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Review

Role of Prelay Nutrition in Modern Layer Management

Lonkar, V. D.*

Assistant Professor, Department of Poultry Science, Krantisinh Nana Patil College of Veterinary Science, Shirwal Dist. Satara 412 801, Maharashtra Animal & Fishery Sciences University, Nagpur, Maharashtra, INDIA

*Corresponding Author: vijulvet1982@gmail.com

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Abstract

Genetic, nutritional, and management efforts were adopted to extend the laying cycle with efficient production in layers. The poultry industry targets layers to get 500 eggs in a 100-week laying cycle positively impacted by manipulating the pullet nutrition because the layer's performance depends on her pullet stage performance. If the feeding programs for pullets are well designed and implemented, egg producers can take advantage of today's modern layer's tremendous genetic potential. The prelay period typically begins two to three weeks before the ovulation of the first ovum. Substantial body reserves before egg production (prelay period) are indispensable to achieve satisfactory hen performance. At the onset of egg production, calcium reserve are crucial in maintaining egg production and eggshell quality. A prelay diet with moderate calcium (2.0-2.5%) allows for the build-up of the medullary bone calcium reserves and maintains eggshell qualities. Dietary energy and protein are the critical nutrients in maturing pullets. The egg production performances improved by feeding pullets with high-energy and high-protein diets during the prelay period. Feeding a prelay diet containing 2700 kcal ME/kg diet and 18% CP with 2.0-2.5% calcium is the best combination for pullets 2-3 weeks before the start of egg production.

Keywords: Calcium, Energy, Protein, Prelay Pullet Nutrition,

Introduction

The prime reason for replacing layer flocks at or around 72 weeks of age was a decline in egg numbers and a deterioration in shell quality. However, genetic progress recently accelerated the tremendous improvement in the performance of commercial layers in the last 20 years, which could allow hens to produce eggs for a more extended period. Egg numbers, egg mass output, and feed efficiency have all improved. The modern egg layer comes into production at an earlier age and with a lighter body weight than its predecessors and has excellent persistency of production. As a consequence of the improved genetic potential of the modern egg layer, we now have a shorter growing period, making it more difficult for pullet growers to reach optimal body weight before the onset of production. Once pullets come into production, daily nutrient intake tremendously impacts the peak production level, persistency of production, early egg size, and all other performance parameters. Genetic, nutritional, and management efforts were adopted to extend the laying cycle with efficient production in layers. Earlier scientific literature has been published on the grower and layer calcium requirement, but less work has been carried out on the calcium requirement of modern pullet during her transition from pullet to layer stage. During this transition phase, just before the start of egg production, the pullet built up calcium reserve in her body in anticipation of the need for a shell calcification process (Themeli, 2003). The poultry industry targets layers to get 500 eggs in a 100-week laying cycle (Bain *et al.*, 2016). This positively impacted them by manipulating the pullet nutrition in her pullet stage performance.

If the feeding programs for pullets and layers are well designed and implemented, egg producers can take advantage of today's modern layer's tremendous genetic potential. Due to the considerable variations in the levels of nutrients given to pullets before egg production, the pullet feeding strategies must be reconsidered and evaluated to match growing pullets' physiological requirements to improve subsequent egg production.

Pullet Development

During pullet development, 6 to 12 weeks of age is the period of fastest skeletal growth in pullets (Fig. 1), when pullets gain an average of 90 to 100 g of body weight per week, and the skeleton is 95% developed at 12 weeks of age (Whitehead 2004). The bone growth plates close at sexual maturity, and not much more bone growth is added. Hence, a delay in growth affects mature bird size and the onset of egg production. The 6 to 12 weeks of age is the fastest skeletal growth in pullets when pullets gain an average of 90 to 100 g of body weight per week, and the skeleton is 95% developed at 12 weeks of age (Whitehead 2004). Once the pullet reaches proper development determined by body weight and uniformity, it is receptive to light stimulation to start the production of the egg (Bain *et al.*, 2016; Whitehead, 2004). The high calcium demand required for eggshell formation in modern layers demonstrated that providing nutrients required for optimum skeletal health is critical from the rearing phase to the end of the production cycle (Korver, 2020).

