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Original article

Different Stages of Poultry Production Require Specific Nutrient Profiles

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Abstract
There is an urgent need for optimized nutritional control based on the prevailing physiology of different production phases for optimizing poultry performance. In this background, the purpose of the study: the purpose of the study is to investigate how the different nutrient requirements of the different stages can impact growth, feed conversion, reproduction, and health. In this research, efforts were made to provide poultry with highly optimized nutritional diets as required by different stages of poultry production, which included starter, grower, finisher, and layer stages. For instance, in this study, some of the parameters under observation included growth rate, feed consumption rate, feed conversion rate, reproduction performances, egg quality, and health conditions. The findings of this research revealed that feeding poultry as per stages can greatly improve their growing performances, especially in the starter and finisher stages, and can also properly meet their reproduction requirements during the layers stage. Additionally, feeding poultry with minerals during the reproductive stages can improve eggshell quality and maintain poultry health, whereas there were low mortality percentages in all stages. These findings clearly indicate that feeding poultry using uniform practices just because of their equal protein and energy requirements is not effective for meeting their optimized requirements throughout their life span. A balanced diet for poultry production will always take into account stage-wise optimization to ensure effective use of poultry feeds and to enhance production, along with environmental and economic sustainability.
Keywords. Chicken Farming, Nutritional Science, Growth Process, Egg, Sustainable Development.

Introduction

Poultry farming depends entirely on proper nutritional management at various stages of growth and development of poultry products. In modern poultry production, feeding evolved from the old traditional ways of feeding into scientifically formulated diets to meet the physiological needs of chickens, depending on the different stages of production: starter, grower, finisher, layer, and breeder. This is informed by emerging global demand for poultry meat and eggs, increasing feed costs, and concern for animal welfare and environmental sustainability. Feed constitutes the greatest cost proportion in poultry, and as such, efficient nutrient utilisation is not only a biological but also an economical one. This implies that the understanding of the requirements of the nutrients throughout the poultry life stage is fundamental to the enhancement of performance, as well as the sustenance of profitability [1].

Each phase of poultry has distinct physiological processes that, in the end, influence nutrition requirements. Starter poultry are at a rapid growth stage of tissues, organogenesis, and development of the immune system, which demand quality proteins, indispensable amino acids, metabolizable energy, vitamins, and minerals. A suboptimal and unbalanced dietetic program in the initial growth stage translates to growth retardation and an im unfit immune system, and hence inedible and low-performing outputs that cannot be entirely addressed in the later growth stages. As poultry reach the grower stages, there is a shift in the nutritional requirement from fast growth to the development of muscles and bones, so that the modified energy-to-protein ratio in the diet induces weight gain with little increase in the adipose contents. Finally, in the finisher stages, there is a refinement in the nutritional needs that maximizes feed conversion rates and yield, and reduces feed wastage and costs.

The dietary requirements of layers, breeders, and meat chickens are relatively different from one another. The reason is that breeders require special care in relation to their reproduction. Layers, as opposed to meat chickens, require a higher requirement of calcium, phosphorus, vitamin D, and trace vitamins. These requirements must not impair their bone structures. The energy levels in layers have to be kept in a well-balanced diet, as high energy can sometimes result in an obese fatty liver, adversely affecting their egg-laying capacity. The breeding chickens, on the other hand, require dietetics of a particularly high order, aiming at maximizing fertility, hatch rate, and offspring qualities. Both deficiency and excess of nutrients at this stage can impact negatively upon the reproductive performance and viability of offspring, thereby giving reason to stage-of-production feeding [2].

Apart from physiological factors, environmental factors, progress in genetics, and management practice can also impact nutrient needs for each stage of production. Present-day chicken lines have higher growth rates, which make them more vulnerable to nutritional disorders. Furthermore, disproportionate chicken feeds might be associated with environmental problems as a result of the significant excretion rates of nitrogen and phosphorus. In an endeavour to meet the aforementioned problems, it has become crucial to formulate

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balanced chicken feeds for various levels of chicken production. This research paper highlights the significance of appropriately balanced chicken feeds for each stage of chicken production in improving productivity, promoting healthier chickens, and making chicken production a sustainable venture in the long run [3].

