EFFECT OF DIFFERENT DIETARY ARGININE LEVEL ON GROWTH PERFORMANCE AND REPRODUCTIVE PERFORMANCE IN DUCKS

ABSTRACT

Arginine (Arg), an essential amino acid for ducks, is pivotal for optimizing growth, reproduction, and metabolic health in poultry production. For meat ducks, Arg requirements vary by production stage. Recent studies in China —the largest duck-producing country—highlight that optimizing dietary Arg levels is key to enhancing production efficiency. For early-stage meat ducks (1–14 days), dietary Arg to Lys ratio at 100% maximizes body weight and feed conversion, while ratios of 93–119% are required in later stages (15–38 days), as validated by China's updated nutritional standards. At the same time, heat stress further elevates Arg demands in ducks likely due to reduction in intestinal absorption of Arg. Arg also improves carcass quality by promoting lean muscle accretion and reducing fat deposition in meat ducks. In breeding ducks, balanced Arg levels enhance egg production, yolk quality, and spermatogenesis. This review consolidates evidences on Arg's multifaceted roles in duck nutrition, offering evidence-based strategies to optimize its use in commercial production.

Keyword Arginine, Ducks, Growth & Carcass Performance, Reproductive Performance, Anti-heat Stress

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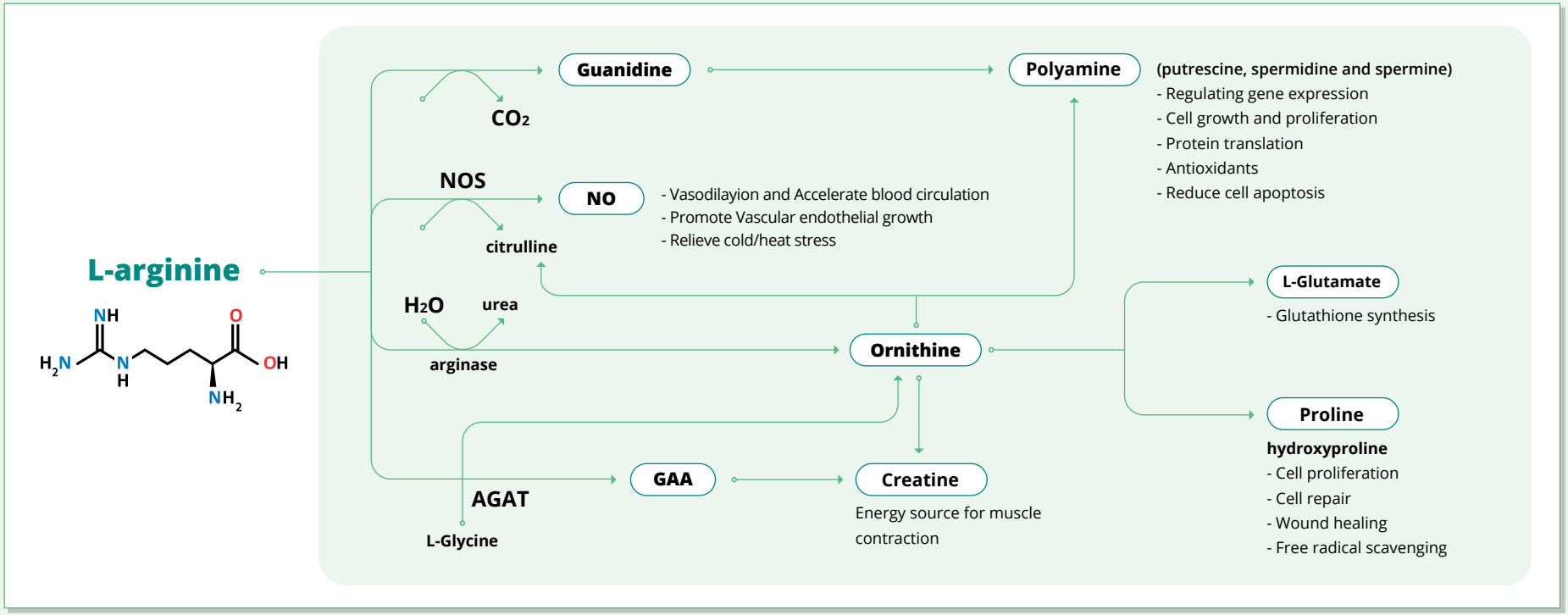
BACKGROUND

