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Phase Feeding Strategies to Optimize Poultry Production Efficiency: Review

Diribi Mijena and Aman Getiso*

Ethiopian Institute of Agricultural Research, Ethiopia

***Corresponding author:** Aman Getiso, Ethiopian Institute of Agricultural Research, Wondogenet Agricultural Research Center, P.O. Box: 198, Shashemene, Ethiopia, Email: aman.getiso@yahoo.com

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Abstract

Phase-feeding strategies have emerged as crucial tools for optimizing poultry production efficiency by aligning feed formulations with the changing nutrient requirements of birds at different stages of production. This review examined the application of phase feeding in both layer and broiler chicken production systems. Layer phase feeding involves adjusting the nutrient composition to match the varying needs of birds throughout the laying cycle, considering factors such as egg size, number, and production stage. Broiler-phase feeding, on the other hand, entails transitioning diets at different growth stages to support rapid muscle development and weight gain while maximizing feed efficiency. This review explores the physiological and economic implications of phase feeding, emphasizing its role in reducing feed costs, minimizing nutrient wastage, and enhancing productivity. Key principles, nutrient requirements, and recommended feeding phases for layers and broilers were outlined, providing insights into effective phase feeding programs. Phase-feeding strategies offer a promising avenue for enhancing poultry production efficiency and profitability by optimizing feed formulations to meet specific nutritional needs at each stage of production.

Keywords: Phase Feeding; Layer Chickens; Broiler Chickens; Nutrient Requirements; Feed Efficiency

Introduction

Modern chicken farming is greatly influenced by the feed farmers provide for their chickens. It is vital to provide the right feed to meet the nutritional requirements of chickens to ensure optimum growth and productivity Saisai H [1]. The nutrient requirements of poultry are influenced by several factors and subject to constant changes. There are two main types of factors that influence nutrient requirements: bird-related factors (genetics, sex, and type and stage of production) and external factors (thermal environment, stress, and husbandry conditions) Ravindran V [2]. Maintaining birds under comfortable, thermo-neutral environmental conditions also reduces feed consumption and improves feed utilization, thereby reducing nutrient excretion Sutton A [3]. The selection of the most economical chicken production system is very important, and small improvements in existing production methods could lead to larger achievements when multiplied by a large volume of results Pope T, et al. [4], Pope T, et al. [5].

Phase feeding divides the growth period into several periods, each with a smaller interval between body weights, allowing producers to provide diets that meet the nutrient requirements of birds more closely Sutton A [3], and is the most effective and efficient method for feeding chicken. By definition, it is the form of feeding that involves the use of specific formulated feeds to meet the changing nutritional

requirements of chickens Saisai H [1]. It is the feeding of several diets for a relatively short period to specifically meet an animal's nutrient requirements Ebegbulem VN, et al. [6]. As described by Warren WA, et al. [7], phase feeding is a nutritional management strategy in which the ingredients and chemical composition of the diet are modified over time. Therefore, the nutrient composition of the diet meets the nutritional requirements of the animal. Mehmood S, et al. [8] also described phase feeding as a process of formulating feed to meet the nutrient requirements of chickens at specific stages of production and capacity Mehmood S, et al. [8].

The main objective of phase feeding programs is to define the proper level of nutrients in a diet using different mixtures, considering the performance and economic advantage of production, and often the environmental sense Saleh EA et al. [9]. According to Sutton A [3], phase feeding of multiple diets during the grow-out period can significantly lower nitrogen (N) and phosphorus (P) excretion. Another authors Roush WB, et al. [10], Tolimir N, et al. [11] described phase feeding as the application of nutrition programs to indicate the optimum level for production by giving due attention to economics and the environment with changing starter, grower, and finisher mixtures fed at different frequencies to birds. Generally, phase feeding requires careful assessment of the nutrient requirements for production, growth, and maintenance as it balances diet in relation to requirements Leeson S, et al. [12]. Therefore, phase feeding is an important part of establishing feed programs to meet animal productivity and profitability objectives.

Literature Review

Layer Phase Feeding

Feeding programs that use only a single feed during the entire lying period are simple and easy to manage, but costly. Hence, BIS [13] recommends a feeding program in two phases: phase I and phase II. Phase feeding is the feeding layer of birds in different phases to adjust their nutrient intake in accordance with the rate of egg production, and to control the feed intake and body weight of layers, as well as egg size Batonon D, et al. [14]. The phase feeding of the layers is described by changing the nutrient composition of the ratio to match the different stages of production. This approach is economical (in the case of protein feed) and physiological (in the case of calcium feed) Kuney DR, et al. [15].

