

Supplemental guanidino acetic acid improved feed conversion, weight gain, and breast meat yield in male and female broilers

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After the ban of meat and bone meal in 2001, European poultry producers observed a certain drop in performance. This may be due to the lack of creatine supply because vegetable feed ingredients do not contain this semi-essential nutrient. Guanidino acetic acid (GAA), which is a natural precursor of creatine, was supplemented (0.04, 0.06, 0.08, and 0.12 % of diet in form of CreAmino™) to a vegetable diet (negative control). A positive control with 6 % meat and bone meal in feed was also included. 1056 male and 1056 female broilers were each equally distributed to 48 floor pens (eight / treatment) and fed starter and grower diets. At day 42, three birds per pen were sacrificed for carcass evaluation. Weight gain of female broilers fed the negative control diets was lower than that of birds fed the positive control diet ($p < 0.05$) – for other performance criteria this effect was only numerical. Supplemental GAA in vegetable diets more than resolved this effect. Analysis of variance revealed that the optimal GAA supplementation level was somewhere between 0.06 % ($p < 0.05$, breast yield – males) and 0.12 % ($p < 0.05$, feed conversion – males and breast yield – females). In a few cases regression analysis was possible suggesting optimum GAA supplementation levels of 0.05 % (weight gain) and 0.11 % (feed conversion).

Keywords: guanidino acetic acid, creatine, broiler, vegetable diets

Introduction

Creatine is a naturally occurring component in the animal's body tissue and plays a major role in energy metabolism. Creatine, which is naturally formed - mainly in the liver - from guanidino acetic acid (GAA) which in turn is – mainly in the kidney - synthesised from arginine and glycine, is mainly used in muscle tissues (Wyss and Kaddurah-Daouk, 2000). It is assumed that about 2/3 to 3/4 of the daily requirement is synthesized by *de-novo* synthesis while the remainder must be supplied by the feed. As long as animal by-products, which are rich in creatine, formed a certain part of the ration, no signs for a creatine deficiency could be detected. With the absence of animal proteins in pure vegetable diets the risk for a creatine deficiency increased. The objective of the following experiment was to investigate the effects of graded dietary levels of supplemental GAA (supplemented as CreAmino™) on growth, feed intake, feed conversion and breast meat yield of male and female broilers in comparison to a negative (pure vegetable diet) and positive control (meat and bone meal containing diet).

Materials and methods

A total of 2112 one-day old male and female Ross 308 broilers were randomly distributed to 96 floor pens (six dietary treatments, two sexes, eight replicates) with 22 broilers each. Feed and water

were supplied *ad libitum*. Environmental conditions during the trial were appropriate to the age of the birds and followed the breeder's recommendation. The dietary treatments comprised a negative control diet which was supplemented with graded GAA levels and a positive control diet which were offered as mashed starter diet from 0-21 days of age followed by a mashed grower diet from 22-42 days of age. The negative control diets consisted of ingredients of only vegetable origin while the positive control diets contained 6% meat and bone meal (Table 1). Inclusion levels of supplemented GAA in both starter and grower diets were 0.04, 0.06, 0.08 and 1.2% of the diet (supplemented as CreAmino™, Degussa Feed Additives). Feed intake and body weights were recorded at allotment, day 21 and day 42. Subsequently, feed conversion ratios were computed. After termination of the growth trial, three birds of median weight from each pen (24 males and 24 females per treatment) were sacrificed at day 42. Breast meat yield was determined.

All data from the six treatments was analysed by using ANOVA. Data for male and female birds was analysed separately according to the following model:

$$Y_{ijk} = \mu + Tr_i + Block_j + Tr*Block_{ij} + e_{ijk}$$

with Tr_i = effect of treatment (i = negative control, positive control, 0.04% GAA, 0.06% GAA, 0.08% GAA, 0.12% GAA), $Block_j$ = effect of body weight blocks which were built at allotment (j = 1,2,3,4), $Tr*Block_{ij}$ = interaction of Tr_i and $Block_j$ and e_{ijk} = residual error.

The LSD test was applied for comparison of means and $p < 0.05$ was considered significant.

Table 1 Composition and calculated nutrient concentrations (%) of the starter (0-21 days) and grower (22-42 days) diets.

