The effect of different levels of choline and betaine on broiler performance and carcass characteristics

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An *in vivo* experiment was conducted to determine the effect of dietary betaine supplementation (Betafine) as a replacement for choline on broiler performance and carcass characteristics. The four betaine levels at 0, 33, 66 and 100% in replacement for choline were added to two various basal diets (without or containing 2.5% oil) in a 2×4 factorial arrangement with four replicates of 10 birds. Three hundred-twenty day-old broiler chicks were fed with the experimental diets from 0 to 49 days of age. At 49 days of age, one bird per replicate was selected randomly for blood sampling and comparison of carcass characteristics. Betaine replacement for choline had mainly no effect on FI, BW gain and feed conversion ratio (FCR), but the significant differences (P < 0.05) in BW gain (at 0-3 and 3-6 weeks of age) and FCR (at 0-3 weeks of age) were observed among the experimental diets Replacing choline with betaine increased breast and reduced abdominal fat percentages (P < 0.05), but had no significant effect on thigh, liver, and liver fat percentages and blood lipoproteins level. The present findings indicated that although dietary addition of betaine instead of choline did not significantly improve the performance parameters, but resulted to favourable changes in abdominal fat and breast meat percentages.

Keywords: broiler; betaine; choline; performance; carcass characteristic

Introduction

Betaine, the common term for trimethylglycine, is a naturally occurring amino acid derivative found in a variety of feedstuffs of plant and animal origin. Betaine has two primary metabolic roles: it is a methyl group donor and it is an osmolyte that assists in cellular water homeostasis (Petronine et al., 1992). Betaine, choline and methionine can serve as sources of methyl (-CH3) groups. It is well understood that choline may act as a methyl group donor but, in order to function as a methyl group donor, it needs to be converted to betaine in the mitochondria (Molitoris and Baker, 1976). Many studies have examined the interrelationship between choline and methionine, and between betaine and methionine to determine if these compounds can spare the needs of the chick for methionine with considerable variation in results. While some studies (Virtanen and Rossi, 1995) suggest that the response to betaine was greater than that obtained from the addition of methionine, other have failed to demonstrate that the methionine content of the diet could be reduced by supplementation with betaine (Rostango and Pack, 1996; McDevitt et al., 2000). However, several studies suggest that addition of betaine may improve breast meat yield (Schutte et al., 1997; McDevitt et al., 2000). Betaine is indirectly involved in the synthesis of carnitine, which is required for transporting long chain fatty acids across the inner mitochondrial membrane for oxidation (McDevitt et al., 2000) and therefore may result in a leaner carcass. Therefore, the objective of this study was to examine the choline sparing effect of betaine, and to evaluate the effect of betaine in enhancement of breast meat yield in male broiler chicks.

Materials and methods

A commercial basal diet was formulated to meet the nutritional requirements of the birds (NRC, 1994). Three hundred-twenty day-old Ross broiler chickens were randomly assigned to cages in a 2×4 factorial arrangement with four replicates and ten birds per each. The dietary treatments consisted of two various basal diets (containing 0 or 2.5%) and four betaine replacements (0%, 33%, 66% and 100% in replacement for supplemental choline; mg/mg), were fed to chicks from 0 to 49 days of age. The experimental diets were formulated to meet chick requirements in starter (first 3 weeks), grower (second 3 weeks) and finisher (last week) stages. Feed and water were provided ad libitum and chicks had access to 24 hour light during the experiment. From 1 to 49 days of age, feed consumption and body weight were recorded weekly. On day 49, one bird from each replicate (close to mean body weight of each replicate) was selected randomly for blood parameter measurements and comparison of carcass characteristics. The thigh, breast, liver and abdominal fat percentages, liver fat and blood lipoproteins were measured. Data were analyzed according to General Linear Model (GLM) procedures of SAS (SAS Institute, 2002) as a factorial experiment. The data in percentage were first transformed to its Arc sin % and then analyzed. The Duncan's multiple range tests was used to compare treatment means at the $P < 0.05$ significant level.

