Opportunities for poultry growth and reproductive performance improvements with L-arginine

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Introduction

Arginine plays a crucial role in numerous metabolic and immunology pathways in poultry (Fig. 1). Arginine is considered an essential amino acid in poultry as they are unable to synthesize endogenous L-arginine because of the lack of a functional urea cycle and therefore, it is essential that the diet provides the optimal level to realize the genetic potential of the modern broiler. Only recently, a feed grade source of L-arginine has become available as an economically viable source for dietary arginine for nutritionists to utilize in current formulations.

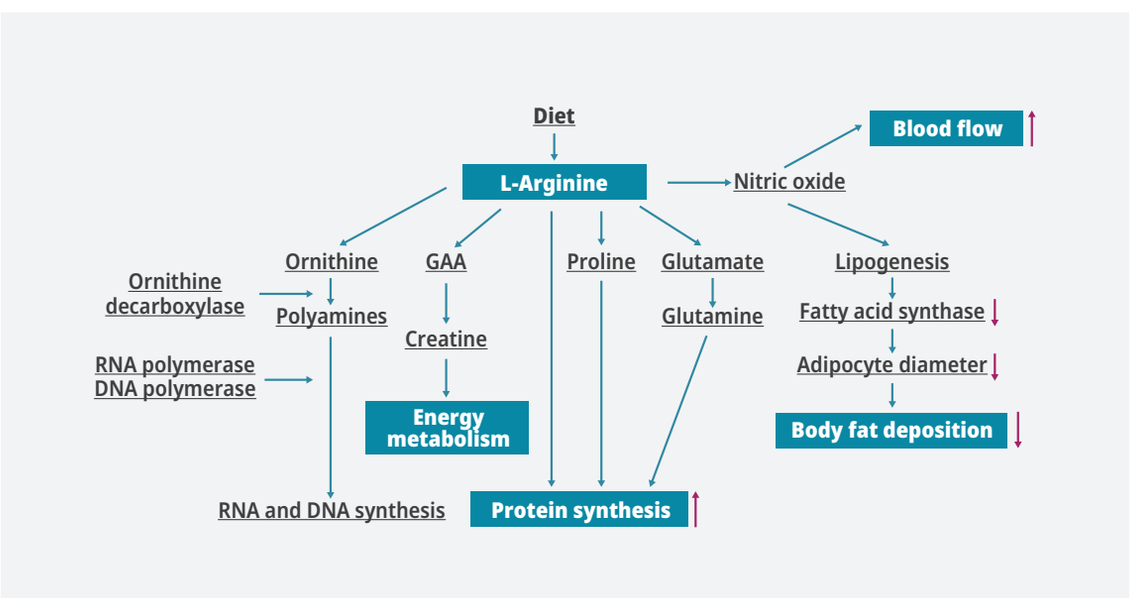

Figure 1. Destination pathways of dietary L-arginine in broilers.

(Adopted from Quimidroga.com)

In modern commercial poultry diets, arginine could potentially be the 4th, 5th, or 6th limiting amino acid depending on dietary ingredient profile. In cases that arginine is 4th, a cost saving opportunity exist with the use of L-arginine in addition to the benefits of decreasing dietary crude protein. Diets that contain ingredients low in arginine as compared to valine and isoleucine as relative to requirement such as corn DDGS, bakery meal, and corn gluten meal, are opportunities for the use of L-arginine to reduce diet cost and reduce crude protein (Fig. 2). In both turkey and broiler diets, depending on ingredient profile, arginine can be the 4th limiting amino acid in many cases (Table 1). Using L-arginine in these diets not only reduces diet cost but also allows producers to take advantage of the benefits of reducing dietary crude protein and lowering nitrogen excretion on environmental and litter conditions, foot pad quality, and intestinal health.

