain, feed intake, feed efficiency or carcass composition. However, the cost of production was reduced. Pope and Emmert (2002) also pointed out that phase feeding could be beneficial to birds reared under high environmental temperature.

Nasril (2003) indicated that intensive multi-phase feeding improved body weight gain and feed to gain ratio only in weeks five and six, but not during the overall seven-week period. Nitrogen excretion and nitrogen retention were unaffected by the intensive multi-phase feeding systems. Economic analysis indicated that intensive multi-phase feeding programmes could potentially lower feed costs per kilogram of gain.

An experiment comparing the standard NRC three phase feeding schedule to that of five and nine phases showed that increasing the number of feed changes had no effect on the performance of broiler chickens, but did result in improved protein conversion ratio and decreased nitrogen excretion (Mohseni, 2008).

In order to achieve this economically, the starter and grower/finisher feeds can be

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blended together daily at the rearing facility whilst the feed is being delivered directly to the chickens. Two feed bins and a proportioning system are required for each chicken house. It must be remembered that the high cost of implementing a continuous multi-phase feeding system may not justify the relatively small savings in lower feed costs. As a result, Nasril (2003) concluded continuous multi-phase feeding of broiler chickens using corn-soy diets does not appear to be justified by either increased performance or reduced nitrogen excretion.

Sequential feeding

Alternating different diets during the day has been termed 'sequential feeding' by Gous and Du Preez (1975), and this has been studied for nutritional purposes (Foote and Rose, 1991; Rose *et al.,* 1995). The sequential feeding of feeds of different nutritional values is practiced in Europe when, for example, whole grain wheat is successfully alternated with a complementary protein-rich feed (Noirot *et al.*, 1998). Sequential feeding recently proved to be effective in reducing mortality under acute heat challenge during the finishing period (De Basilio *et al.*, 2001) and to reduce gait score and increase activity of young broiler chickens (Bizeray *et al.*, 2002). Feeding high and low protein feeds on alternate days has been shown to induce a relatively small and insignificant reduction in weight gain compared with complete diets and shorter sequential phases (Rosebrough *et al.*, 1989; Shariatmadari and Forbes, 1993; Forbes and Shariatmadari, 1996). Rapid adjustments of muscle protein synthesis and lipogenesis were reported after re-feeding or changing the dietary protein concentration of the feed (Kita *et al.*, 1996; Rosebrough *et al.*, 1996; Aman Yaman *et al.*, 2000a,b), suggesting that sequential feeding might be an effective technique to monitor broiler metabolism. Intermittent feed restriction in young domestic fowl alters hormonal status and contributes to a metabolic status that might enhance immunocompetence (Nir *et al.*, 1996).

According to Bouvarel *et al.* (2004) several questions arise from this brief survey of published studies regarding sequential feeding:

- Do sequentially fed chickens adjust their intake according to the energy or according to the protein concentration of each feed?
- Would extending the period of each feed up to 24 h be an effective way to enforce the intake of each feed
- Would an interval that is too long between imbalanced energy-protein nutrient sources hinder effective anabolism and muscle growth?

Certainly, the time gap between two feed are of importance, and that this is more evident at high environmental temperature (De Basilio *et al.*, 2001).

Separate feeding

A diversion feeding programme that was developed from sequential feeding is that of separate feeding. The sequential feeding of feeds of different nutritional values is practiced in Europe when, for example, whole grain wheat is successfully alternated with a complementary protein-rich feed (Noirot *et al.*, 1998).

Presentation of such divided diets as a choice is also being practiced. This will be more covered at choice feeding section.

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Restricted feeding

An adverse feeding schedule to that of NRC programme and others is the early restriction or low protein diet presentation followed with a higher nutritious diet. The advocates of these types of feeding programme argue that, due to the dramatic increases in both growth rate and appearances of metabolic disorders of broiler chickens in recent years, it is better to slow down early growth rate and enjoy later faster growth rate which results in better feed conversion ratio. The concept of feed restriction and compensatory growth has been well covered by Zubair and Leeson (1999).

