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A B S T R A C T

Dimethylglycine (DMG) is a naturally occurring glycine derivative, which is useful as additive to broiler diets as it improves nutrient digestibility and reduces the development of broiler ascites syndrome. This study evaluated the efficacy of dietary DMG to enhance performance of broiler chickens. Three trials were conducted to evaluate the effect of dietary supplementation with 1 g Na DMG/kg on growth performance and carcass characteristics. In Trial 1, the effect of sex was also assessed in a 2 x 2 factorial arrangement of treatments. In Trials 1 (Germany), 2 (Austria), and 3 (Italy), each treatment consisted of 6, 12, and 11 replicate pens with 20, 15, and 16 one-day-old broiler chickens per pen, respectively. Dietary DMG supplementation resulted in improved feed conversion ratio (FCR) in the starter phase by 8.8 (P = 0.004), 6.4 (P = 0.001), and 4.8% (P = 0.006) compared with the control diet in Trials 1, 2, and 3, respectively. The overall FCR improved in broiler chickens fed the diets supplemented with DMG by 3.8 and 4.1% in Trials 1 (P = 0.007) and 3 (P = 0.006), respectively. In addition, final body weight increased by 5.5% (P = 0.001) in Trial 2 and production value improved by 6.8% (P = 0.015) in Trial 1 by dietary DMG supplementation. Mortality in all trials was similar between dietary treatments. In all 3 trials, cold carcass weight and total meat yield were as well similar between broiler chickens fed the control and DMG diets. In Trial 1, dietary DMG had no effect on breast meat yield in male broiler chickens, but it increased breast meat yield in female broiler chickens (diet x sex, P = 0.004). Organoleptic quality of roasted breast meat assessed only in Trial 2 was not affected by dietary treatments. In conclusion, dietary supplementation of DMG at 1 g Na DMG/kg can considerably improve ~~s~~ production performance in broiler chickens.

Keywords: Broiler; Dimethylglycine; Growth performance ; Feed efficiency

1. Introduction

Dimethylglycine (DMG) is a naturally occurring tertiary amino acid in the intermediary metabolism of betaine in living organisms. Dietary supplementation in broiler diets results in improved apparent faecal digestibility of the crude protein and carbohydrate fraction. This is hypothesized to result from an emulsifying effect of DMG in the intestinal tract, which allows non-fat nutrients to be more efficiently absorbed, rendering more nutrients available for utilization (Kalmar et al., 2010; Prola et al., 2013). Dietary DMG has also been shown to improve carcass characteristics by decreasing fat deposition and increasing meat yield. These changes are linear in the range between 0 and 1 g Na DMG/kg feed and are more pronounced with increased level of dietary polyunsaturated fatty acids (Kalmar et al., 2011). Kalmar et al. (2011) suggested enhanced utilisation of dietary fat as an energy source as a possible underlying basis. Namely, dietary fat is utilised as a source of energy, instead of being deposited as body fat. Consequently, less protein is used to provide energy, which promotes lean growth. Therefore, dietary DMG not only reduces feed costs, but also has potential environmental benefits because of improved protein utilization, which has been demonstrated by reduced N excretion into urine (Kalmar et al., 2010). Possibly, DMG also influences hepatic gene expression by affecting DNA methylation, as has been demonstrated for other methylamine derivates (Emmert et al., 1996; Niculescu et al., 2006). Effects of dietary DMG on hepatic gene expression are currently under investigation (T. Erkens et al., unpublished data).

The aim of this study was to assess the efficacy of dietary supplementation with DMG at a level of 1 g Na DMG/kg to improve broiler performance. Three broiler trials were conducted at different European locations, at which distinct broiler strains and basal diets were used.

2. Materials and methods

2.1. Experimental design and treatments

Three broiler trials were conducted at different European locations. Trial 1 was conducted at the Free University of Berlin (Berlin, Germany). Trial 2 was conducted at the poultry trial station in Äussere Wimitz (Kraig, Austria). Trial 3 was conducted at the certified (ISO 9001) poultry farm, "Luca Fornello" in Settimo (Torinese, Italy). In each trial, 1-d-old broiler chickens were randomly allocated to pens and fed control, basal diets or basal diets supplemented with 1 g Na DMG/kg. In all trials, feed was offered *ad libitum*.