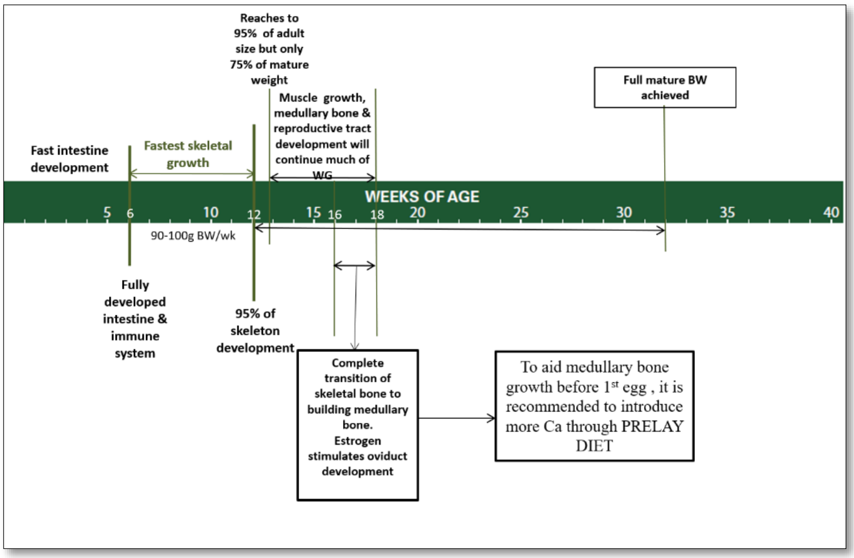

Fig. 1. Development of Pullet

Prelay Period

Today's commercial egg-laying strains are distinctly different in production and nutrient utilization than birds in the 1980s. Due to a genetic selection for optimum performance, today's pullets mature earlier than the hen of two decades ago. The modern pullet experiences the potential to rise quickly to peak production. The physiological and nutritional aspects of egg-laying divide into two distinct periods of a hen's life. First is the prelay period, generally considered the period before the first egg oviposition, during which rapid development of the reproductive organ proceeds. The prelay period typically begins two to three weeks before the ovulation of the first ovum. The second is the period during egg-laying. Several specific changes were observed during a short period before and immediately after the onset of egg production. At the onset of her egg production, the pullet's quality greatly determines profitability during the laying cycle. Substantial body reserves before egg production (prelay period) are indispensable to achieving satisfactory hen performance (Eusebio-Balcazar *et al.*, 2018). Adopting proper nutrition and rearing regime needs to produce modern pullets that develop into profitable layers.

Earlier studies on the productive performance of laying hens during egg production phases fed with different nutrient density (high vs. low-nutrient-density) diets concerning Metabolic Energy (ME), Crude Protein (CP), Lysine, and Methionine during the different laying phases of the egg production cycle suggests no beneficial effect by feeding high-nutrient-density diets during laying period (Zhang and Kim, 2013; Rama Rao *et al.*, 2014; Ismail *et al.*, 2015). However, egg production performances improved by feeding pullets with high-energy and high-protein diets before the start of egg production (Cransberg *et al.*, 2001; Babiker *et al.*, 2010). A transitional phase of two to three weeks (prelay) before the commencement of egg production is an extremely important period in the life of a successful and efficient layer.

Prelay Calcium

The preparation of egg-laying is obvious in the skeleton during the prelay period. The most significant change is the formation of medullary bone, which begins two weeks before the onset of egg production. The most prominent feature of medullary bone is its lability. Medullary bone is more calcified than cortical bone. The medullary bone acts as a labile calcium store for eggshell formation (Taylor *et al.*, 1971), corresponding with increased calcium and phosphorus retention during the prelay period (Themeli, 2003). Negative calcium balance in layers during early egg production cannot be alleviated by high dietary calcium in their layer diet. The skeletal calcium reserve is used for eggshell formation during initial egg production. Therefore, at the onset of egg production, calcium reserve's importance is crucial in maintaining egg production and eggshell quality (Hurwitz and Griminger, 1960). Earlier scientific literature has been published on the grower and layer calcium requirement. However, less work was done on the calcium requirement of the pullet during her transition from the pullet stage to the layer stage. During this transition phase, just before egg production, the pullet built up calcium reserve in her body in anticipation of the need for a shell calcification process.

The primary feeding programs currently used in the layers involve feeding of grower diet containing 1.0% calcium until the first egg is laid and then switching to layer feed containing 3.5% calcium (BIS, 2007). Feeding such a low-calcium diet during a growing period result in an insufficient build-up of medullary bone reserves and negative calcium balance and affects egg production (Roland and Bryant, 2000; Miles and Jacqueline, 2008). The second feeding program involves introducing a layer diet containing 3.5 % calcium as early as 16 weeks of age, but since excess calcium gets excreted, it may cause undue stress on the kidney (Niznik *et al.*, 1985; Leeson and Summers, 2008). Thus, using moderate calcium in the prelay diet represents a compromise between these feeding programs. A prelay diet with moderate calcium (2.0-2.5%) allows for the build-up of the medullary bone calcium reserves without adversely affecting kidney function. Prelay calcium may affect eggshell quality during laying (Jacob, 2014; Sujatha and Rajini, 2015).

Moreover, an initial adequate bone reserve is crucial in reducing cage fatigue, maintaining egg production, and forming eggs with good eggshell quality (Williams *et al.*, 2000). Prelay Ca represents a compromise between the grower and layer diet because it provides pullets with more Ca than most grower diets without excess Ca as in layer diets. Such a diet allows for the build-up of the medullary bone reserves.

