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Effects of Dietary Nutrient Levels on Growth Performance, Meat Quality, and Sexual Maturity in Yellow-Feathered Broiler Chickens (Postprint)

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Abstract

This experiment was conducted to investigate the effects of dietary nutrient levels on growth performance, meat quality, and sexual maturity in yellow-feathered broiler chickens. A single-factor completely randomized design was adopted, with 432 1-day-old commercial Beijing You chickens randomly allocated to three dietary nutrient level groups (high, medium, and low), with 4 replicates per group and 36 chickens per replicate, provided ad libitum access to feed and water. Diets were formulated according to the feeding standards for medium-growth-rate yellow-feathered broilers and divided into three phases (1–5 weeks, 6–9 weeks, and 10–13 weeks), with high, medium, and low nutrient levels set for each phase while maintaining a constant protein-to-energy ratio.

The results showed that during 1–5 weeks, the low nutrient level group had extremely significantly lower average daily feed intake and average daily gain than the medium and high nutrient level groups ($P<0.01$); the medium nutrient level group had significantly higher average daily gain ($P<0.05$) and significantly lower feed conversion ratio than the low nutrient level group ($P<0.05$). Dietary nutrient levels showed no significant effect on meat quality ($P>0.05$). Hens in the high nutrient level group had extremely significantly higher comb weight and comb length than the medium and low nutrient level groups ($P<0.01$), and significantly higher comb height than the medium and low nutrient level groups ($P<0.05$), with a trend toward increased ovary weight in the high nutrient level group ($P=0.08$). Dietary nutrient levels showed no significant effect on sexual maturity indicators in roosters ($P>0.05$).

It can be concluded that for medium-growth-rate yellow-feathered broilers, a medium nutrient level diet can achieve better growth performance, while a high nutrient level diet can promote sexual maturity in hens.

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Full Text

Effects of Dietary Nutrient Levels on Growth Performance, Meat Quality and Sexual Maturity of Yellow-Feathered Broilers

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Abstract

This study investigated the effects of dietary nutrient levels on growth performance, meat quality, and sexual maturity in yellow-feathered broilers. Using a single-factor completely randomized design, 432 one-day-old commercial Beijing-You chicks were randomly allocated to three dietary nutrient level groups (high, medium, and low), with four replicates per group and 36 birds per replicate. Feed and water were provided ad libitum. Diets were formulated according to the feeding standards for medium-speed yellow-feathered broilers across three growth phases (1–5 weeks, 6–9 weeks, and 10–13 weeks). Within each phase, three nutrient levels (high, medium, and low) were established while maintaining a constant protein-to-energy ratio.

The results showed that during the 1–5 week period, the low nutrient level group exhibited significantly lower average daily feed intake (ADFI) and average daily gain (ADG) compared to the medium and high nutrient level groups ($P<0.01$). The medium nutrient level group showed significantly higher ADG and lower feed-to-gain ratio than the low nutrient level group ($P<0.05$). Dietary nutrient levels did not significantly affect meat quality parameters ($P>0.05$). In hens, the high nutrient level group displayed significantly greater comb weight and comb length compared to the medium and low nutrient level groups ($P<0.01$), and significantly greater comb height ($P<0.05$). The high nutrient level group also showed a tendency to increase ovary weight ($P=0.08$). Dietary nutrient levels did not significantly affect sexual maturity indicators in cocks ($P>0.05$).

These findings indicate that for medium-speed yellow-feathered broilers, a medium nutrient level diet optimizes growth performance, while a high nutrient level diet promotes sexual maturity in hens.

Keywords: Beijing-You chickens; nutrient level; growth performance; meat quality; sexual maturity

Introduction

Yellow-feathered broilers represent a distinctive sector of China' s poultry industry, with inventory levels comparable to those of white-feathered broilers. By 2014, commercial yellow-feathered broiler production had reached nearly 4 billion birds. Since market performance is largely determined by breed characteristics, optimizing feed formulation to improve feed conversion efficiency while maintaining meat flavor is crucial for reducing production costs in yellow-feathered broiler operations.