China produced approximately 4.5 billion meat ducks per year, accounting for over 70% of global production. Exceeding 10 million metric tons of meat production in 2022, making duck the third most consumed meat in China after pork and chicken. Most of the meat ducks in China are white feather duck (Cherry Valley ducks), accounting for 86%, the rest are Shelducks and Muscovy /hybrid Muscovy ducks. Corn and plant protein materials, like cottonseed meals are commonly used in duck feeds in China, while soybean meal is also included in formulations when its price becomes competitive. Unlike mammals, uricotelic species such as ducks lack a complete urea cycle and cannot synthesize Arg endogenously, making dietary or exogenous supplementation critical for optimal growth, production, and reproduction (Edmonds et al., 1985; Wu et al., 2009). Arginine exhibits multiple physiological functions, including promoting growth and muscle development, enhancing intestinal health, mitigating heat stress, and regulating skeletal muscle development Figure 1. This review synthesizes evidence from multiple studies demonstrating that Arg supplementation effectively enhances growth performance, carcass composition, stress resilience, and reproductive outcomes in ducks.

Figure 1 **Arginine's role in animal physiology** (Shahna et al., 2024)

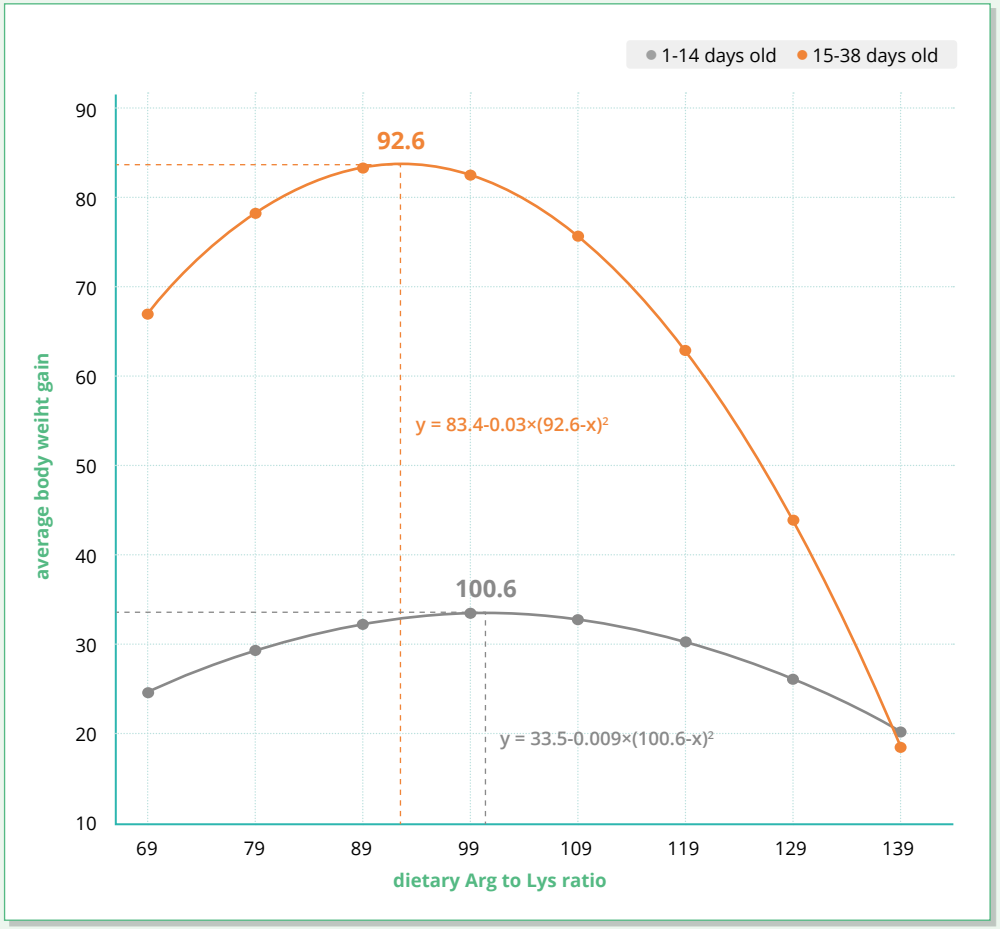


ARGININE REQUIREMENTS IN MEAT DUCKS

Optimal Arg levels in diets are essential for maximizing growth in ducks. Chen and Shen (1979) established the minimum dietary Arg level requirement for mule ducklings at 1.08% of the diet (18.0% of dietary crude protein), which significantly improved weight gain and feed efficiency. Similarly, Wang et al. (2013) determined that modern white feather ducks aged 1–21 days (22.0% of dietary crude protein) required 0.95% dietary Arg level for maximum weight gain, 1.16% for optimal feed conversion, and 0.99% for breast muscle yield.