In the present investigation, various parameters such as growth, feed intake, feed conversion ratio, reproduction performances, quality of eggs, health conditions, etc., have been kept under observation. In the present study, an assessment of the way in which levels of energy, protein, essential amino acids, minerals, and vitamins can modify the growth and production levels of the bird at various production phases is taken into account. The originality of this research is based on the comprehensive convergence of the demands of poultry physiology and the exact requirements of different stages of poultry production by linking continuous poultry production stages rather than focusing on individual stages of poultry production. By defining the significance of dynamic poultry production requirements according to growth and production stages, this research presents actual and fresh perspectives that can assist in making poultry production fully sustainable and economical.

The conceptual framework of this research rests on the principle of stage nutrition in poultry rearing, which states that at different stages of their life cycle, chickens require diverse nutrient inputs to maximize their performance. Raising poultry can broadly be classified into several categories, such as starter, grower, finisher, and layers, which grow at specified growth rate categories, depending upon their life stage [4]. The nutritional requirements of the chickens are dynamically changing instead of being constant at every stage of their life [4]. Hence, this research intended to address such nutritional requirements of the chickens.

To understand the mechanisms, causes, and effects of HS, and to know how to counteract and control such an event in the world scenario, would help address some of the current issues regarding the global insecurity generated on the topic of food. HS impact and measures to counteract and cope with the negative effects associated with it have been profoundly examined in this review. Figure 1 below depicts the physiological, metabolic, and genetic changes between HS and meat production, quality in chicken. [5].

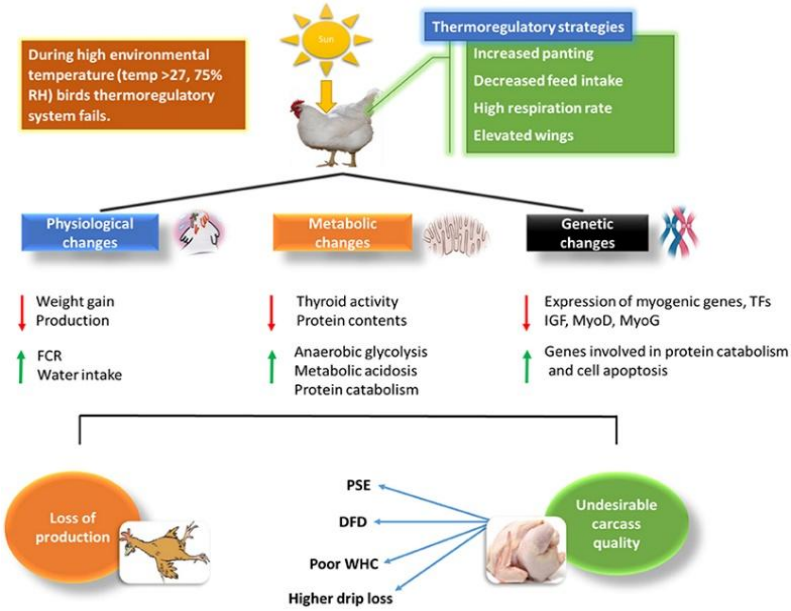

Figure 1. Relationship Of Heat Stress With Physiological And Biochemical Changes In Chicken [5].

High protein, essential amino acid, energy, vitamin, and mineral requirements exist during the starter phase because of rapid growth of tissue, organogenesis, and the development of the immune system. The grower and finisher phases are highly focused on muscle deposition and on skeletal development, demanding a harmonious ratio between protein and energy to attain maximum feed efficiency and to avoid excessive amounts of fat deposition. During reproductive phases, such as the layer and breeder phase, nutrient nourishment is directed toward the production of eggs, eggshell quality, reproductive performance, and hatchability. The need for a sufficient amount of calcium, phosphorus, and trace minerals is essential, as energy and protein need to be adjusted to support continuous production without triggering any problems associated with metabolism [6].