Previous research has demonstrated that high-nutrient diets can increase body weight and improve feed conversion efficiency in broilers while promoting sexual maturity. However, Wu et al. reported that low nutrient levels reduce feed conversion efficiency. Some studies indicate that high-nutrient diets increase intramuscular fat content and decrease water loss rate, while Li et al. found that carcass moisture correlates positively with dietary energy levels. Research has also suggested significant correlations between meat quality and precocity, with the traditional view holding that early-maturing broilers offer better flavor due to higher fat content.

Beyond growth performance, comb size and coloration serve as important indicators of sexual maturity and influence consumer purchasing decisions, making sexual maturity a key economic trait in yellow-feathered broilers. While sexual maturity is primarily genetically controlled, nutrition level also exerts significant influence. Excessive or insufficient nutrient levels can cause uncontrolled body weight gain, advancing or delaying sexual maturity while simultaneously affecting meat quality. China' s indigenous broiler breeds exhibit considerable variation in body size and have distinct nutritional requirements and utilization characteristics. Previous research on dietary nutrient levels in local breeds has focused mainly on growth performance, with inconsistent findings regarding meat quality and particularly limited investigation of effects on sexual maturity.

This study aimed to identify optimal dietary nutrient levels that enhance growth performance, meat quality, and sexual maturity in medium-speed yellow-feathered broilers, providing a scientific basis for their production.

1.1 Experimental Animals and Treatments

This experiment employed a single-factor completely randomized design. A total of 432 one-day-old commercial Beijing-You chicks of similar body weight were obtained from Beijing Bainian Liyuan Ecological Agriculture Co., Ltd. and randomly divided into three groups, each comprising four replicates (cages) with 36 birds per replicate (stocking density: 15 birds/m^2). LED lighting provided a 16-hour supplemental photoperiod (12L:3D:2L:3D:2L:2D). Light intensity was 20 lx during the first week and 5 lx from the second week onward. Birds were raised on slatted floors with wire mesh positioned 0.5 m above ground level;

each cage measured 2.0 m × 1.2 m. Feed and water were available ad libitum. Daily management and vaccination protocols followed the standard operating procedures of Beijing Bainian Liyuan Ecological Agriculture Co., Ltd.

Basal diets were formulated according to the Yellow-Feathered Broiler Feeding Standard (NY/T 33-2004) for three growth phases: 1–5 weeks, 6–9 weeks, and 10–13 weeks. Within each phase, three nutrient levels (high, medium, and low) were established by increasing or decreasing metabolizable energy by 210 kJ from the standard level, with corresponding adjustments in crude protein content while maintaining a constant protein-to-energy ratio. The composition and nutrient levels of the basal diets are presented in .

1.2.1 Growth Performance

Feed intake and body weight gain were recorded for each replicate during three periods: 1–5 weeks (starter), 6–9 weeks (grower), 10–13 weeks (finisher), and across the entire 1–13 week period. Average daily feed intake (ADFI), average daily gain (ADG), and feed-to-gain ratio (F/G) were calculated for each period.

1.2.2 Meat Quality

At the end of the experiment, birds from each replicate were separated by sex and weighed to determine average body weight for each sex. Three cocks and three hens with body weights closest to their respective sex-specific means were selected from each replicate for slaughter and sample collection. The left pectoral muscle was excised to determine meat color, pH, drip loss rate, and intramuscular fat content.

Meat color: Two fixed locations on each pectoral muscle sample were measured using a colorimeter to determine lightness (L*), redness (a*), and yellowness (b*) values.

pH: Pectoral muscle pH was measured at 1 hour and 24 hours post-slaughter (samples stored at 4 °C).

Drip loss rate: A cylindrical muscle sample (~2.0 g) was cut from each pectoral muscle, weighed (initial weight), placed in a drip loss tube, stored at 4 °C for 24 hours, and reweighed (final weight). Drip loss rate (%) = [(initial weight - final weight) / initial weight] × 100.

Intramuscular fat content: Determined using the Soxhlet extraction method according to GB/T 9695.7-2008.

1.2.3 Sexual Organ Indices

At 13 weeks of age, three cocks and three hens selected from each replicate for slaughter were used to measure comb length, height, and thickness using vernier calipers. Following slaughter, testes, ovaries, and combs were dissected and weighed to calculate testis index and ovary index.