2.1. Animals and management

Housing conditions were in all trials in compliance with the minimal space restrictions according to the revised European Treaties series No. 123 (ETS 123). Ingredient, and energy and nutrient composition of basal diets are presented in Tables 1 and 2, respectively.

2.1.1. Trial 1

A total of 480 one-day old broiler chickens (Cobb Germany Avimex GmbH, Regenstauf, Germany) were randomly assigned to 12 pens with 20 females and 12 pens with 20 males, and reared until 39 d of age. Pens were randomly assigned within sex to 2 dietary treatments with 6 replicate male pens and 6 replicate female pens per treatment. A 3-phase feeding program was used with a starter diet from d 1 until d 14, a grower diet from d 15 until d 28, and a finisher diet from d 29 until d 39. Each floor pen was 2.2 x 1.8 m (length x width) and had softwood shaving litter as bedding. Lighting schedule was 24 h light during the first 3 d, followed by 23 h light:1 h darkness until d 7, and then 18 h light:6 h darkness until slaughter. Ambient temperature was kept at 28°C during the first 2 wk, and after d 15, it was reduced by 0.5°C per day until 22°C was reached. Additionally, the temperature at the surface of the bedding was monitored and maintained at about 34°C by infra-red heaters until d 21. Relative humidity was 60.0 ± 3.5%. All birds were vaccinated against coccidiosis (Paracox; Essex Pharma GmbH, Munich, Germany) at 9 d of age by individual oral application at the dose level of 0.1 mL/broiler chicken.

2.1.2. Trial 2

A total of 360 one-day old Ross 308 broiler chickens were randomly allocated in 24 pens of 15 unsexed chickens and reared until 36 d of age. A three-phase feeding program was used with a starter diet from d 1 until d 14, a grower diet from d 15 until d 28, and a finisher diet from d 29 until d 36. Each floor pen was 2.0 x 1.5 m (length x width), and had wood shavings as litter. Lighting schedule was 24 h light during the first 3 d, followed by 22 h light:2 h darkness until slaughter. Ambient temperature was initially kept at 28°C and gradually reduced to 20°C.

2.1.3. Trial 3

A total of 352 one-day old Ross 508 broiler chickens were randomly allocated in 22 pens of 16 birds of both sexes (8 males and 8 females) per pen, and reared for 35 d. A 2-phase feeding program was used with a starter/grower diet from d 1 until d 21 and a finisher diet from d 22 until d 35. Each pen was 1.5 x 1.0 m (length x width), and had rice hulls as litter. Lighting schedule was 23 h light:1 h darkness until d 7 and 18 h light:6 h darkness until slaughter. Infrared lamps were used for heating during the first 3 wk. Minimum and maximum temperatures were 21.9 and 30.4°C in the starter-grower period and 22.4 and 26.3°C in the finisher period. At hatching, chicks were vaccinated against coccidiosis, Newcastle disease, and infectious bronchitis (Izovac I.B. H120; Izo S.p.A., Brescia, Italy). The vaccine against coccidiosis was administered in the drinking water, while those for Newcastle disease and infectious bronchitis were administered by inhalation.

2.2. Assessed variables

Body weight (BW) and feed remainders were recorded at the beginning and end of all feeding phases. Mortality was recorded daily. Average daily gain (ADG), average daily feed intake (ADFI), and feed conversion ratio (FCR) were calculated for each feeding phase.

Production value (PV) were calculated as follows: PV = [100 - mortality (%) x BW (g)]/[rearing period (d) x FCR x 10].