The focal point of precision feeding lies in the concept of stage-specific nutrition, which concentrates on the compatibility of nutritional composition to match physiological requirements to maximize productivity, prevent feed wastage, and minimize the negative impacts of poultry farming on the environment. On this foundational theory, the philosophy underscores the complementary relationship of growth, reproduction, health, and resource management in poultry production, as evidenced by improvement in growth, reproduction, and health [7].

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Efficiency in feed utilization is an important economic trait in the extended laying period; however, studies on this trait in laying chickens are still limited. The trait is host-genetically determined as well as microbially affected. In order to achieve the target of prolonging the laying period, scientists must study the mechanism of efficiency in feed utilization to solve the problem of reduced feed in the later period of egg production. [8]. Modern biological technology promotes the rapid development of laying hens feed efficiency improvement techniques based on molecular breeding. 1. This efficiency is attained through optimization of gene screening, metabolism optimization, optimization of gut microbial count, nutrition optimization in feeds, and optimization of stress response in organisms (Figure 2) [9].

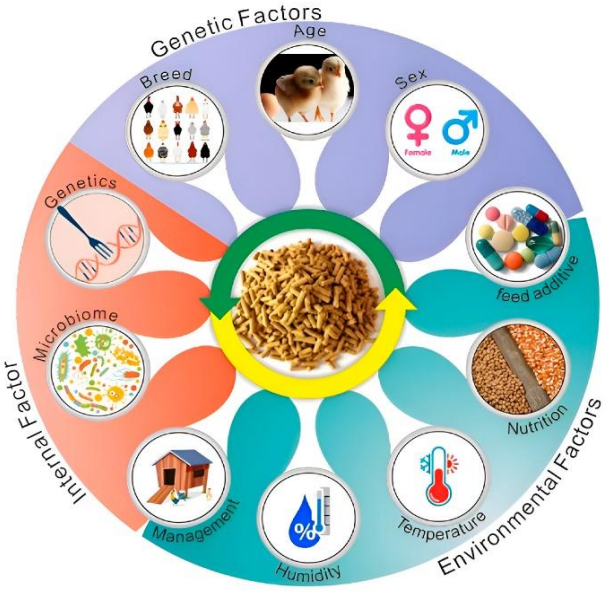

Figure 2. The Primary Determinants of Feed Efficiency in Laying Hens [9].

Materials and methods

Study design and sampling

The approach used in this study was a quantitative experimental design that employed a controlled feeding trial in which stage-specific nutrient profiles were evaluated for poultry performance at different levels of the production stages. This research was conducted in a commercial-scale poultry research facility under standardized management and environmental conditions. Poultry chickens were categorized based on stages of production, such as the starter, grower, finisher, and layer phases. A stratified sampling approach was used in which the chickens were distributed among these stage-based treatment groups to ensure uniformity in age, body weight, and genetic strain. Each group was given a diet that was prepared to meet the specific nutritional requirements considered correct for its particular phase of production, basing the evaluation on the general nutritional guidelines established for them.

A total of 200 healthy poultry chicks were used in this study. The healthy poultry chicks were uniformly divided into four groups of production stages, with each group consisting of 50 chicks: starter stage, grower stage, finisher stage, and layer stage. Again, each stage was divided into five groups with ten chicks per group for sound statistical purposes. Sample size was believed to be sufficient for detecting meaningful differences in growth performance, feed efficiency, and production parameters among the different nutrient profiles applied.