Phase feeding in layers should be determined by egg size, egg number, and not by percent production Leeson S, et al. [12]. The feed formulated for poultry should also be based on the consumption level and stage of the production cycle. The first eggs laid by pullets are usually small and few, so nutrient requirements are not as high, and feed consumption during this age is 70-80 g/bird/day. Therefore, supporting large egg production and egg weight (56–63 g) is the target of daily feed consumption of approximately 100–105 g/bird/day before 30 weeks of age Alex O [16]. Because feed intake and egg production go in different directions (feed intake increases but egg production decreases), the nutrient content of the diet should be reduced. During this time, it is relevant to consider the egg production curve of a layer and pay due attention to both egg weight and daily egg mass output Leeson S, et al. [12].

Protein requirements in the feeding phase can be divided into four categories according to the requirements for growth, maintenance, feather replacement, and egg production. The period between 20 and 42 weeks of age is a critical time of feeding since growth and egg production are rapidly increasing. After 42 weeks of age, the rate of egg production is reduced, but egg size increases, and phase feeding is usually considered Kuney DR, et al. [8]. As the growth of the bird increases, amino acid levels decrease gradually; thus, phase feeding is designed to remove excess amino acids, reducing feed cost, nitrogen excretion Pope T, et al. [4], and egg size Leeson S, et al. [12]. Feed cost reduction will be more visible when the cost of protein source feed is high, whereas the importance of egg size reduction will vary depending on the current price of eggs. Phase feeding will not be as significant if the value for extra-large eggs is high unless eggshell quality is a problem. However, reducing the nutrient content should not occur directly after peak egg production; it must occur after peak egg production Leeson S, et al. [12].

The protein level of the diet should also be reduced by considering the effects of temperature on feed consumption, age, bird production, and energy level of the diet. This requires consideration of every flock on an individual basis before decision making. As a general guideline (its application needs proper consideration of all factors), it is recommended that if production is reduced to 90%, protein intake will be reduced from 19 to 18 g/day, and if production drops to 80%, protein intake will be reduced to 15-16 g/day. An average feed intake of 95 g/day is equivalent to diets containing 20, 19%, and 16% protein. If a reduction in dietary protein levels decreases egg production, egg production should be directly increased. However, if production is constant and egg size is not reduced, protein levels can still be reduced. Since methionine is an amino acid that has the greatest effect on egg size, it needs more emphasis than the other amino acids. Slow reduction in methionine can lead to loss of egg production and possibly increase feed intake; that is, 20% methionine reduction at one time reduces egg size by 3% with 8% production loss Leeson S, et al. [12].

The mineral content of the diet (including calcium and phosphorus) must be adjusted according to the age of the layer, particularly after 40 weeks of age. When the target egg

size or weight is achieved or exceeds the switch to rations with lower oils, methionine/total sulfur amino acid level (TSAA) and phosphorus, and increase the level of calcium. When egg weight and production level from aged layers are not reduced, it only needs adjustments in calcium and phosphorus levels are required to maintain eggshell quality Alex O [16]. The phosphorus level at peak production is 0.42-0.46%, which is reduced to less than 0.3% at the end of laying, using the principle of phase feeding Leeson S, et al. [12].

Generally, phase feeding in layers is based on several key principles Alex O [16]. A single-layer bird requires 18-19 grams of protein per day for large egg production, and a significant reduction in protein levels can decrease egg numbers, although supplementation with artificial amino acids can balance amino acid requirements at lower protein levels. Lowering methionine and Total Sulfur Amino Acids (TSAA) in the diet can reduce egg size. Each layer bird also requires 280-310 kcal/day for large egg production; however, heat stress can reduce feed and energy intake, consequently decreasing both the number and size of the eggs. The levels of unsaturated fatty acids (such as linoleic acid) and total fat in the diet affect yolk and egg size, with lower levels reducing egg size and excess fat increasing yolk and egg size. Most vegetable oils (such as soybeans and canola) contain higher levels of unsaturated fatty acids than animal fats do. Adjusting the diet, pen environment, and management practices can help manage the daily feed intake. Birds that efficiently convert feed to early production tend to lay more but smaller eggs. Additionally, each layer requires 4 g of calcium daily for large egg production, and as egg size increases, the shell becomes thinner. In a phase feeding program, the calcium level in the diet should be increased, whereas the phosphorus level should decrease as the layers age (Table 1).