Sequential studies (Cransberg *et al.*, 2001) of skeletal calcium reserves and structural bone volume in a commercial layer flock mentioned that significant shifts in skeletal mineral content occurred in early to mid-lay, proportionally more prominent than the shifts in live weight. Considering the magnitude of the shifts in skeletal mineralization that can occur in early lay, there might be a relationship between the persistency of production, shell quality, and calcium metabolism, which new nutritional approaches could moderate. Furthermore, the close association between the development of osteoporosis in early lay and the drain of production supports the premise that production-induced osteoporosis is much more influential in caged hens' induction of bone fragility. According to Bouvarel *et al.* (2011), calcium requirements are in the order of 0.9-1.2% in the pullet's early growth period, 2.0-2.5% for medullary bone formation about two weeks before laying, and 3.5- 4.0% during the laying period. The dietary calcium needs to be increased at least three to four weeks before sexual maturity (Sujatha and Rajini, 2015) for an effective prelay diet, as increased dietary prelay calcium favors bone weight. Khanal *et al.* (2019) offered 2.5% pre-lay Ca for 2 weeks (16^{th} and 17^{th} week) and then switched to 4.0% Ca from the 18^{th} week age to 50^{th} egg in two strains (Lohmann Brown and Lohmann Selected Leghorn-Lite). They found that pre-lay dietary Ca did not affect feed consumption ($p>0.05$). Recently, Lonkar (2021) in his study concluded that the feeding of a prelay diet (2700 kcal ME/kg, 18.0% CP, and 2.5% Ca) three weeks (16-18 weeks age) before the onset of egg production and subsequent feeding of layer diet as per BIS (2007) specifications (2600 kcal ME/kg, 18.0% CP, 3.0% Ca) during the first phase of production (19-40 weeks age) is the best combination for improving layer production performance, egg qualities and found to be economical in White Leghorn layers. The transition from ‘immature pullet’ to ‘laying hen’ is crucial. It is essential to increase dietary Ca from 1.0 to 2.5% two weeks before the first eggs to enhance the formation of medullary bone and eggshells of the first eggs. However, introducing a layer diet too soon encourages under-consumption, whereas delayed introduction reduces the quality of the first eggs and subsequent eggs, even if the hen then receives a diet rich in Ca. It seems that the 2.0 to 2.5% prelay Ca is recommended to ensure the Ca balance might help to facilitate the medullary bone development than 1.0% Ca during the prelay period of 16-18 weeks of age in laying hens.

Prelay Energy and Protein

Once the bird starts to produce eggs, its ability to build fat reserves is minimal. As with most bird classes, the fat content of the pullet can best be manipulated by changing the energy: protein balance of the diet. If labile fat reserves are thought necessary, then high-energy, high-fat prelay diets should be considered (Babiker *et al.*, 2010; Sujatha and Rajini, 2015). Based on the metabolic changes before the onset of egg production, a traditionally low-density diet, as per BIS (2007), during the growing stage may not support a present high-yielding layer to establish essential reservoirs. Summers *et al.* (1987) reported that dietary energy is a critical nutrient in maturing pullets. Husseins *et al.* (1996) and Elliot (2008) also reported that White Leghorn's rearing diet containing high dietary energy was beneficial during 15-18 weeks. Similar to the present findings, Sujatha and Rajini (2015) recommended a prelay diet containing 2700 kcal ME/kg for pullets before sexual maturity.

Dietary protein improves growth and feed utilization and maximizes productive performance and immune functions. Also, protein assists in tissue biosynthesis, having biological functions for the growth and renewal of the body. This protein reserve is required in more significant quantities for tissue synthesis during the prelay period of rapid physiological development. Improved protein nutrition permitted increased liver hypertrophy (Yu and Marquardt, 1974), usually occurring during the prelay and early laying period. A large mass of labile protein in the liver could provide a reservoir of available protein. High-quality protein with a sufficient amino acid balance is one of the most crucial factors (Soares *et al.*, 2003) for egg production in poultry. The higher dietary proteins are required at the beginning of the laying period to produce bigger eggs and to compensate for body growth. The low dietary protein impairs the development of the reproductive system.

Consumption of an extra 1.0g of protein per day results in an average increase in EW of 1.4g. However, the amount of protein consumption is dependent on the energy concentration of the diet and the form of the diet (Bouvarel *et al.*, 2011). The prelay diet containing 18.0% CP produced a pullet with better body protein before sexual maturity (Sujatha and Rajini, 2015). The pullets fed with 18.0% prelay CP had higher body protein than 16.0% prelay CP. Lonkar (2021) found that the 18.0% CP in the prelay diet during 16-18 weeks of age significantly ($p<0.01$) increased the daily PI of pullets more than the inclusion of 16.0% CP in the prelay diet. The 2700 kcal ME/kg diet and 18% CP is the best combination for pullets 2-3 weeks before the start of egg production.

Conclusion

The positive body energy, protein balance, and calcium reserves in the medullary bone during the prelay period (transitional phase) are essential for sustained egg production and egg quality in modern layers. Feeding a prelay diet containing 2700 kcal ME/kg diet and 18% CP with 2.0-2.5% calcium is the best combination for pullets 2-3 weeks before the start of egg production.

Contribution by authors

All the authors contributed equally to writing the manuscript. The final manuscript was read by all others and consented to publication.

Conflict of Interests

There is no conflict of interest.

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