Data collection

Data was recorded throughout the experimental duration, representing each production phase. The growth parameters of the experimental animals were measured weekly. Parameters included body weight, weight gain, and feed intake. The feed conversion ratio was calculated from the feed intake recorded and the weight gain. The parameters measured in the layer subgroup were the production rate of the laying animals, egg weight, and the parameters of eggshell quality. Health status was determined through the number of mortalities recorded as well as the physical observation of sickness. Nutrient composition of the experimental diets, through proximate analysis, was determined to confirm compliance with the predetermined parameters. [10].

Data analysis

The collected information was compiled for statistical analysis. For descriptive statistics, performance measures, as well as production requirements, were evaluated. One-way analysis of variance was used to examine the significance of variation in levels of production with regard to growth rates, feed conversion

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rate, and levels of production. [11]. In cases of significance, post-analysis tests were employed to check for variations in the groups. The computations of statistical significance were considered at 95 percent level of confidence, which means < 0.05. Results of the study are important in the determination of the relevance of various nutrient profiles in order to attain optimum poultry production.

Results

As can be viewed from Table 1, analysis data indicate that body weight gain is significantly different among the stages of production, reflecting variations in physiological growth priorities.

It can be observed in Table 1 that body weight gain showed a substantial rise in the finishing phase. During the initial growth stage, the weight of the chickens in the early stage was increasing rapidly. The average weight of the chickens in the growing stage was, whereas the finishing stage recorded the highest weight. This indicates a good development of muscles. Layers recorded the lowest gain of body weight of 120.2 ± 10.8g, thus proving that during this stage, the nutrients are more utilized in the development of eggs as opposed to the development of body weight.

Table 1. Average Body Weight and Body Weight Gain Across Production Stages

Production Stage	Initial Body Weight (g)	Final Body Weight (g)	Body Weight Gain (g)
Starter	45.2 ± 1.8	420.5 ± 15.6	375.3 ± 14.2
Grower	420.5 ± 15.6	1,150.8 ± 32.4	730.3 ± 26.1
Finisher	1,150.8 ± 32.4	2,050.6 ± 45.7	899.8 ± 38.9
Layer	1,600.3 ± 40.2	1,720.5 ± 42.6	120.2 ± 10.8

As shown in Table 2, feed consumption increased from 38.5 ± 2.1g/bird/day in the starter phase to 145.6 ± 5.2g/bird/day in the finisher phase to meet their increased energy requirements. The lowest value for FCR was recorded in the starter phase (1.45 ± 0.08), showing highly efficient feed conversion. The values for FCR increased in the grower phase (1.65 ± 0.07) and finisher phase (1.90 ± 0.09), with the highest values recorded in the layer phase (2.10 ± 0.11), showing less efficient feed conversion, possibly because their energy would be diverted for producing eggs rather than for growth.

Table 2. Feed Intake and Feed Conversion Ratio (FCR) at Different Production Stages

Production Stage	Average Feed Intake (g/bird/day)	Total Feed Intake (kg)	Feed Conversion Ratio (FCR)
Starter	38.5 ± 2.1	1.35 ± 0.06	1.45 ± 0.08
Grower	82.4 ± 3.8	3.95 ± 0.15	1.65 ± 0.07
Finisher	145.6 ± 5.2	5.80 ± 0.22	1.90 ± 0.09
Layer	110.2 ± 4.7	4.10 ± 0.18	2.10 ± 0.11

Table 3 presents a number of variations in nutritional requirements. Taking into consideration the reduced requirements for the development of tissues, the crude protein level was progressively lowered from 22.0% in the starter phase to 17.5% in the finisher phase. Taking into account the requirements for the growth and development requirements, the ME level was raised from 3,000 kcal/kg for the starter phase to 3,200 kcal/kg for the finisher phase. However, taking into consideration the increasing requirements, primarily for shell hardening in egg production, the Ca level was increased to 3.8% in the layer phase development period compared to 0.8 to 1.0% in broilers.