No	Type of nutrients	Nutrient requirement				
		Chick	Grower	Layer Complete	High energy	Low calcium
1	Metabolizable Energy	2800 Kcal/Kg (min)	2800 Kcal/Kg (min)	2750 Kcal/Kg (min)	2850 Kcal/Kg (min)	2700 Kcal/Kg (min)
2	Crude protein	22%	16%	16.50%	17%	16%
3	Crude fat	6% (max)	6% (max)	8% (max)	8% (max)	8% (max)
4	Crude fibre	5% (max)	6% (max)	8% (max)	7% (max)	8% (max)
5	Calcium	1% (min)	1% (min)	3.7% (min)	3.7% (min)	2.5% (min)
6	Phosphorus, available	0.5% (min)	0.35% (min)	0.5% (min)	0.5% (min)	0.5% (min)
7	Lysine	1% (min)	0.80% (min)	0.70% (min)	0.75% (min)	0.70% (min)
8	Methionine	0.45% (min)	0.32% (min)	0.28% (min)	0.30% (min)	0.28% (min)
9	Methionine + Cystine	0.80% (min)	0.70% (min)	0.60% (min)	0.65% (min)	0.60% (min)

Table 1: Optimum nutrient requirements of the layers [17].

Broiler Phase Feeding

Feed constitutes approximately 60-70%of the total broiler production costs Saveewonlop N, et al. [18]. The broiler industry has achieved peak efficiency by leveraging advancements in poultry science, particularly in genetics and nutrition, enabling the breeding of rapid-growing, feed-efficient commercial broiler chicks Anonymous [19], Mehmood S, et al. [8]. Because of the significant proportion of feed cost in broiler meat production, extensive research has focused on enhancing the nutrition and feed efficiency of broiler chicks, recognizing their precise nutrient needs for rapid growth and development, and necessitating diets that can effectively meet these requirements Skinner-Noble D, et al. [20]. Phase feeding in broiler chickens involves adjusting the diet at different growth stages to meet the changing nutritional needs, thereby optimizing growth, feed efficiency, and overall health Moss AF, et al. [21]. Initially, broiler chickens are fed high-protein starter diets to support rapid early growth and development Kamely M, et al. [22], and as they grow, the diet is gradually transitioned to a grower phase with slightly lower protein and higher energy levels to support continued muscle development and weight gain Van Emous RA, et al. [23], with the final finisher phase diet adjusted to lower protein and higher energy levels to maximize weight gain and improve feed conversion efficiency before market Maharjan P, et al. [24] (Table 2). This phased approach ensures that broilers receive the appropriate nutrients at each stage of development, reducing feed costs and minimizing nutrient waste, while promoting optimal growth performance. The broiler feeding program is divided

into three phases: Broiler Starter Phase: 0 to 10 days, Broiler Grower Phase: 11 to 25 days and Broiler Finisher Phase: 26 to 42 days or longer Dhandu AS, et al. [25]. The diets or feeds provided in these phases are broiler starter, broiler grower, and broiler finisher diets Warren WA, et al. [7]. The diets or feeds given in these phases were broiler starter, broiler grower, and broiler finisher diets, which are presented in Table 3.

Phase nutrition in broilers includes the application of nutrition programs with different frequencies of changing starter, grower, and finisher mixtures with the aim of determining the optimum for production in the economic and environmental sense Tolimir N, et al. [11]. Phase feeding programs are important for maximizing broiler productivity by managing their nutrient requirements. It takes advantage of changes in the nutrient requirements of broilers at various stages of growth Mehmood S, et al. [8]. Phase feeding reduces feed costs without affecting the performance of broilers during the grower and finisher phases and has environmental benefits Pope T, et al. [4], Mehmood S, et al. [8]. Feed intake, body weight, and feed conversion ratio are directly correlated with the feeding phase Mehmood S, et al., [8]. According to Ebegbulem VN, et al. [6], feeding of broiler chickens using phase four feeding phases (starter, first finisher, second finisher, and third finisher diets) be embraced by poultry farmers as it would provoke reduced dietary cost without compromising the optimum performance of the birds. Similarly, Mudhunguyo A, et al. [26] stated that, four phase feeding programme yielded better results when compared to two and three phase feeding programmes as shown by superior live weight gains, carcass weight and feed conversion ratio and recommend that small scale farmers should adopt four phase feeding programs in their broiler production so as to achieve superior growth rates, carcasses weight and high feed conversion ratio. On the other hand, Ravindran V [2] stated the three recommended growth periods for meat chickens are up to three weeks, three to six weeks, and six to eight weeks to meet their nutrient requirements. However, these selected growth periods can vary from four to ten weeks of age depending on the needs of the local market, and it is important to recognize the variation in nutrient requirements during the growth periods. (PTC+) also classified broiler feeds into three groups (starter, finisher 1, and finisher 2) with the following nutrient requirements.