There is a major problem with the theoretical basis of this feeding programme. Postponement of growth to a later stage could indeed exacerbate the metabolic disorders as most of these problems occur at late stages of growth period. Furthermore, there are many variables (sex, strain, time of enforcing restriction, duration and types) that could affect the outcome of any restriction. The outcome of restriction period is also affected by the nutrition programme put in place to encourage compensatory growth.

The question as to whether the birds needs change during the compensatory programme, *i.e.* where it needs higher nutrition or feed intake, has not yet been clarified. The few experiments regarding this issue have not shown any clear answers.

As the production cycle shortens due to improvements in genetic selection and nutrition, the implementation of early restriction will come under increasing question. Most experiments examining compensatory growth were carried out during early 1990s, when it took birds about 60 days to reach 2 kg. As such, it was recommended that the birds be restricted at 10 days of age and for a further seven days. This allowed the birds to reach the slaughter weight at the desired target age. The question now is whether present birds that reach 2 kg at 35 days are able to compensate during remaining 18 days of growth or if a new set of experiments are needed to identify and optimise phasing thresholds.

Choice feeding

A detailed review of the literature concerning choice feeding is beyond the scope of this paper. Suggested references include: Forbes (1995), Forbes and Shariatmadari (1994), Forbes and Covasa (1995). A brief overview will be given instead.

A choice feeding programme allows birds to chose from various (usually two) diet sources (mainly protein) within a combination which is non-limiting. Supporters of choice feeding systems have questioned single feeding programmes, as most of the flocks will be in a state of either under- or over-nutrition supply due to individual differences in growth, genetic potential, sex and ambient temperature (Kyriazakis, 1989). They further claim that diet selection has value in understanding the specific requirements of the animals, and this could be used to recommend diet specifications, especially at high environment temperature (Sinuart and Balnave, 1986).

A number of comparative studies by Emmans (1991) identified the economic advantages of choice feeding. Under a choice feeding system, a saving of 5%, 2.5% and 1.5% of total protein intake was been attributed to growth, sex variation and temperature respectively (Rose and Kyriazakis, 1991).

Special automatic weighing mechanisms, to enable choice feeding to be applied to automated choice feeders in broiler sheds, are available in Denmark, where choice feeding of broilers has been widely accepted (Cumming, 1987). A further possible advantage of choice feeding is the increased development of the gizzard and

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promotion of a normal sized proventriculus in chickens fed whole grain, which apparently increases resistance to coccidiosis challenge (Cumming, 1987).

However these attributed advantages are based on the assumption that birds have enough opportunity (in terms of time) to recognise the differences between the diets on offer and can actually make an appropriate choice. Opinions regarding the ability to choose wisely are divided between those who give the credit to birds for such ability and those who reject this idea (Shariatmadari and Forbes, 1993). However, if the birds are given enough time to learn or be trained, then applying choice feeding in the field seems to have some merit (Shariatmadari, 1992).

Conclusions

Replacing traditional or classical NRC feeding schedules with alternatives appear interesting and, at times, impressive, but often lack substance. Many claims of benefits come from single groups of researchers and not all the merits proposed have been confirmed by other researchers or applied commercially. There are many variables that affect the outcome of alternative feed phasing and further research needs to be carried out before implementation in the field. Furthermore, there are so many suggestions that many growers may face confusion regarding commercial application of such ideas. As a result, it seems as that there is little alternative to the phasing recommendations of NRC in the near future.

FOOTNOTE

1. In recent years a drive to introduce an extra nutritious feed called "pre starter diet" or "in hatchery feeding" has found many supporters. The very theory that the followers of his type of feeding present oppose those who prefer to allow the birds a lower nutritious diet at early stage of broilers age with view of compensatory growth. There has been no experiment to compare these two method as yet.
2. *in ovo* feeding is another type of feeding that has attracted some researcher in recent years. However, it is in its early stages, and further investigation is needed before elaborating on its effectiveness and extend that it could influence the following feeding programmes.

The subject of early feeding including *in ovo* is well covered in review by Uni and Ferket (2004).

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