Table 3. Nutrient Composition of Experimental Diets by Production Stage

Nutrient Component	Starter (%)	Grower (%)	Finisher (%)	Layer (%)
Crude Protein	22.0	19.0	17.5	18.0
Metabolizable Energy (kcal/kg)	3,000	3,100	3,200	2,800
Calcium	1.0	0.9	0.8	3.8
Available Phosphorus	0.45	0.40	0.35	0.45

The egg production performance, as indicated in Table 4 above, reveals that layer chickens performed better in their rate of 87.5 ± 3.2%, coupled with an egg weight of 60.8 ± 2.5 g. The egg mass produced per bird per day reflects the efficient utilization of the nutrients to produce eggs through 53.2 ± 2.1 g/h/d. This nutrient efficiency of feed consumption in egg production, as demonstrated by these chickens, is further proved by their least feed requirement of 1.65 ± 0.07 kg per dozen eggs.

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Table 4. Eggshell Quality Parameters of Layer Chickens

Parameter	Mean Value ± SD
Hen-Day Egg Production (%)	87.5 ± 3.2
Average Egg Weight (g)	60.8 ± 2.5
Egg Mass (g/hen/day)	53.2 ± 2.1
Feed per Dozen Eggs (kg)	1.65 ± 0.07

Characteristics of eggshell quality, as reflected in Table 5, show the effectiveness of Mineral-supplemented diets fed during the laying phase. However, eggshell thickness measured was 0.38 ± 0.02 mm, while eggshell strength measured 3.5 ± 0.3 kg/cm², eggshell percentage measured only 9.8 ± 0.4%, and Calcium retention measured 68.2 ± 3.1%, which indicates efficient use of calcium supplement provided in the diet.

Table 5. Average Body Weight and Body Weight Gain Across Production Stages

Parameter	Mean Value ± SD
Eggshell Thickness (mm)	0.38 ± 0.02
Eggshell Strength (kg/cm²)	3.5 ± 0.3
Eggshell Weight (%)	9.8 ± 0.4
Calcium Retention (%)	**68.2 ± 3.1**

As shown in Table 6 below, the mortality percentage is very small at every stage of production. The percentage is between 1.2% and 2.5%. The mortality rate of grower chickens is at 1.8%, while it is at 2.0% in layers. The low mortality rate indicates that the nutritional components for each stage are sufficient for the health status of the chickens. The higher rate at the starter and layer production stages may be connected with high physiological stress during the growth period.

Table 6. Health Status and Mortality Rate Across Production Stages

Production Stage	Mortality Rate (%)	Observed Health Status
Starter	2.5	Good
Grower	1.8	Very Good
Finisher	1.2	Very Good
Layer	2.0	Good

Discussion

The research findings of this study underscore the significance of nutrient profiles at each growth stage in ensuring enhanced growth, feed conversion, health, and performance in poultry farming. Poultry, at each stage of growth, experiences intrinsic changes in their physiology, leading to diverse nutritional requirements at each stage of poultry farming. Initially, at the growth phase, high-quality protein and proper amino acid nutrition are required to facilitate rapid tissue growth, organ development, and immune system development of poultry. Moreover, adequate nutrition at this point of growth ensures that poultry attain their maximum growth potential and lays the cornerstone for subsequent performance at later stages of growth. Subsequent growth stages of poultry require higher amounts of energy to facilitate muscle growth, followed by proportional adjustments in the level of protein to optimize feed conversion, thereby indicating that the growth performance of poultry is highly reliant on their nutrient availability, as growth performance at each point of poultry farming shall not be aptly addressed by standard feeding practices at all stages [12]. Feed intake is expected to increase with bird growth to match their metabolic demands for growth and maintenance. Nevertheless, feed conversion efficiency differs during growth phases, with growth phases being more efficient in feed conversion compared to other phases and growth phases. This is mainly because, during growth phases, a smaller amount of feed is required for energy-requiring processes like egg production. The key to meeting economic sustainability within poultry farms is to optimize feed conversion efficiency, given that feed is currently the highest production cost component. Efficient feed conversion is not only beneficial for growth and productivity but is also important for waste reduction, with implications for economic and environmentally sustainable benefits [13].