At slaughter age, 1 broiler chicken per pen in Trial 1 and 1 female and 1 male broiler chickens per pen in Trials 2 and Trial 3 were randomly chosen and humanely euthanised after an 8-h fasting period. In Trial 1 and 2, broiler chickens were euthanised by concussion followed by exsanguination. In Trial 3, broiler chickens were euthanised by individual CO_2 gassing followed by exsanguination. In all trials, live weight with empty crop was determined immediately prior to euthanasia. Then, broiler chickens were mechanically plucked after immersion in hot water, manually eviscerated, and weight of abdominal depot fat measured. The remaining carcass was chilled for 24 h at 3°C. Head, neck, and feet at hock joint were removed from chilled carcasses to determine cold carcass weight. Breast meat, legs, and wings were manually dissected to assess meat yield.

In Trial 2, organoleptic quality of breast meat was determined using 12 males (1/pen from 12 pens) and 12 females (1/pen from 12 pens) per treatment. Pieces of breast meat (3 x 3 x 1 cm) were roasted on both sides for 6 min at 180°C and then graded by a taste panel consisting of 4 independent, trained individuals. The meat was subjectively graded for tenderness, juiciness, and taste using scores ranging from 1 to 6.

2.3 Statistical analyses

Data on growth performance were statistically analysed with data per pen as the experimental unit, whereas euthanized birds were used as the experimental unit for carcass characteristics. Normality and homogeneity were tested with the Kolmogorov-Smirnov and modified Levine test, respectively. All traits, except mortality, were analysed using one-way ANOVA. Growth performance data in Trial 1 were analysed with diet, sex, and interactions as independent variables, whereas in Trials 2 and 3, diet was used as an independent variable. Carcass characteristics in all trials were analysed with diet, sex, and interactions as independent variables. Results of the organoleptic test were subject to the general linear model repeated measures analysis of variance with an individual taste panellist as within-subject variable and diet as between-subject variable. Mortality was not normally distributed, hence these data were analysed with the non-parametrical two-way Wilcoxon test with diet as grouping variable. Average values are expressed as means ± standard error of the means (SEM). All statistics were done in S-plus 8.0 (TIBCO Software Inc., Palo Alto, CA) and SPSS 16.0 (SPSS Inc., Chicago, IL).

3. Results

Dietary supplementation with DMG improved FCR during the starter phase in all trials (Tables 3 and 4). Compared to the control, FCR during the starter phase was reduced by 8.8 (5.7% for females and 11.8% for males; $P = 0.004$), 6.4% ($P = 0.001$), and 4.8% ($P = 0.006$) in Trial 1, 2, and 3, respectively. In Trial 3, FCR during the finisher phase was 3.6% lower in DMG supplemented broilers ($P = 0.036$). The overall FCR was improved by 3.8% in Trial 1 (4.0% for females and 3.6% for males; $P = 0.007$) and 4.1% in Trial 3 ($P = 0.006$). Production value in Trial 1 was 25 units or 6.8% greater in broiler chickens supplemented with DMG (25 units or 6.7% for females and 26 units or 6.9% for males; $P = 0.015$). There was no diet x sex interaction on growth performance in Trial 1. In Trial 2, dietary DMG resulted in an increase in both ADFI (3.9%, $P = 0.002$) and ADG (7.0%, $P = 0.001$), and final BW increased by 5.5% ($P = 0.001$). In Trial 3, dietary DMG reduced ADFI by 3.7% ($P = 0.027$), but ADG and final BW were similar compared to the control.

In Trial 1, dietary DMG had no effect on breast meat yield in male broiler chickens, but it increased breast meat yield in female broiler chickens (diet x sex, $P = 0.004$; Table 3). There was no effect of dietary DMG on carcass characteristics in Trial 2 (Table 4) . In Trial 3, abdominal depot fat was 0.3% lower ($P = 0.002$) in broiler chickens fed the DMG diets than those fed the control diets. This small decrease in fat deposition resulted in a 24.7% greater meat yield to abdominal fat ratio (P = 0.013). Tenderness, juiciness, and taste of roasted breast meat assessed in Trial 2 were comparable between treatment groups (Table 5).