Ingredients	Starter vegetable (negative control)	Starter MBM (positive control)	Grower vegetable (negative control)	Grower MBM (positive control)
Corn	33.6	38.5	38.7	41.2
Sorghum	20.0	20.0	20.0	20.0
Soybean meal	38.4	31.4	32.3	27.3
Meat and bone meal	-	6.0	-	6.0
Soybean oil	3.7	2.3	5.1	4.0
Dicalcium phosphate	1.8	-	1.7	-
Limestone	1.0	0.4	0.9	0.2
Salt	0.5	0.4	0.4	0.3
DL-Methionine	0.36	0.34	0.30	0.30
L-Lysine	0.16	0.23	0.21	0.23
L-Threonine	0.05	0.09	0.08	0.08
Vitamins and minerals	0.43	0.34	0.31	0.39
Calculated nutrients				
Crude protein	22.5	22.5	20.2	20.8
ME (MJ/kg)	12.6	12.6	13.2	13.2
Crude fiber	3.4	2.3	3.1	2.9
Crude fat	6.0	5.3	7.4	7.0
Met + Cys	1.03	1.03	0.92	0.92
Lysine	1.32	1.33	1.21	1.22
Threonine	0.92	0.92	0.84	0.85
Tryptophan	0.29	0.26	0.25	0.24
Arginine	1.49	1.49	1.31	1.36
Calcium	1.0	1.0	0.9	0.9
Available phosphorus	0.5	0.5	0.4	0.5

Results and discussion

Performance data is shown in Table 2. Weight gain and feed conversion of both male and female broilers were somewhat behind breeder's recommendation of 819 g / 1.29 kg/kg (male) and 778 g / 1.32 kg/kg (female; Aviagen, 2002). However, birds caught up and final performance at day 42 was close to or partly exceeded recommended performance (2634 g / 1.68 kg/kg – male; 2230 g / 1.77 kg/kg – female). Mortality was in reasonable range and not correlated to dietary treatments.

Table 2 Effects of increasing levels of supplemental GAA on weight gain, feed intake, feed conversion ratio and breast meat yield in 1-42 days old broilers in comparison to an unsupplemented vegetable treatment (negative control) and a treatment where 6% meat and bone meal was included in the diet.

Treatment	Starter phase 1-21 days			Overall 1-42 days			
	Weight gain g	Feed intake g	Feed per gain kg/kg	Weight gain g	Feed intake g	Feed per gain kg/kg	Breast fillet % of CW
MALE							
Neg. control	675 ^b	941 ^{bc}	1.395 ^a	2695 ^{bc}	4658 ^{ab}	1.728 ^a	26.1 ^{bc}
Pos. control	673 ^b	922 ^c	1.371 ^{ab}	2681 ^c	4546 ^{bc}	1.696 ^{ab}	26.0 ^c
0.04% GAA	691 ^{ab}	951 ^{abc}	1.376 ^{ab}	2758 ^{ab}	4572 ^{abc}	1.657 ^{bc}	26.8 ^{ab}
0.06% GAA	692 ^{ab}	957 ^{ab}	1.382 ^{ab}	2719 ^{abc}	4573 ^{abc}	1.682 ^{bc}	27.0 ^a
0.08% GAA	704 ^a	980 ^a	1.392 ^a	2770 ^a	4679 ^a	1.690 ^{abc}	26.8 ^{ab}
0.12% GAA	682 ^{ab}	924 ^c	1.356 ^b	2697 ^{bc}	4452 ^c	1.651 ^c	26.8 ^{ab}
FEMALE							
Neg. control	590 ^b	841 ^b	1.424 ^a	2171 ^d	3891	1.792 ^a	26.2 ^d
Pos. control	615 ^a	865 ^{ab}	1.409 ^{ab}	2215 ^c	3920	1.769 ^{abc}	26.7 ^{bcd}
0.04% GAA	624 ^a	868 ^{ab}	1.390 ^{ab}	2214 ^c	3924	1.772 ^{ab}	26.4 ^{cd}
0.06% GAA	625 ^a	877 ^{ab}	1.404 ^{ab}	2233 ^{bc}	3910	1.751 ^{bc}	26.8 ^{bc}
0.08% GAA	625 ^a	879 ^a	1.407 ^{ab}	2263 ^a	3938	1.741 ^c	27.2 ^b
0.12% GAA	637 ^a	871 ^{ab}	1.367 ^b	2254 ^{ab}	3936	1.747 ^{bc}	27.7 ^a

^(a-d)Means within a column sex with different superscripts differ significantly (P<0.05).