The nutritional composition of the diets at different stages of production also indicates the nutritional strategy that has to be employed in order to satisfy the nutritional requirements. The diets in the first growth stage are nutritionally rich, especially in protein and amino acids, in order to induce fast growth and optimization of the immune system. As the chickens grow into the next stages of growth, the protein content is gradually decreased, and energy is increased to induce constant growth and accumulation of muscle tissue. During the reproductive stages, the diets are nutritionally supplemented with minerals such as calcium and phosphorus to induce the formation of eggs in the reproductive stages to ensure the efficacy of the bones. These variations indicate that the nutritional requirements have to fluctuate continuously according to the stages of development. Inadequate nutritional supply for the stages may induce suboptimal growth, low feed conversion ratios, and low reproduction [14].

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Reproductive function is very responsive to nutrient supply. Nutrient feeds containing the precise nutritional requirements of laying chickens make valuable contributions to efficient egg-laying. A balanced supply of energy, proteins, and minerals is vital for making eggs at optimal levels, with hard-shelled eggs of proper weight, while maximizing the efficiency of feed used. The importance of egg quality cannot be overemphasized, as not only is this vital in enhancing reproductive efficiency, but poor eggshell quality can result in losses of products. Nutrient regulation during this booster phase is also vital in ensuring efficient avoidance of diseases such as metabolic disorders associated with improper feeding, thus promoting longevity in chickens [15].

The relationship between health outcomes and mortality in poultry and nutrient supply is interrelated. A balanced diet that responds to physiological demands at different growth or production periods builds and maintains the immune status and ability to counter both environmental and physiological stresses. Low mortality rate periods show that poultry are in good health and are performing well at all times, suggesting that perhaps the nutritional programs are adequate to provide necessary nutrients. A slightly higher mortality rate at growth and production periods may show that growth and production are stressful and not necessarily due to inadequate nutrient supply. This illustrates that poultry and production programs should be integrated to provide an environment that ensures productivity and welfare [16].

The findings presented within this study are also significant to the aspect of economic and environmental sustainability within chicken production. Nutrient requirement targeting, according to the appropriate production stage, prevents feed wastage, hence cutting down production costs as a result of increased efficiency within the process. Moreover, feed potency reduces the amount of nitrogen and phosphorus, significant nutrients, throughout intensive chicken production, thus acting as a contaminant within chicken production environments. The sustainability trickles within the industry as chicken production adheres to industry trends, amid increased outcomes, as identified [17]. within modern chicken production. The findings also reinforce that poultry nutrition is not a stagnant field but should adapt to accommodate the varying requirements of the bird according to different stages of life. In the early stages of life, the nutritional requirements are geared towards growing and developing tissue quickly, while in the later stages, it is efficient muscle accretion and feed conversion that take center stage. During the reproductive stages of life, there is a need to properly manage the mineral and energy needs in order to effectively maintain egg production. Should there be any neglect in these requirements, there are possible risks of subnormal growth rate, less efficient feeding rate, egg quality, and diseases. [18].

The implications of such discoveries have very significant meanings to the poultry farm owner as well as the practitioner. Nutrient requirements for each stage of growth provide optimized use of inputs, hence optimized growth, reproduction, and product, as well as optimized costs and minimal environmental damage. Nutritional balance will provide optimal health and enhanced resistance to diseases, hence minimal death rates. The optimized feeding programs will provide sustainable poultry enterprise development by optimized use of feed resources and minimal environmental damage [19]. Therefore, from this approach, the optimal use of nutrition that addresses the requirements for each growth stage of poultry is a valuable tool that can be used for the accomplishment of economic as well as environmental objectives.