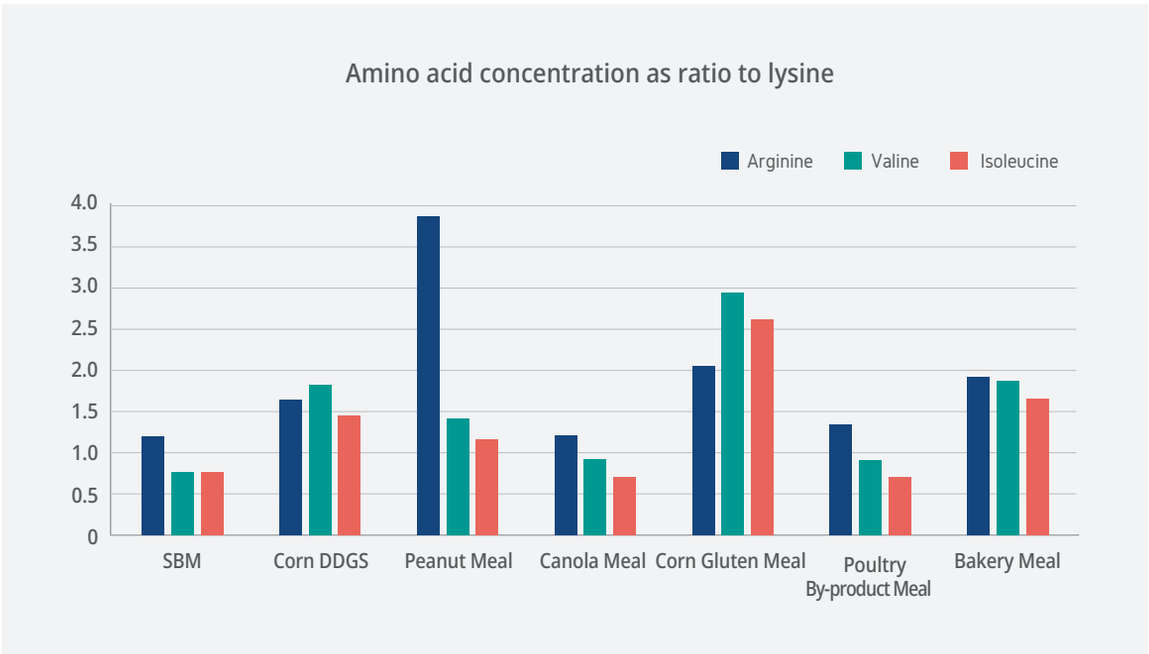

Figure 2. Arginine, valine, and isoleucine to lysine ratio as a percentage of a broiler's amino acid requirement.

Table 1. Turkey and broiler diet formulations providing access to L-arginine in the formulation (lbs/ton)

	Turkey Grower 1 Diet Nicholas recommendations		Broiler Withdrawal Diet Aviagen recommendations	
Ingredients	Without L-ARG	L-ARG	Without L-ARG	L-ARG
Corn	951.22	996.42	1189.69	1226.96
SBM, 48%	747.78	707.21	484.42	450.89
DDGS	100.00	100.00	200.00	200.00
Fat	112.26	103.80	76.14	69.19
L-Lysine - HCl	6.09	7.35	4.26	5.29
L-threonine, 98.5%	1.36	1.91	1.47	1.93
L-methionine, 99%	5.58	5.91	4.52	4.79
L-arginine, 98.5%	0.00	1.16	0.00	0.96
Other	75.71	76.21	39.50	39.99
Total	2000.00	2000.00	2000.00	2000.00
Cost ($/ton)	$256.58	$255.74	$221.84	$221.10
Calculated Analyses	Without L-ARG	L-ARG	Without L-ARG	L-ARG
Crude Protein, %	24.48	23.86	20.13	19.62
AME (kcal/lb)	1432	1432	1462	1462
SID Lysine, %	1.24	1.24	1.00	1.00
SID M+C/Lys, %	67.0	67.0	68.0	68.0
SID Ile/Lys, %	65.0	62.5	70.8	68.0
SID Val/Lys, %	70.5	68.0	79.6	76.9
SID Trp/Lys, %	18.0	17.2	18.4	17.5
Calcium	1.24	1.24	0.74	0.74
Available Phos	0.62	0.62	0.37	0.37
Sodium	0.17	0.17	0.18	0.18

L-arginine has garnered recent interest due to its role in vasodilation, blood flood, and nitric oxide production and a potential benefit on meat quality and reproductive performance. The recent introduction of feed grade L-arginine provides nutritionists the ability to increase arginine ratio in an economically viable way without increasing dietary crude protein. Recently multiple published reports have linked elevated levels of arginine with reductions in breast muscle myopathies (Bodle et al., 2018; Zampiga et al., 2019). However, during these investigations, additional benefits on growth performance were observed. Bodle et al. (2018) reported an increase of 40 gram of body weight and 2 point reduction in feed efficiency at 36 days of age with increasing the ratio from 105 to 125. Similarly, Zampiga et al. (2018) observed an increase of 65 g of body weight and a 3 point improvement in feed efficiency with an arginine ratio increase of 10% at 43 days of age (Fig. 3). These results are similar to data reported by Corzo et al. (2012) in which a 114% Arg ratio was found to optimize feed efficiency during the starter phase of production. This optimal ratio matches a recent meta-analysis reported by Dr. Ospina-Rojas of CJ BIO Brazil identifying the optimal ratio for performance to be 114 to 115% of dig Lys (https://en.engormix.com/poultry-industry/articles/optimal-dietary-arginine-levels-t43741.htm).