Considering the influence of different breeds and dietary nutritional levels, a study was conducted in 2024 to determine the Arg requirement of white feather ducks in China, based on commonly used commercial diets,containing corn, wheat, rapeseed meal and some corn by-products. In 1-14 days of age, birds were diets with a CP level of 20.4%, SID lysine level was 1.12% while in 15-38 days of age, the dietary CP level was reduced to 17.9% with a SID lysine level of0.93%. By using quadratic broken-line model to fit the data, the results showed that dietary Arg/Lys ratio corresponding to the optimal Average Daily Gain (ADG) reached 100.6% in the early stage (1-14 days) of meat ducks. And in the late stage of meat duck (15-38 days), the appropriate dietary Arg/Lys ratio is approximately 92.6% Figure 2. In 2024, the Ministry of Agriculture and Rural Affairs of China released the recommended nutritional requirements for meat ducks (GB/T 45103-2024), which stated that during the growth and fattening period (21-42 days), the true available Arg to Lys ratio in the diet of commercial white feather ducks should reach 105-110%. For breeding ducks, the ratio of Arg to Lys that can be truly utilized in the diet at the developmental stage (9-22 weeks old) should reach 115% based on the recommendation.

Figure 2 **Prediction of the required ratio of dietary Arg to Lys ratio for white feather duck using quadratic broken-line model** (CJ trial)



ARG ENHANCES GROWTH & CARCASS PERFORMANCE IN MEAT DUCKS

Insufficient Arg in the diet can inhibit feed inktake in meat ducks, reduce feed conversion efficiency, and lower breast muscle production. Arg deficiency suppresses feed intake by altering hypothalamic protein expression. Wang et al. (2013) found that ducks fed Arg-deficient diets (0.71% vs. 1.27% dietary Arg level) exhibited reduced feed intake and downregulated hypothalamic proteins involved in energy metabolism. Conversely, Wang et al. (2014), by the same authors found Arg sufficiency enhances NO production, which stimulates appetite-related neuropeptides. Intraperitoneal injection of Nω-nitro-L-arginine methyl ester (L-NAME), which is a NO synthase inhibitor, confirmed that NO mediates Arg's orexigenic effects, as suppressed NO levels correlated with reduced feed intake. Similarly, sufficient arginine in the diet can improve feed conversion efficiency while ensuring feed intake. Sun et al. (2022) demonstrated that the feed to gain ratio of 1.08% and 1.18% dietary Arg/Lys ratio groups was significantly lower than that of 0.88% dietary Arg/Lys ratio group in dual-purpose type ducks during 8 to 35 days.

For carcass performance, Arg supplementation reduces excessive fat deposition, a common issue in meat ducks. Wu et al. (2011) reported that 10 g/kg dietary Arg decreased carcass fat by 7.2%, abdominal fat by 4.9%, and skin fat by 7.6%, while promoting lean tissue accretion, by increasing breast muscle protein (+9.2%) and intramuscular fat (+11.9%). These changes were linked to reduced hepatic lipogenic enzyme activity (e.g., FAS, G-6-PDH), underscoring Arg's role in redirecting energy toward protein synthesis rather than lipid storage.

Besides, the carcass yield of meat ducks is also regulated by Arg because number of matured muscle fibres in poultry does not increase after hatch, the meat yield is mainly determined during embryogenesis. Guo et al. (2024) demonstrated that Arg metabolism critically influences embryonic breast muscle development in Muscovy ducks. Transcriptomic analysis identified Arg deficiency inhibited myoblast proliferation. Tangara et al. (2013) successfully achieved an increase in hatch weights (+4.6%), and sustained growth advantages up to 7 days post-hatch by injecting 23-day-old duck embryos with Arg combined with carbohydrates. This suggests that Arg promotes energy metabolism in duck eggs, supporting the development of offsprings after hatching.

ARGININE ENHANCES REPRODUCTIVE PERFORMANCE IN DUCKS

Nitric oxide (NO) as a metabolite of Arg is considered to regulate follicular development, maturation, and even

egg production. Xia et al. (2016) conducted experiments on local dual-purpose type ducks from 17 to 31 weeks of age and found that dietary Arg level linearly increased the egg weight and the yolk percentage, where the maximum values were obtained at 1.26% dietary Arg level. According to the regression analysis, the dietary Arg level was 1.06% to obtain the maximum yolk percentage. Lei et al. (2016) found that adding L-arginine to corn-soybean laying diet (CP=18.56%), increased dietary Arg to Lys ratio to 1.33%, significantly enhanced the total egg and yolk weights of laying ducks ($P < 0.05$), and trendy increased albumen and eggshell weights in local duck layers.