Based on the research, ensuring a proper diet addressing various life phases is fundamental in the quest to achieve maximal outcomes in chicken farming. The accuracy of nutritional requirements involving protein, energy, and minerals, within poultry production, is essential in enhancing growth rate, feed conversion rate, rate of reproduction, and health targets within poultry. Integration of proper nutrition strategies with proper management techniques is fundamental in making up a holistic approach directed at ensuring sustainable outcomes within chicken production. Further research should be focused on the integration of the levels of nutrients and management levels in an endeavour to deliver even better results in poultry production [20].

Conclusion

This research has pointed out that the provision of phase-specific nutrient profiles is quite necessary in order to maximize the productivity, growth, and health of chickens. Meeting a diet that matches the particular physiological demands of the phase can result in the improvement of growth rates, feed conversion efficiency, productivity of reproduction, as well as the welfare of the chicken. The growth phase shall be fed with highly nutritious food that is rich in protein and amino acids to increase growth rates and immunity, while in later growth phases, their diet should be provided with changed energy to protein values to optimize muscle growth and feed conversion efficiency. The reproductive phase, especially layers, should be provided with properly changed mineral values to improve their productivity and the eggs laid. Adoption of phase-specific feeding programs can help to attain linked growth and economic sustainability by curtailing feed wastage and lessening detrimental effects on the biosphere. Based on these findings, it is recommended that the poultry industry should focus on precision feeding practices that take into account the nutrient requirements of protein, energy, and mineral sources as per the growth stage of the chickens. Periodic monitoring should be done in order to ensure that the nutrient sources are properly attuned as per the requirements at various stages of growth. In conclusion, it can be noted that the application of stage-specific nutrient concepts can help improve the efficiency of the poultry industry with respect to productivity, profitability, and sustainability. Future studies should focus on various nutrient sources vis-à-vis various

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breeds, environmental aspects, and management practices of rearing these chickens.