Testis index = (testis weight / body weight) × 100
Ovary index = (ovary weight / body weight) × 100

1.3 Statistical Analysis

All performance data were analyzed using the General Linear Model (GLM) procedure in SAS 8.0 software for one-way ANOVA. Duncan' s multiple range test was used for pairwise comparisons among treatment means. Differences were considered significant at $P<0.05$ and highly significant at $P<0.01$. Results are expressed as "mean ± standard deviation."

2.1 Effects of Dietary Nutrient Levels on Growth Performance of Yellow-Feathered Broilers

As shown in , during the 1-5 week period, the low nutrient level group exhibited significantly lower ADFI and ADG compared to the medium and high nutrient level groups ($P<0.01$). The high nutrient level group showed a significantly lower feed-to-gain ratio than the medium and low nutrient level groups ($P<0.05$). The medium nutrient level group demonstrated significantly higher ADG and lower feed-to-gain ratio than the low nutrient level group ($P<0.05$). Except for feed-to-gain ratio during 1-5 weeks, no significant differences were observed between the high and medium nutrient level groups across all growth phases ($P>0.05$).

2.2 Effects of Dietary Nutrient Levels on Meat Quality of Yellow-Feathered Broilers

As shown in , dietary nutrient levels did not significantly affect any meat quality parameters ($P>0.05$).

2.3 Effects of Dietary Nutrient Levels on Sexual Organ Development of Yellow-Feathered Broilers

As shown in , no significant differences were observed in sexual maturity indicators among the three nutrient level groups in cocks ($P>0.05$).

As shown in , the high nutrient level group exhibited significantly greater comb weight and comb length in hens compared to the medium and low nutrient level groups ($P<0.01$), and significantly greater comb height ($P<0.05$). The high nutrient level group also showed a tendency to increase ovary weight ($P=0.08$).

3.1 Effects of Dietary Nutrient Levels on Growth Performance of Yellow-Feathered Broilers

Nutrient level is a critical factor affecting broiler growth. In this study, ADFI and ADG during the 1–5 week period increased with dietary nutrient level, consistent with findings from Li, Sikur et al., and Fanatico et al. in white-feathered broilers and Tang in Beijing-You chickens. Throughout the entire growth period, the low nutrient level group exhibited significantly reduced ADG and increased feed-to-gain ratio. Diets with excessively low nutrient levels contain larger quantities of low-quality ingredients, and combined with the small digestive tract capacity of broilers, result in lower feed intake. Consequently, low-nutrient diets reduce digestibility, decrease ADG, and increase feed-to-gain ratio.

In this study, the high nutrient level diet did not significantly improve ADG or reduce ADFI and feed-to-gain ratio, which aligns with findings from Zhang et al. in Suqin black-bone chickens. However, Tang et al. reported that high-energy diets significantly reduced feed-to-gain ratio and increased ADG in broilers, while Wang et al. found that high-nutrient diets significantly reduced feed-to-gain ratio in Lingnan yellow-feathered broilers. These discrepancies may arise from differences in broiler breeds and dietary nutrient levels. The present results indicate that high-nutrient diets increase feed costs without significantly improving growth performance, representing an unnecessary expense. Conversely, low-nutrient diets result in slower growth and development. A medium nutrient level diet adequately meets the growth requirements of yellow-feathered broilers, reducing production costs and maximizing economic efficiency.

3.2 Effects of Dietary Nutrient Levels on Meat Quality of Yellow-Feathered Broilers

Appropriate dietary energy and protein levels can improve broiler meat quality. Studies by Lin et al. in yellow-feathered broilers and Li et al., Chen et al., and Tang et al. in Arbor Acres broilers demonstrated that high-nutrient diets significantly reduced drip loss. Tang et al. reported that increasing dietary energy level significantly increased pH at 24 hours post-slaughter in Arbor Acres broilers. Jiang et al. found that increasing dietary metabolizable energy level significantly increased pH in Lingnan yellow-feathered broilers. Lower L* values indicate darker meat color, while higher a* values indicate greater redness. L* values below 55 indicate normal meat color, whereas values reaching 60 suggest pale meat with poor water-holding capacity. In this study, dietary nutrient levels

did not significantly affect any meat quality parameters. These divergent results may be attributed to breed differences and varying gradients of dietary energy and protein levels. The inconsistent findings also suggest that intramuscular fat deposition is a complex trait that may not have a linear relationship with dietary nutrient levels. Therefore, practical production should tailor dietary nutrient levels to specific breeds and their growth characteristics.