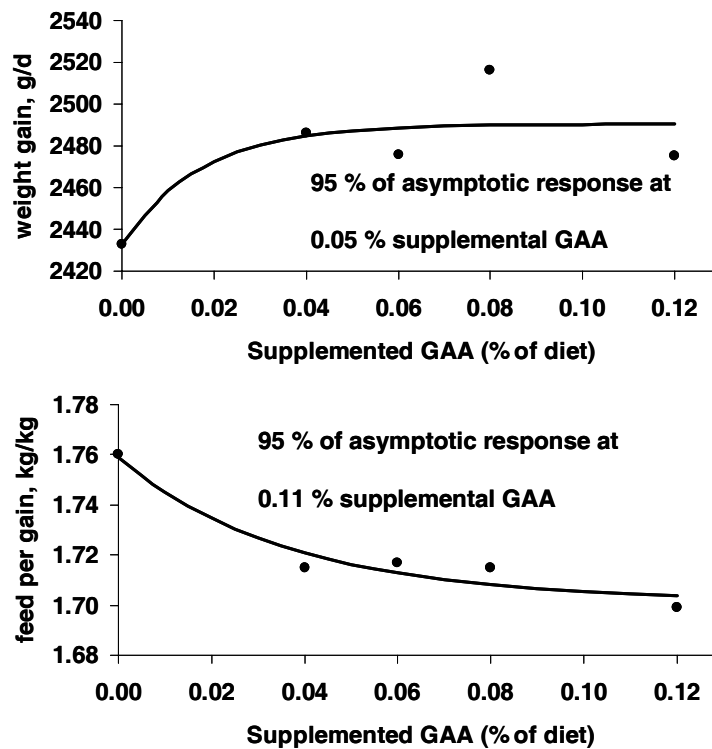


Figure 1 Weight gain (top) and feed conversion (bottom) of male and female broilers 1-42 days of age fed graded levels of supplemental GAA. Exponential regression of data revealed the following equations: gain = 2433.0 + 57.4 * (1-EXP(-58.44 GAA)), r²: 0.69 and feed conversion = 1.759 - 0.057 * (1 - EXP(-27.57 GAA)), r²: 0.94.

Although diets were formulated on identical energy, mineral and digestible amino acid levels, slight performance impairment due to the pure vegetable diet (negative control) compared to the positive control containing also meat and bone meal in the diet was expected. In this respect, female birds responded more clearly as weight gain of the positive control was significantly higher than that of the negative control both at 21 days and at 42 days. This was not reflected by feed conversion but

breast yield. In males, however, no differences between the positive and negative control treatments could be detected.

Supplementation of GAA resulted in improvements of some performance criteria when compared to the negative control. Although responses did not consistently show dose-related effects to increasing dietary GAA, optimal performance ranged between 0.06 % and 0.12 % supplemental GAA. Accordingly, maximum weight gain of male broilers was achieved at 0.08 % added GAA both in the starter phase and over the entire feeding period. Feed conversion minimised even at 0.12 % at both ages. The responses of female broilers were similar: Best performance after 21 days was achieved at 0.12 % dietary GAA while after 42 days performance was best at 0.08 % dietary GAA. Breast fillet yield maximised at 0.06 % and 0.12 % in male and female birds, respectively. So, particularly for female birds it can be stated that GAA has the potential to resolve the decrease in performance caused by a change from diets containing animal by-products to pure vegetable diets. This is in line with observations by Ringel et al. (2007) and might be due to improving the cell energy metabolism because supplemental GAA increased the muscle creatine content (Lemme et al., 2007, Ringel et al., 2007) and some metabolites related to the energy metabolism such as phospho-creatine and adenosine tri-phosphate (Lemme et al, 2007). Such changes might improve the utilisation of nutrients for muscle accretion and growth and thus feed utilisation.

Although arranged as a dose-response study, data of many response criteria were not suitable for regression analysis. One exception is breast fillet yield of females which linearly responded to the supplementation (Breast fillet yield = $26.1 + 13.3 \text{ GAA}$; $r^2 = 0.95$) suggesting an optimum dietary GAA level higher than 0.12 %. In contrast, males almost achieved maximum breast fillet yield with 0.04 % GAA and no further improvement was observed.

Pooling weight gain and feed conversion data of both sexes allowed for regression analysis. With respect to weight gain, optimum supplementation level for GAA would be 0.05 % for the entire feeding period, respectively, when taking 95 % of the asymptotic response as basis (Figure 1). For feed conversion ratio only the 42-day data were suitable for exponential regression analysis. The latter would even suggest an optimum supplementation level of 0.11 %. In other studies gain was maximised at 0.04 % (Lemme et al., 2007) and 0.09 % (Ringel et al., 2007) while feed conversion was minimised at 0.04 and 0.12 %, respectively. Averaging the optimal inclusion level for weight gain and feed conversion of this experiment with those of the mentioned studies would reveal an optimum supplementation level of about 0.07 % GAA.

From the responses observed in the experiment it is concluded that

- broiler performance generally can be improved by supplemental GAA
- a performance impairment due to a change from animal by-product supplemented diets to pure vegetable diets can be resolved by supplemental GAA. This was obvious particularly in female broilers.
- depending on performance parameters the optimum supplementation level of GAA ranges from 0.06 % to 0.12 % and taking results from other studies optimum supplementation level averaged to 0.07 % GAA.

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