Conflict of interest. Nil

References

1. Nassar FS, Abbas AO. Crisis and risk management in poultry production: Preparing future leaders for sustainability and food security. Poult Sci. 2025;104(12):105903. doi:10.1016/j.psj.2025.105903.
2. Klasing K, Dozier W, Mateos G, Persia M, Walzem R, Sakomura N, Reis M, Viana G, Riveros R, Elkin R, Angel C, Korver D. Informal nutrition symposium: Overview of the nutrient requirements of poultry, 10th revised edition. J Appl Poult Res. 2025;34(4):100616. doi:10.1016/j.japr.2025.100616.
3. Korver D. Review: Current challenges in poultry nutrition, health, and welfare. Animal. 2023;17:100755. doi:10.1016/j.animal.2023.100755.
4. Shastak Y, Pelletier W. From metabolism to vitality: Uncovering riboflavin's importance in poultry nutrition. Animals (Basel). 2023;13(22):3554. doi:10.3390/ani13223554.
5. Nawaz AH, Amoah K, Leng QY, Zheng JH, Zhang WL, Zhang L. Poultry response to heat stress: Its physiological, metabolic, and genetic implications on meat production and quality including strategies to improve broiler production in a warming world. Front Vet Sci. 2021;8:699081. doi:10.3389/fvets.2021.699081.
6. Alabi T, Adedokun S. Amino acid nutrition in poultry: A review. Animals (Basel). 2025;15(22):3323. doi:10.3390/ani15223323.
7. Glencross B, Fracalossi DM, Hua K, Izquierdo M, Mai K, Øverland M, Robb D, Roubach R, Schrama J, Small B, Tacon A, Valente LM, Viana T, Xie S, Yakupityage A. Harvesting the benefits of nutritional research to address global challenges in the 21st century. J World Aquac Soc. 2023;54(2):343-63. doi:10.1111/jwas.12948.
8. Gao Z, Zheng J, Xu G. Molecular mechanisms and regulatory factors governing feed utilization efficiency in laying hens: Insights for sustainable poultry production and breeding optimization. Int J Mol Sci. 2025;26(13):6389. doi:10.3390/ijms26136389.
9. Gao Z, Zheng J, Xu G. Molecular mechanisms and regulatory factors governing feed utilization efficiency in laying hens: Insights for sustainable poultry production and breeding optimization. Int J Mol Sci. 2024;26(13):6389. doi:10.3390/ijms26136389.
10. Mousa MA, Asman AS, Ali RMJ, Sayed RKA, Majrashi KA, Fakiha KG, Alhotan RA, Selim S. Impacts of dietary lysine and crude protein on performance, hepatic and renal functions, biochemical parameters, and histomorphology of small intestine, liver, and kidney in broiler chickens. Vet Sci. 2023;10(2):98. doi:10.3390/vetsci10020098.
11. Micus C, Schramm S, Boehm M, Krcmar H. Methods to analyze customer usage data in a product decision process: A systematic literature review. Oper Res Perspect. 2023;10:100277. doi:10.1016/j.orp.2023.100277.
12. Perera WNU, Ravindran V. Role of feed additives in poultry nutrition: Historical, current and future perspectives. Anim Feed Sci Technol. 2025;326:116371. doi:10.1016/j.anifeedsci.2025.116371.
13. Rauw W, Baumgard L, Dekkers J. Review: Feed efficiency and metabolic flexibility in livestock. Animal. 2024;19(1):101376. doi:10.1016/j.animal.2024.101376.
14. Escobedo-Monge MF, Parodi-Román J, Escobedo-Monge MA, Marugán-Miguelsanz JM. The biological value of proteins for pediatric growth and development: A narrative review. Nutrients. 2025;17(13):2221. doi:10.3390/nu17132221.
15. Yan L, Liu J, Chen R, Lei M, Guo B, Chen Z, Dai Z, Zhu H. Reproductive characteristics and methods to improve reproductive performance in goose production: A systematic review. Poult Sci. 2025;104(6):105099. doi:10.1016/j.psj.2025.105099.
16. Ghaleghafi A, Khorshidi KJ, Jafari MA. Nutritional and managerial interventions on growth performance, nutrient transport-related genes and behavioral responses in heat-stressed broiler chickens. Vet Anim Sci. 2025;100561. doi:10.1016/j.vas.2025.100561.
17. Bist RB, Bist K, Poudel S, Subedi D, Yang X, Paneru B, Mani S, Wang D, Chai L. Sustainable poultry farming practices: A critical review of current strategies and future prospects. Poult Sci. 2024;103(12):104295. doi:10.1016/j.psj.2024.104295.
18. David LS, Anwar MN, Abdollahi MR, Bedford MR, Ravindran V. Calcium nutrition of broilers: Current perspectives and challenges. Animals (Basel). 2023;13(10):1590. doi:10.3390/ani13101590.
19. Dong S, Li L, Hao F, Fang Z, Zhong R, Wu J, Fang X. Improving quality of poultry and its meat products with probiotics, prebiotics, and phytoextracts. Poult Sci. 2024;103(2):103287. doi:10.1016/j.psj.2023.103287.
20. Luo C, Ai C, Yu Y, Yuan J. Optimizing broiler growth performance through balanced net energy, standard ileal digestible lysine, and amylose/amylopectin ratios: A Box-Behnken response surface approach. Poult Sci. 2025;104(8):105287. doi:10.1016/j.psj.2025.105287.
21. Ravindran V, Abdollahi MR. Nutrition and digestive physiology of the broiler chick: State of the art and outlook. Animals (Basel). 2021;11(10):2795. doi:10.3390/ani11102795.
22. Solka M, Marchewka J, Jaszczyk A, Sefaty A, Seidavi A, Bouyeh M, Ondrašovičová S, Michnowska H, Sztandarski P. Feed quantitative restriction effect on performance, carcass quality, blood parameters and immunity of broiler chickens. Vet Res Commun. 2025;50(1):35. doi:10.1007/s11259-025-10973-9.

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