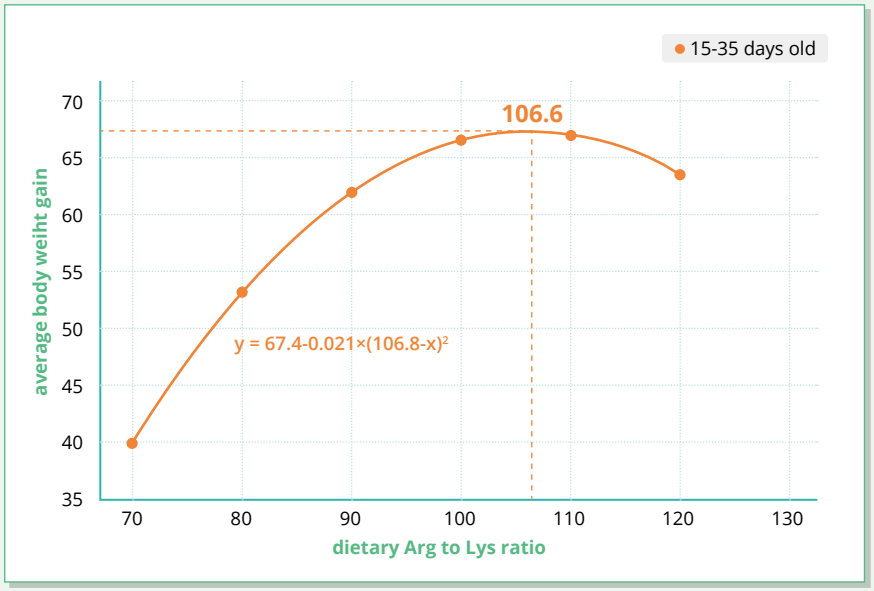
Furthermore, Arg is also involved in male reproductive performance including the synthesis of sperm cells. Meng (2021) observed that after 75 days of feeding a diet supplemented with 0.4% Arg increased the number of spermatogenic epithelium, spermatogenic cells and mature sperm in testis tissue sections of Muscovy ducks. Collectively, Arg enhances both female reproductive outcomes—via improved yolk and egg weight—and male fertility through spermatogenic enhancement.

ARGININE'S ROLE IN ANTI-HEAT STRESS

Brugaletta et al. (2023) reported that the optimum Arg/Lys ratio for birds increase at high temperatures, because of a reduced uptake of arginine from the digestive tract, and a change from the optimum ratio could have adverse effects on the performance of growing poultry. Zhu et al. (2014) demonstrated that an environmental temperature at 37±1C for 3h markedly decrease the bodyweight at 6.5% ($P < 0.01$) at 49 days. Afterwards, they continued the experiment by adding 5 g L-Arg/kg to meet the Arg requirements under cyclic high temperatures, and significantly improved feed conversion ratios (FCR) by 3.7% in whole stages of ducks ($P < 0.05$).

Last summer in Beijing, it was found out that in the late stage of meat duck (15-38 days), quadratic broken-line model showed the appropriate dietary Arg/Lys ratio to be 106.6% Figure 3. Zhu et al. (2014) also demonstrated that heat stress significantly decreased the absolute liver weight liver weight by 33% ($P < 0.001$) in meat ducks. Because blood flow is redistributed to dissipate body heat via peripheral circulation, liver is experiencing ischaemic conditions. Moreover, supplementation with 5 g L-Arg/kg significantly increased relative liver weight at 21 days ($P < 0.05$). This improvement was attributed to Arg's role in NO synthesis, which enhances blood flow and nutrient utilization.

Figure 3 **Prediction of the required ratio of dietary Arg to Lys ratio for white feather duck in summer using quadratic broken-line model** (CJ trial)



CONCLUSIONS

As uricotelic species, ducks depend entirely on dietary Arg due to their inability to synthesize it endogenously, a limitation exacerbated by modern production challenges such as heat stress and high yield demands. To address these challenges, in corn-based meal diets prioritizing Arg sufficiency ensures optimal nutrient partitioning towards body growth and development. For breeding ducks, sufficient supply of Arg enhances egg quality and fertility. China's updated nutritional standards provide a foundational framework in feed formulations for meat ducks, yet dynamic adjustments are warranted when exposed to environmental stressors like high temperature and humidity. Finally, the incorporation of crystalline Arg into feed formulations offers a practical solution for an efficient duck farming.