3.3 Effects of Dietary Nutrient Levels on Sexual Maturity of Yellow-Feathered Broilers

Comb development represents the most prominent and important secondary sexual characteristic in broilers and serves as a qualitative indicator of sexual maturity. In this study, dietary nutrient levels did not significantly affect testis weight, testis index, or comb measurements in cocks, though the low nutrient level group showed slower development of sexual maturity indicators, consistent with Tang' s report. Comb size correlates positively with testis weight. However, Fang et al. found that medium nutrient level diets significantly increased testis index in Avian broilers. In the present study, the high nutrient level group had higher body weight than the medium nutrient level group but did not show optimal sexual maturity development, indicating that a medium nutrient level diet adequately meets the sexual maturity requirements of male yellow-feathered broilers.

Yang et al. reported that ovary weight and follicle number increased with age and energy level in Hy-Line brown laying hens. Tang found that high nutrient level diets resulted in significantly greater comb weight in Beijing-You hens and promoted ovarian development. These findings align with the present results. Hens showed significantly affected comb and ovary development by dietary nutrient level, with the high nutrient level group exhibiting both maximum body weight and optimal sexual maturity development. This indicates that female yellow-feathered broilers have higher nutritional requirements, a conclusion supported by Li et al.' s research on nutrient requirements for different sexes in Hetian chickens. These results demonstrate that nutritional regulation can effectively promote sexual maturity in hens, resulting in desirable appearance characteristics (large, red combs) that meet consumer preferences. Therefore, production systems focusing on hens, particularly in southern China, may benefit from increased dietary nutrient levels to promote both growth and sexual maturity. For mixed-sex operations, separate feeding during the later growth stage could be considered, with moderately increased nutrient levels for hens to enhance sexual maturity while improving overall flock uniformity.

References

[1] TESSERAUD S, PYM A R, LE BIHAN-DUVAL E, et al. Response of broil-

ers selected on carcass quality to dietary protein supply: live performance, muscle development, and circulating insulin-like growth factors (IGF- and -)[J]. Poultry Science, 2003, 82(6): 1011–1016.

[2] LI Z R, FENG Y L, YANG Y, et al. Effects of adding whole grain rice to diet on growth performance and slaughter performance of Hetian chickens[J]. Fujian Animal Husbandry and Veterinary Medicine, 2003, 25(2): 3–5.

[3] WU G, BRYANT M M, GUNAWARDANA P, et al. Effect of nutrient density on performance, egg components, egg solids, egg quality, and profits in eight commercial leghorn strains during phase one[J]. Poultry Science, 2007, 86(4): 691–697.

[4] LEI Q X, CAO D G, HAN H X, et al. Effects of different nutrient levels on muscle quality of Luqin No. 3 partridge chicken matching system[J]. Shandong Agricultural Sciences, 2008(1): 100–103.

[5] LI W B. Effects of different lighting systems and nutrient levels on production performance, meat quality and immune function of broiler chickens[D]. Master' s thesis. Lanzhou: Gansu Agricultural University, 2010.

[6] LI Z R, YANG Y, LIU J, et al. Effects of dietary energy and protein levels on carcass quality of Fujian Hetian chickens[J]. Journal of Fujian Agricultural University, 2000, 29(3): 371–375.

[7] WEI F Y, LIAO Y Y, LUO M H, et al. Selection and application of early-maturing strains of Yinxing partridge chickens and Xiayan chickens[J]. China Poultry, 2002, 24(18): 12–14.

[8] JI C L, ZHANG D X, ZHANG X Q, et al. Effects of sexual maturity on pectoral muscle quality of Guangxi Sanhuang chickens[J]. China Poultry, 2008, 30(7): 12–14.

[9] JI J L, QIN H R, WEI Z Y. Regulation of sexual maturity in broiler breeders[J]. Sichuan Animal Husbandry and Veterinary Medicine, 2002, 29(Suppl.): 50–51.

[10] YANG Y, HUANG Y X. Research progress on nutrition regulation of poultry reproduction[J]. Journal of Shanxi Agricultural University: Natural Science Edition, 2008, 28(2): 198–202, 226.