No	Type of nutrients	Nutrient requirement		
		Starter	Finisher 1	Finisher 2
1	Metabolizable Energy	3000 Kcal/Kg (min)	3200 Kcal/Kg (min)	3100 Kcal/Kg (min)
2	Crude protein	22%	20%	19%
3	Crude fat	9% (max)	10% (max)	10% (max)
4	Crude fibre	5% (max)	5% (max)	5% (max)
5	Calcium	1% (min)	1% (min)	0.90% (min)
6	Phosphorus, available	0.5% (min)	0.5% (min)	0.5% (min)
7	Lysine	1.2% (min)	1% (min)	0.95% (min)
8	Methionine	0.5% (min)	0.45% (min)	0.44% (min)
9	Methionine + Cystine	0.9% (min)	0.80% (min)	0.76% (min)

Table 2: Optimum nutrient requirements of broilers [17].

No	Type of nutrients	Nutrient requirement		
		Starter	Grower	Finisher
1	Metabolizable Energy	3000 Kcal/Kg	3050 Kcal/Kg	3100-3200 Kcal/Kg
2	Crude Protein	21-22%	19-20%	18-19%
3	Crude Fat	5% (max)	5% (max)	6% (max)
4	Crude Fibre	5% (max)	8% (max)	8% (max)
5	Calcium	0.85% (min)	0.8% (min)	0.80% (min)
6	Phosphorus, available	0.45% (min)	0.45% (min)	0.45% (min)
7	Lysine	1.10% (min)	1.05% (min)	0.95% (min)

8	Methionine	0.37% (min)	0.33% (min)	0.30% (min)
9	Methionine + Cystine	0.88% (min)	0.80% (min)	0.74% (min)
10	Threonine	0.77	0.69% (min)	0.65% (min)
11	Tryptophan	0.18% (min)	0.17% (min)	0.17% (min)

Table 3: Nutritional Requirements for Broilers.

In starter feed, the crude protein level is high (21-22% CP) and the metabolizable energy level is low (3000 Kcal/kg ME). The crude fiber content is low (4-5% CF) because chicks cannot digest fiber very well. Hence, the starter feed must contain supplements, essential minerals, and vitamins.

Broiler feed must contain balanced crude protein (19-20% CP) and metabolizable energy (3050 Kcal/kg ME) with a fairly low fiber content (7-8% CF). Broiler finisher diets must contain high energy and low protein contents. The metabolizable energy should be 3100-3200 Kcal/kg while the crude protein should be 18-19%. Therefore, phase feeding is advantageous for maximizing performance and increasing profit margins. A modest reduction in dietary protein and amino acid levels in different feeds determines requirements and economics Ravindran V [2].

Phase feeding would not be economically feasible if six or more diets were fed during the grow-out period because of the increased costs associated with diet preparation, transport, and storage. Rather, it may be possible to accomplish phase feeding by initially delivering a nutrient-dense starter-type diet and a less dense finisher-type diet, which could be blended at a desired rate to achieve a gradual decrease in dietary amino acid levels. Phase feeding closely meets dietary amino acid requirements over the entire grow-out period Warren WA, et al. [7].

Summary

Phase feeding refers to the method of formulating poultry feed according to the nutrient requirements of birds at a specific stage of production. This is because, as the age of the chicken increases, its feed intake increases, while egg production is reduced. The system was specially developed to reduce the protein and amino acid levels of the diet with the progress of the laying cycle of layers or the growth stage of broilers. Phase feeding of protein, methionine, and phosphorus is related to controlling egg size, optimizing shell quality, and minimizing feed costs.

The phase feeding of layers is described by changing the nutrient composition of the ration to match the different stages of production, which have economic and physiological importance. This should be determined by egg size, egg number, and not the percentage production. The phase feeding of broilers has three commonly selected growth periods: up to three weeks, three to six weeks, and six to eight weeks for maintaining their nutrient requirements, which can vary based on the local market. This is important for maximizing broiler productivity by managing their nutrient requirements. In general, phase feeding not only provides the nutritional requirements and enhances the productivity of chickens but also reduces the cost of feed.

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