Guanidinoacetic acid improves performance and carcass quality in broilers

In high yielding broilers, the capacity of de-novo synthesis of creatine might be a limiting factor and supplementation via feed can be beneficial.

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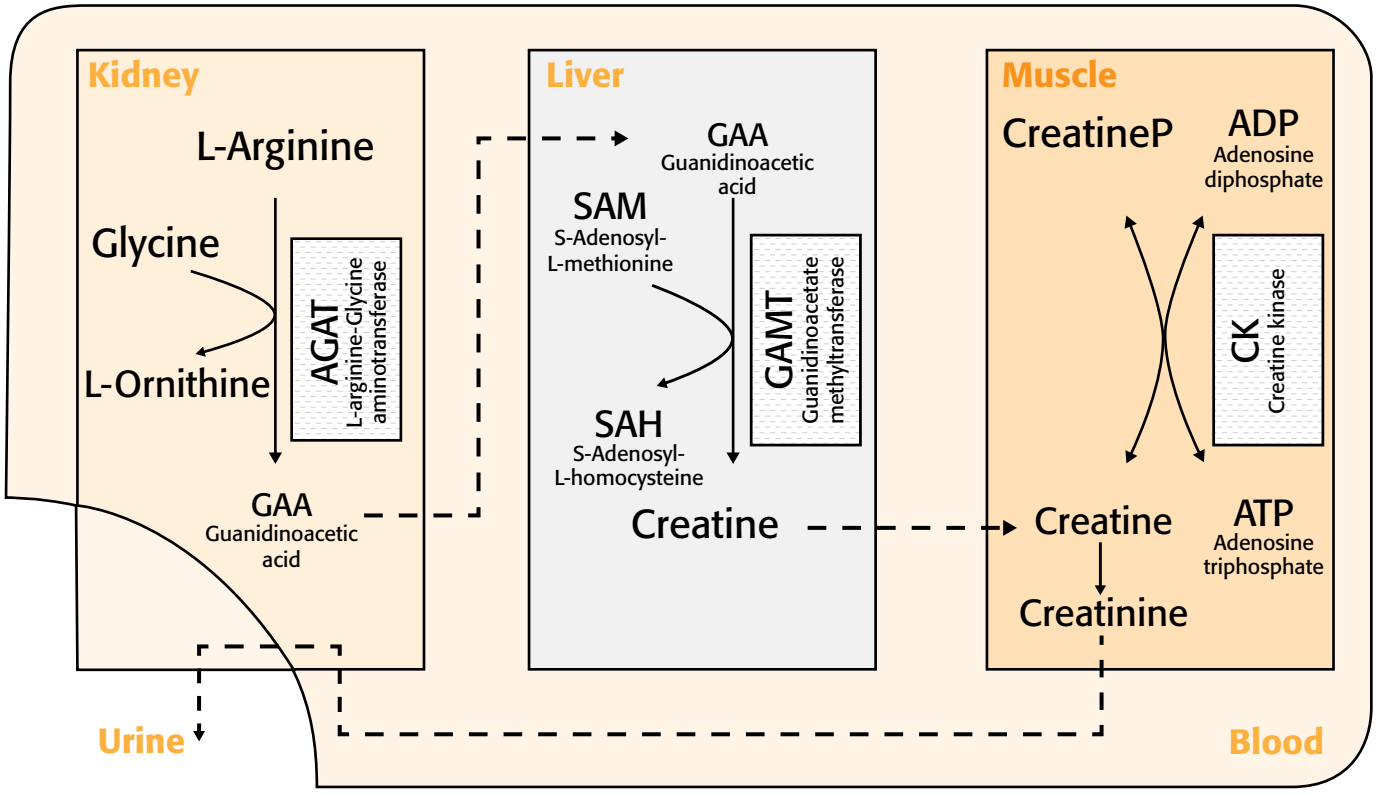
Guanidinoacetic acid (GAA) is an immediate substrate for biosynthesis of creatine, which is important in energy metabolism, particularly of muscle cells. BALACHANDAR JAYARAMAN and PRADEEP KRISHNAN* report a trial that shows GAA can significantly improve growth performance in broilers.

Creatine (Crea) is an important constituent of animal tissue. Crea and its phosphorylated form, phosphocreatine (PCrea) play a dynamic role in cellular energy metabolism of animals. The Crea/PCrea system functions as a backup to adenosine triphosphate (ATP)/adenosine di-phosphate (ADP) system in order to store and mobilize energy when required on an immediate need, particularly in muscle cells. Readily available PCrea and ATP molecules improve the efficiency of various biological processes in cells that require energy in the form of ATP.