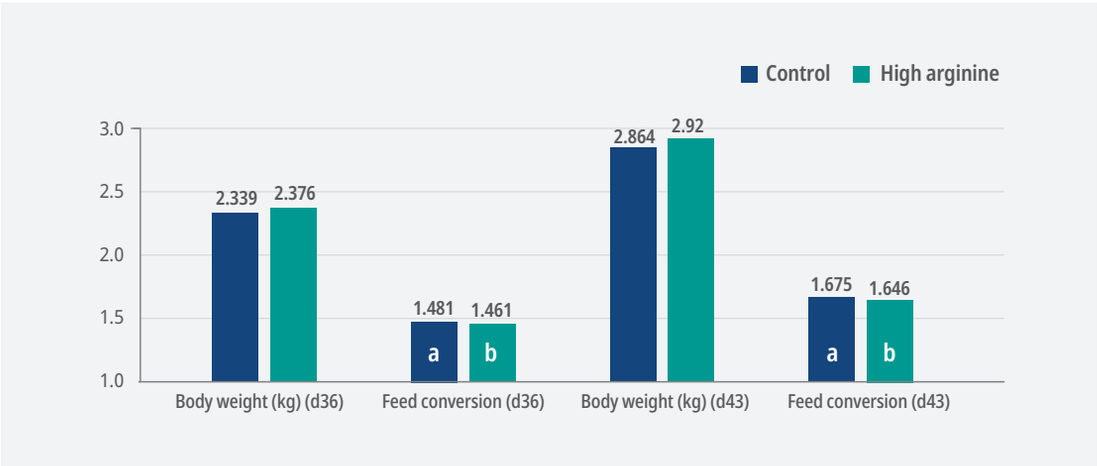

Figure 3. Body weight and feed efficiency of broilers fed diets with increased arginine level through 36 (Bodle et al., 2018 – 20% increase) and 43 days of age (Zampiga et al., 2018 – 10% increase).

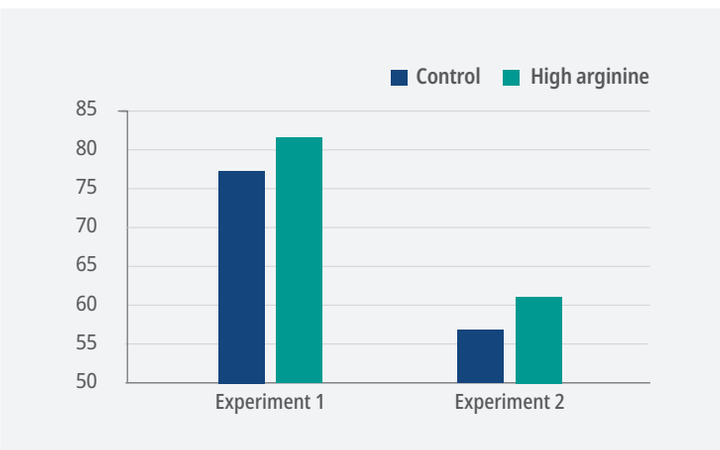

Figure 4. Effect of increasing digestible arginine level on broiler breeder hen egg production in two different experiments.

Experiment 1 (Silva et al., 2012) evaluated an increase of 0.15% (0.94% vs 1.09% in hens from 25 to 56 weeks of age. Experiment 2 (Duan et al., 2015) evaluated an increase of 0.20% (0.96% vs 1.16%) in hens from 60 to 69 weeks of age. Both experiments reported an increase of 4% egg production for the experimental period.

Higher dietary arginine concentration can also be beneficial to reproductive performance. Increasing digestible arginine levels by 0.15% increased egg production in broiler breeder hens by 4% over a 30 week experimental period (Silva et al., 2012). Similarly, Duan et al. (2015) reported a 4% increase in egg production in 60 week old broiler breeder hens during a 9 week experimental period with an increase of 0.20% in dietary digestible arginine level (Fig. 4). These authors correlated the increase in egg production with increasing digestible arginine to effects on the ovaries and ovarian follicles to stimulate the exudation of luteinizing hormone. Additionally, increasing dietary arginine levels could be beneficial for breeder males. Administration of L-arginine has shown to increase sperm count and motility in mammals. Sperm are known to be particularly susceptible to lipid peroxidation which impairs functionality and mobility and thus stimulating the production of nitric oxide with L-arginine could inactivate superoxide anions and improve sperm quality (Srivastava et al., 2006).

As the poultry industry adjusts management and nutritional practices based on consumer demand, for example, raising market broilers and turkeys without antibiotics, it may be necessary to re-evaluate and re-assess our nutritional programs and recommendations. The scientific community has just recently begun to unlock and understand the benefits of dietary arginine on modulating an active immune response, enhancing intestinal maturation, health, and permeability. Barekatain et al. (2019) reported that feeding L-arginine to broilers increased body weight, reduced feed conversion, and increased villi surface area. Similarly, during periods of pathogen challenge, higher levels of dietary arginine can attenuate the overexpression of pro-inflammatory cytokines (Tan et al., 2013) and increase jejunal villus height (Tan et al., 2014), thus improving digestibility and conserving nutrients for growth during an active immune response. Additionally, Tan et al. (2015), determined the dietary arginine level required for maximal performance increased by 15% in infectious bursal disease vaccine challenged broilers as compared to non-challenged control broilers.

The development of feed grade L-arginine provides nutritionists an opportunity to reduce diet cost, reduced crude protein, and enhance growth and reproductive performance of poultry. The mechanisms of this performance improvement can vary depending on nutritional program and management strategies as arginine has numerous biological functions and participates in multiple biological pathways.

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