4. Discussion

Feed conversion ratio in the control groups varied among trial sites, i.e., outstanding in Trial 1 (FCR = 1.55 for males and 1.52 for females), satisfactory in Trial 3 (FCR = 1.70), and rather inefficient in Trial 2 (FCR = 1.81). Still, FCR was improved by DMG in Trial 1 and Trial 3. In Trial 2, FCR was only improved during the starter phase. These data indicate a beneficial effect of dietary DMG on FCR over a wide range of broiler chickens, with growth performance being influenced by broiler strains, basal diets, and rearing conditions. Overall, the effect of dietary DMG on FCR was greatest and most consistently present during the starter phase. The underlying mechanism of improved feed efficiency is likely to be, at least partly, the result of improved digestibility of protein and N-free extract because of the emulsifying action of DMG at the intestinal tract (Kalmar et al., 2010; Prola et al., 2013). The indirect effect of increased fat emulsification on improved digestibility of non-fat fractions can be explained by enhanced accessibility for digestive enzymes (Kalmar et al., 2011). Apart from yolk utilization, for which the importance of pancreatic and biliary secretions seems to be negligible, the digestive capacity of fat in broilers increases with age (Freeman, 1976; Krogdahl, 1985). In particular, digestion of vegetable oils, which were the sole or main fat source in current trials, is underdeveloped in broiler chicks until the first 2 wk of age (Freeman, 1976). Therefore, an emulsifying agent is indeed expected to be most efficient in improving digestibility in the broiler chicken during the starter phase. Furthermore, DMG also acts as a glycine precursor (Craig, 2004), and, consequently, leads to the improvement of protein biosynthesis in chicks, where this amino acid is essential (Klasing, 2000). The fact that highest effects of DMG on FCR are consistently noticed in the starter period is thus not surprising.

Although sample size was rather limited, an important increase in the ratio between meat yield and abdominal fat was observed in Trial 3. This implies enhanced lean growth in broiler chickens fed the diets supplemented with DMG. Fat accretion has a greater energetic cost per mass unit compared to lean accretion (protein plus water). Thus, an increase in meat to fat ratio also contributes to a more efficient feed conversion. These results are in agreement with previous data, in which a linear inverse relation was observed between abdominal fat pad and dietary DMG supplementation with a range of 0 to 1 g Na DMG/kg feed (Kalmar et al., 2011). A plausible cause of lower fat deposition relative to lean growth in DMG supplemented broilers can be an increase in protein supply as a result of its increased digestibility. This agrees with results of, for instance, Namroud et al. (2008). Those authors showed a decrease in abdominal fat deposition and a concomitant lower FCR in broiler chickens when increasing dietary protein content from 17 to 21%. This is within the range of protein content of current finisher diets. Abdominal depot fat in the control groups of current investigation was also inversely related to protein content of finisher diets. In contrast to Namroud et al. (2008), in which the degree of improvement in FCR was greatest when increasing dietary protein content from 17 to 19% compared to an increase from 19 to 21%, the lowest improvement in FCR on account of DMG was observed at lowest dietary protein content of finisher diet in the current trials. Hence, additional factors are likely to be involved in the working mechanism of DMG.

5. Conclusion

Three feeding trials were conducted at different locations. Although FCR varied widely among trial sites, supplementation with DMG at a dose of 1 g Na DMG/kg resulted in an improvement of feed efficiency during, at least, the starter phase in all trials. Although effects on FCR were most consistently observed and most pronounced during the starter phase, FCR was in 2 of the 3 trials improved over the whole rearing period. In addition, finishing BW and PV were increased in 1 of the 3 trials. Organoleptic quality of roasted breast meat was similar between control and DMG groups. On the whole, this investigation demonstrated beneficial effects of supplementary DMG over a wide range of broiler strains, basal diets, and rearing conditions. A previous tolerance and safety study demonstrated that DMG does not accumulate in edible parts of broiler chickens when supplemented at a dosage of 1 g Na DMG/kg and, therefore, does not pose a consumer risk of involuntary intake of DMG intended as a broiler feed additive (Kalmar et al., 2012).

Conflict of interest statement

We declare that there is no conflict of interest in the publication of this paper.

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Table 1

Ingredient composition of basal diets (%) [1].