Endogenous synthesis of Creatine

The metabolism of Crea involves a series of enzymatic reaction as illustrated in Figure 1. Crea is synthesized in liver from guanidinoacetic acid (GAA) formed mainly in the kidney from glycine and arginine. GAA is transported via bloodstream to the liver, where most of GAA is methylated to Crea. Crea synthesized in liver is transported largely to muscles cells. Once Crea enters the muscle cell, it is phosphorylated ▷

Figure 1. Biochemical pathway of Creatine.



to PCrea by Creatine Kinase (CK) through a reversible metabolic pathway. Part of this Crea pool (1.6-1.8% per day) is irreversibly lost and excreted as creatinine. This rapid turnover of Crea indicates the need to steadily replenish Crea pool either by *de-novo* synthesis or by dietary intake especially in fast-growing broilers. ▷

◁ Fast-growing broilers have a requirement for Creatine

It is estimated that about two-thirds of the daily Crea requirement would be met by *de-novo* synthesis while the other one-third must be provided by dietary supplementation. Crea is only present in feed ingredients of animal origin like fish meal (~1,100 ± 800 mg/kg), meat and bone meal and poultry by-product meal (PBP) (~200 ± 107 mg/Kg) while plant-based ingredients are devoid of Crea. However, contribution from animal by-products to dietary Crea would be rather marginal explaining why there is a need for supplemental Crea in fast-growing broilers. Inclusion level of 5% fishmeal in the diet would contribute <10 mg Crea/day at 150 g daily feed intake (50 kg fish meal per metric ton*1.11 g Crea/kg fishmeal*150 g feed intake). The daily Crea requirement of a 1 kg and 2 kg broiler is estimated to be 210 mg and 295 mg respectively, of which approximately 140 mg and 195 mg can be endogenously synthesized (66%). This creates a gap of 70-100 mg in daily Crea requirement for the birds weighing 1 and 2 kg respectively.

Creatine is a conditionally essential nutrient for broilers

Based on the above facts, Crea can be defined as a conditionally essential nutrient. In contrast to humans where Crea accretion happens over a long period of time, feeding studies in broilers demonstrated that dietary supplementation of GAA reflected in a spike in the metabolic pool of Crea in muscle tissue within weeks. Studies on digestibility and utilization of metabolic intermediates clearly provide evidence that bird's metabolism determines the supplemental sources of Crea like other nutrient sources with digestibility co-efficient of 99% and utilization efficiency of 76.2%. GAA is the natural precursor of Crea. From an application perspective, it turned out that Crea monohydrate is not stable in feed processing while GAA has shown to be thermally stable. From an economic perspective, supplementation of Crea in the form of GAA is more cost efficient compared to Crea monohydrate.

GAA is heat stable during feed production process

Heat stability is an essential criterion for any feed additive used in commercial broiler feed production conditions. In a recent review article on GAA applications, the heat stability of GAA over Crea is well discussed. At 0.15% GAA supplementation under simulated extrusion process (130°C), GAA recovery was close to 100%, whereas Crea monohydrate recovery differed widely (Figure 2). Thus, it clearly elucidates the guaranteed heat stability of GAA as it is processed into compound broiler feeds.

Previous GAA trials showed consistent improvement in broiler performance

Previous studies conducted in broilers on GAA supplementation under normal and heat stressed conditions covering all modern broiler strains showed consistent improvement in growth performance. Very often, feed conversion ratio (FCR) was improved by 5 points, body weight gain by 50 g with an added breast meat yield of 15 g.