[11] QIN H R, JI J L, YANG X Z. Study on reproductive organ development and sexual maturity regulation in broiler breeders[J]. Acta Agriculturae Boreali-occidentalis Sinica, 2006, 15(6): 34–36.

[12] SIKUR V R, ROBINSON F E, KORVER D R, et al. Effects of nutrient density on growth and carcass traits fast- slow-feathering female turkeys[J]. Poultry Science, 2004, 83(9): 1507–1517.

[13] FANATICO A C, PILLAI P B, EMMERT J L, et al. Meat quality of slow- and fast-growing chicken genotypes fed low-nutrient or standard diets and raised indoors or with outdoor access[J]. Poultry Science, 2007, 86(10): 2245–2255.

[14] TANG S. Effects of different photoperiods and nutrient levels on growth performance, sexual characteristic development and welfare of yellow-feathered broilers[D]. Master' s thesis. Beijing: Chinese Academy of Agricultural Sciences, 2013.

[15] ZHANG X Y, HAN W, SU Y J, et al. Effects of dietary energy and protein content on daily weight gain of Suqin black-bone chickens[J]. Acta Agriculturae Universitatis Jiangxiensis, 2010, 32(2): 199-205.

[16] TANG J P, CAI H Y, CHANG W H, et al. Effects of stocking density and dietary energy level on growth performance and meat quality of broiler chickens[J]. Chinese Journal of Animal Nutrition, 2012, 24(2): 239-251.

[17] WANG W W, JIANG S Q, ZHOU G L, et al. Effects of different dietary nutrient levels on production performance and meat quality of Lingnan yellow-feathered broilers[C]//Proceedings of the 6th National Symposium on Feed and Nutrition. Beijing: Chinese Association of Animal Science and Veterinary Medicine, 2010: 24.

[18] SHI J S, LIU F Z, NIU Z Y. Study on energy and protein requirements of broiler chickens aged 21-42 days[J]. Acta Agriculturae Boreali-occidentalis Sinica, 2009, 18(3): 67-73.

[19] LIN S Q, LI J L, SHI Z G, et al. Effects of different dietary nutrient levels on slaughter performance and meat quality of yellow-feathered broilers[J]. China Animal Husbandry and Veterinary Medicine, 2008, 35(8): 9-13.

[20] LI W B, GUO Y L, CHEN J L, et al. Influence of lighting schedule and nutrient density in broiler chickens: effect on growth performance, carcass traits and meat quality[J]. Asian-Australian Journal of Animal Science, 2010, 23(11): 1510-1518.

[21] CHEN C M, SONG Y, TANG M Y, et al. Effects of dietary protein and lysine levels on growth performance and muscle quality of AA broiler chickens[J]. Journal of China Agricultural University, 2006, 11(6): 55-59.

[22] TANG M Y, MA Q G, CHEN X D, et al. Effects of dietary metabolizable energy and lysine on carcass characteristics and meat quality in Arbor Acres broilers[J]. Asian-Australasian Journal of Animal Science, 2007, 20(12): 1865-1873.

[23] LEWIS P D, TYLER N C, GOUS R M, et al. Photoperiodic response curves for plasma LH concentrations and age at first egg in female broiler breeders[J]. Animal Reproduction Science, 2008, 109(1/2/3/4): 274-286.

[24] JIANG S Q, JIANG Z Y, ZHENG C T, et al. Effects of dietary metabolizable energy and crude protein levels on production performance and meat quality of yellow-feathered broilers[J]. Scientia Agricultura Sinica, 2013, 46(24): 5205-5216.

[25] FANG L C, SONG D J, DONG G Z, et al. Effects of dietary nutrient level on

testicular development of broiler chickens[J]. Journal of Southwest Agricultural University, 2001, 23(6): 557–560.

[26] YANG Y, HUANG Y X, HE J P, et al. Effects of dietary energy level on ovary weight and E2 and P4 levels during sexual maturity in laying hens[J]. Journal of Nuclear Agricultural Sciences, 2008, 22(3): 365–369.

[27] LI Z R, FENG Y L, YANG Y. Effects of adding whole grain rice to diet on meat quality traits of Hetian chickens[J]. Fujian Journal of Agricultural Sciences, 2003, 18(2): 97–102.

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