Ingredient	Trial 1 (Germany)			Trial 2 (Austria)			Trial 3 (Italy)	
	Starter	Grower	Finisher	Starter	Grower	Finisher	Starter/grower	Finisher
Corn	56.49	59.26	62.21	47.24	48.03	54.29	25.20	25.20
Corn gluten meal	-	-	-	0.00	0.00	2.00	-	-
Wheat	-	-	-	10.00	10.00	10.00	27.38	30.80
Wheat DDGS [2]	-	-	-	5.00	5.00	5.00	-	-
Soybean meal	33.80	29.80	26.10	29.13	26.51	18.09	27.50	20.40
Soybean extruded (whole)	-	-	-	-	-	-	10.00	12.50
Grass meal	-	-	-	1.00	2.00	3.00	-	-
Soy oil	3.70	5.00	5.70	-	-	-	5.60	6.80
Sunflower oil	1.50	1.50	1.50	-	-	-	-	-
Feed fat [3]	-	-	-	3.98	4.81	4.30	-	-
Calcium carbonate/limestone	1.48	1.48	1.46	1.257	1.224	1.231	1.15	1.12
$Ca(H_2PO_4)_2$	1.42	1.34	1.32	1.186	1.246	1.078	1.30	1.24
Sodium bicarbonate	-	-	-	-	-	-	0.13	0.15
Sodium chloride	-	-	-	-	-	-	0.23	0.22
Vitamin-trace mineral premix [4]	1.20	1.20	1.20	0.085	0.085	0.085	0.50	0.50
DL-Met	0.26	0.26	0.28	0.236	0.207	0.133	0.39	0.38
L-Lys.HCl	0.13	0.12	0.18	0.404	0.406	0.423	0.20	0.20
L-Thr	0.02	0.02	0.04	0.118	0.114	0.113	0.08	0.11
L-Trp	0.00	0.02	0.01	-	-	-	-	-
Choline chloride	-	-	-	0.08	0.08	0.04	0.05	0.04
Coccidiostat [5]	-	-	-	0.050	0.050	0.000	-	-
6-phytase [6]	-	-	-	0.010	0.010	0.010	-	-
3-phytase [7]	-	-	-	-	-	-	0.10	0.10
Antioxidant [8]	-	-	-	0.010	0.010	0.010	-	-
1,4 beta-xylanase [9]	-	-	-	-	-	-	0.20	0.20

[1] Basal diets were divided into 2 batches, and 0 or 1 g dimethylglycine sodium salt was added per kg diet.

[2] DDGS = dried distiller's grains and solubles (Actiprot, Wien, Austria).

[3] Mixture of 50% animal fat and 50% vegetable oil.

[4] Provided vitamins and trace minerals per kilogram of diet. Trial 1 (Germany): 4,800 IU vitamin A; 480 IU vitamin D_3; 50.4 mg vitamin E; 2.4 mg vitamin K_3; 2.4 mg vitamin B_1; 3.0 mg vitamin B_2; 42 mg niacin; 4.8 mg vitamin B_6; 0.04 mg vitamin B_{12}; 240 mg biotin; 18 mg calcium pantothenate acid; 1.2 mg folic acid; 60 mg Zn; 90 mg Fe; 60 mg Mn; 14.4 mg Cu; 0.60 mg I ; 0.48 mg Co; 0.42 mg Se; 1.6 g Na; 2.0 g Mg; and 1,300, 1,000, or 700 mg (starter, grower, or finisher, respectively) choline. Trial 2 (Austria): 34,000 IU vitamin A; 14,000 IU vitamin D; 0.14 mg vitamin E; 11.48 µg vitamin K; 8.50 µg vitamin B_1; 21.25 µg vitamin B_6; 63.75 µg vitamin B_{12}; 195.50 mg niacin; 55.25 mg pantothenic acid; 5.53 µg folic acid; 0.34 µg biotin; 102 mg Fe; 102 mg Zn; 153 mg Mn; 25.5 mg Cu; 1.7 mg I; 1.7 mg Co; and 0.68 mg Se. Trial 3 (Italy; starter and grower): 17,500 IU vitamin A; 30 mg vitamin E; 5 mg vitamin K_3; 3 mg vitamin B_1; 6 mg vitamin B_2; 2.5 mg vitamin B_6; 30 µg vitamin B_{12}; 200 µg biotin; 20 mg Ca panthothenic acid; 750 µg folic acid; 75 mg vitamin C; 40 mg niacin; 75 mg Zn, 79 mg Fe; 71.15 mg Mn; 27.5 mg Cu; 925 µg I; 350 µg Co; 270 µg Se; 200 µg Mo; 125 mg DL-Met; and 125 mg BHT. Trial 3 (Italy; finisher): 12,500 IU vitamin A; 5,000 IU vitamin D_3; 50 mg vitamin E; 3.5 mg vitamin K_3; 2 mg vitamin B_1; 4 mg vitamin B_2; 2 mg vitamin B_6; 20 µg vitamin B_{12}; 150 µg biotin; 14 mg Ca panthothenate acid; 500 µg folic acid; 75 mg vitamin C; 28 mg niacin; 52.5 mg Zn, 54.6 mg Fe; 49.75 mg Mn; 17.75 mg Cu; 685 µg I; 250 µg Co; 350 µg Se; 150 µg Mo; 125 mg DL-Met; and 125 mg BHT.