Recent GAA study in broilers

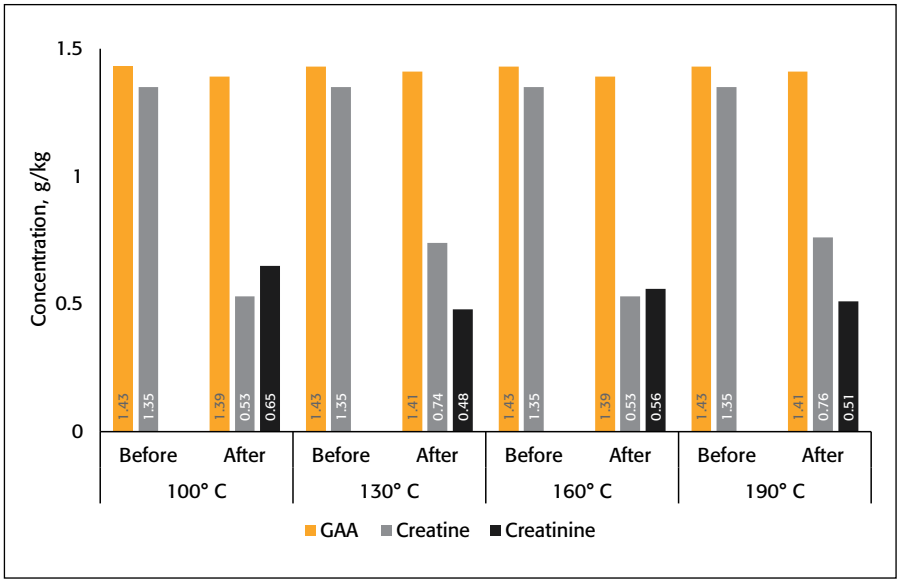
In south Asia, it is customary to include animal by-products (ABPs) in broiler diets as a source of dietary crude protein, calcium and phosphorus. Growth performance is highly inconsistent in broilers fed ABPs due to inherent variation in nutrient composition and product quality of ABPs. Inclusion level of 5% poultry by-products (PBPs) in broiler diets would contribute <2 mg Crea/day at 150 g daily feed intake. This is far below the exogenous Crea requirement of 70-100 mg on a daily-basis. Thus, a study was conducted to evaluate the effects of GAA supplementation in broilers fed corn-soy based diets with and without PBP on performance and carcass quality. Dietary treatments consisted of the inclusion of PBP in the diets at 0% and 5%, and either without GAA or on top supplementation of GAA at 600 g/tonne. A total of 1,280 male Ross 708 chicks were placed in 64 floor pens with 20 birds/pen. Response criteria measured include performance [(body weight gain (BWG), feed intake and feed conversion ratio (FCR)] and carcass characteristics (carcass yield and breast meat yield were measured on day 56). Data were analyzed as a randomized complete block design in a 2 x 2 factorial arrangement

Table 1: Effects of GAA and PBP on performance and carcass quality in broilers.

Main Effects	BWG, g	FI, g	FCR_{adj}	Live weight, g	Carcass weight, g	Breast meat weight, g
PBP						
Without	5,012[a]	8,362	1.650[b]	4,975	3,915	1,506
With	4,966[b]	8,429	1.673[a]	4,948	3,902	1,487
GAA						
0 g/ton	4,966[b]	8,418	1.671[a]	5,006[a]	3,950[a]	1,511[a]
600 g/ton	5,012[a]	8,373	1.652[b]	4,917[b]	3,867[b]	1,481[b]
p-Value						
PBP	0.0295	0.1268	**0.0001**	0.394	0.667	0.173
GAA	**0.0340**	0.3036	**0.0009**	**0.009**	**0.007**	**0.031**

*No interaction effects were observed in this study; FCR_{adj} – Feed conversion ratio adjusted for mortality of broilers; [a, b] Means followed by different superscripts within a column are significantly different ($p \leq 0.05$)

Figure 2: Heat stability of GAA during feed manufacturing process at different extrusion temperatures.



with PBP inclusion and GAA supplementation as main effects.

Results

Growth performance

Broilers that were fed diets without PBP had improved ($p < 0.05$) BWG and FCR compared to those fed diets with PBP (Table 1). GAA supplemented birds had better ($p < 0.05$) FCR_{adj} compared to those without GAA supplementation.

Carcass characteristics

GAA supplemented diets had higher ($p < 0.05$) carcass weight (3,950 g) compared to those (3,867 g) fed without GAA (Table 1). Birds fed diets with PBP were not different ($p > 0.05$) from that fed without PBP.

Take home messages

GAA serves as the direct precursor for Crea synthesis which is important for energy metabolism in muscles. Creatine phosphate (Cr PO_4). the muscle creatine is a major source of energy for skeletal muscle fiber. Daily creatine need for broilers can be partly met by *de novo* synthesis; however, remaining Crea must be supplied via the feed. There is a supply-demand gap of Crea in muscle tissue and application of GAA has demonstrated to bridge this gap. GAA as a novel feed additive improved growth performance and carcass quality in broilers at inclusion levels of 600 g/ton of feed. *Ap*

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