[5] Monensin sodium 20% (Elancoban; Elanco Animal Health, Wien, Austria).

[6] Natuphos G500 (BASF, Limburgerhof, Germany).

[7] Phytase/ZY (DSM, Basel, Switzerland).

[8] Endox (Kemin Industries Inc., Des Moines, US).

[9] Belfeed B1100MP (Beldem SA, Andenne , Belgium).

Table 2
Nutrient composition (g/kg) and metabolizable energy content (MJ/kg) of basal diets (as-fed) [1].

Item	Trial 1 (Germany) [2]			Trial 2 (Austria) [3]			Trial 3 (Italy) [4]	
	Starter	Grower	Finisher	Starter	Grower	Finisher	Starter/grower	Finisher
DM	912	915	924	889	886	884	902	906
NfE	485	500	520	512	531	542	508	479
CP	222	209	187	211	189	178	205	201
EE	117	118	129	74	82	76	96	111
CA	57	57	55	56	56	51	56	76
CF	31	31	33	37	38	38	37	39
ME_n	12.6	13.1	13.3	13.0	13.0	12.9	13.4	13.8

[1] DM: dry matter, NfE: N-free extract, CP: crude protein, EE: ether extract, CA: crude ash, CF: crude fibre, and ME_n: metabolisable energy corrected at zero N-balance. Basal diets were divided into 2 batches, and 0 or 1 g dimethylglycine sodium salt was added per kg diet.

[2] Standard methods of VDLUFA (1988); carried out by the Institut für Tierernärhung (Free University of Berlin, Berlin, Germany).

[3] Standard methods of the AOAC (1980); carried out by the Futtermittel-Labor Rosenau (Wieselburg, Austria).

[4] Standard methods of the AOAC (2000); carried out by the Dipartimento di Scienze Veterinarie (University of Torino, Torino, Italy).

Table 3

Effect of dimethylglycine (DMG) as a feed additive on growth performance and carcass characteristics of broiler chickens (Trial 1) [1].

Item	Male (n = 6)		Female (n = 6)		SEM	*P*-value		
	Control	DMG	Control	DMG		Diet	Sex	Diet x sex
BW (g)								
Initial	45.0	45.0	42.2	42.2	0.3	0.986	0.001	0.991
Final	2,287	2,335	2,143	2,210	23	0.130	0.001	0.787
Growth performance								
ADG (g/d)	58	59	54	56	0.6	0.130	0.002	0.787
ADFI (g/d)	89	88	82	81	0.9	0.435	0.001	0.834
FCR (g/g)								
Starter	1.42	1.25	1.40	1.32	0.01	0.004	0.562	0.265
Grower	1.45	1.44	1.50	1.48	0.01	0.479	0.037	0.813
Finisher	1.67	1.62	1.59	1.50	0.02	0.065	0.012	0.683
Overall	1.55	1.49	1.52	1.46	0.01	0.007	0.209	0.881
Mortality (%)	1.7	0.8	0.0	0.8	0.4	1.000	0.304	-
PV	373	399	360	385	5	0.015	0.166	0.934
Carcass characteristics								
CW (% BW)	80.6	81.1	81.1	81.0	0.3	0.733	0.761	0.627
Meat parts (% CW)	62.6	63.6	59.3	60.3	0.8	0.574	0.059	0.988
Breast (% CW)	24.1	23.8	21.5	23.3	0.3	0.030	0.001	0.004
Legs (% CW)	27.8	30.0	27.9	27.0	0.5	0.569	0.174	0.148
Wings (% CW)	10.7	9.8	9.9	10.0	0.2	0.400	0.597	0.289
Depot fat (% CW)	2.1	1.8	1.8	1.8	0.1	0.482	0.280	0.518
Meat/fat	24.4	31.0	28.7	28.7	1.5	0.277	0.733	0.282

[1] SEM: standard error of the mean; ADG: average daily gain; ADFI: average daily feed intake; BW: bodyweight; FCR: feed conversion ratio; PV: production value; and CW: cold carcass weight. Final BW at 39 d of age.

Table 4

Growth performance and carcass characteristics of broiler chickens fed a control diet or the same diet supplemented with DMG at 1 g Na-DMG/kg feed in Trials 2 and 3 [1].

Item	Trial 2 (n = 12)				Trial 3 (n = 11)			
	Control	DMG	SEM	*P*-value	Control	Diet	SEM	*P*-value
BW (g)								
Initial BW	42	42	0	0.979	40	40	0	0.116
Final BW	2,105	2,221	17	0.001	1,736	1,750	11	0.509
Growth performance								
ADG (g/d)	57	61	0.5	0.001	48	49	0.3	0.523
ADFI (g/d)	103	107	0.7	0.002	82	79	0.6	0.027
FCR (g/g)								
Starter	1.41	1.32	0.01	0.001	1.25	1.19	0.01	0.006
Grower	1.61	1.60	0.01	0.445	1.63	1.61	0.01	0.178
Finisher	2.30	2.30	0.02	0.396	2.20	2.12	0.03	0.036
Overall	1.81	1.78	0.01	0.211	1.70	1.63	0.01	0.006
Mortality (%)	1.7	3.3	0.9	0.355	1.1	1.70	0.6	0.631
PV	318	337	4	0.058	291	304	4	0.165
Carcass characteristics								
CW (% BW)	69.3	69.9	0.2	0.177	74.6	74.4	0.4	0.757
Meat parts (% CW)	69.2	69.1	0.3	0.824	60.7	61.3	0.2	0.068
Breast (% CW)	29.1	29.6	0.3	0.407	23.6	24.1	0.1	0.057
Legs (% CW)	28.8	28.4	0.2	0.385	27.4	27.6	0.2	0.489
Wings (% CW)	11.3	11.1	0.1	0.309	9.8	9.7	0.1	0.457
Depot fat (% BW)	2.0	2.1	0.1	0.637	1.6	1.3	0.1	0.002
Meat/fat	24.9	24.5	0.7	0.757	30.0	37.4	1.5	0.013

[1] DMG: dimethylglycine; SEM: standard error of the mean; ADG: average daily gain; ADFI: average daily feed intake; BW: bodyweight; FCR: feed conversion ratio; PV: production value; and CW: cold carcass weight. Final BW at 36 d of age in Trial 2 and 35 d of age in Trial 3.

Table 5

Organoleptic quality of roasted breast meat in chickens fed a control diet or the same diet supplemented with dimethylglycine (DMG) at 1 g Na DMG/kg feed (Trial 2; n = 24) [1].

Item	Control	DMG	SEM	*P*-value		
				Diet	Taster	Diet x taster
Tenderness	4.95	4.85	0.07	0.546	<0.001	0.748
Juiciness	4.56	4.38	0.07	0.277	0.032	0.703
Taste	4.69	4.53	0.07	0.387	0.031	0.756

[1] Based on scores between 1 to 6 (≤ 3: below average, and ≥ 4: above average).