Results and discussion

The effects of the experimental diets on feed consumption, body weight gain and feed conversion ratio are shown in *Tables 1*. Feed consumption within given periods were not affected by treatments. Body weight gain was reduced significantly at 0 to 3 and 3 to 6 weeks of age in Treatment 1 (without oil & 0% replacement) and Treatment 4 (without oil & 100% replacement). Since the demand of broiler chicks for betaine is increased by growth rate as well as stress, and because the chicks are under the stress conditions during the first weeks of age; so it is obvious that the betaine needs of chicks is high during this period. At growth phase, the choline requirements of broiler chicks are stated as two forms: essential needs and replaceable needs. The needs for choline not only did not decrease by age, but followed the increasing pattern. Because all cells and body components enlarge with age and choline is present in the all membrane structures, so it is clear that the choline requirements are high during the growth stage. This explanation may be the reason of the decline in body weight gain in betaine-supplemented groups compared with non-supplemented group.

Table 1 Effect of different levels of choline replaced with betaine on body weight gain (g/bird), feed intake (g/bird) and feed conversion ratio (g/g) from 0 to 49 days of age

Basal diet types	diets without oil				diets with 2.5% oil				SE
Replacement level (%)	0	33	66	100	0	33	66	100	
BWG[1] (0-21 d)	457.3^{b}	477.8^{a}	477.0^{a}	471.8^{a}	472.8^{a}	479.8^{a}	491.1^{a}	492.3^{a}	17.10
BWG (21-42 d)	1482.5^{b}	1572.0^{a}	1579.8^{a}	1550.0^{b}	1581.3^{a}	1609.3^{a}	1607.0^{a}	1538.3^{b}	22.42
BWG (42-49 d)	372.8	347.3	367.8	366.5	378.5	350.3	352.5	394.8	16.09
BWG (0-49 d)	2312.5	2426.0	2423.0	2343.3	2432.5	2439.3	2451.0	2405.0	30.81
FI[2] (0-21 d)	828.3	824.3	824.3	820.0	880.3	874.3	871.0	879.0	18.51
FI (21-42 d)	3115.0	3178.3	3120.5	3180.0	3176.0	3195.0	3111.0	3137.3	59.11
FI (42-49 d)	1195.0	1160.3	1191.0	1198.3	1267.0	1252.0	1264.0	1270.0	43.73
FI (0-49 d)	5133.5	5162.8	5135.8	5198.3	5332.3	5321.3	5246.0	5286.3	43.74
FCR[3] (0-21 d)	1.78^{a}	1.73^{b}	1.74^{b}	1.76^{b}	1.83^{a}	1.80^{a}	1.80^{a}	1.76^{b}	0.038
FCR (21-42 d)	2.05	1.93	1.92	1.94	2.01	1.93	1.93	2.03	0.317
FCR (42-49 d)	3.27	3.31	3.22	3.32	3.26	3.29	3.29	3.23	0.047
FCR (0-49 d)	2.35	2.32	2.28	2.32	2.39	2.31	2.31	2.30	0.037

[1]BWG: Body Weight Gain; [2]FI: Feed Intake; [3]FCR: Feed Conversion Ratio
[ab]Means with common superscripts do not differ significantly ($P < 0.05$).

There was significant effect of betaine replacement on feed to gain ratio at 0 to 3 weeks of age. As noted, the use of 66% betaine as a replacement for choline in broiler diets had beneficial effects on this parameter during the first stage of growth (starter phase), but the diets should be supplied with unreplaced amounts of choline to meet the needs of choline for particular and essential functions.

Carcass components were not affected, except of breast and abdominal fat percentages, by betaine replacement (*Table 2*). The breast meat percentage showed a significant increase ($P<0.05$) with increasing the amount of betaine within the Treatment 8 (with 2.5% oil & 100% replacement). Also the abdominal fat percentage showed a significant reduction ($P<0.05$) within the Treatment 3. These results are in agreement with Rostango and Pack (1996), and Waldroup and Fritts (2005), who also showed that feeding the diets containing different levels of betaine increase breast percentage. Otherwise, researchers have reported the reduction in abdominal fat as the result of betaine supplementation to diets because of the betaine effects on lipid metabolism in organism. The results of the present study confirm the results of Wang et al. (2004) who reported similar results in respect to betaine role in lipid metabolism. It is appears the betaine play this role via carnitine synthesis.

Table 2 Effect of different levels of choline replaced with betaine on carcass characteristics (%) and some blood parameters (mg/dl) at 49 days of age (%)

Basal diet types	diets without oil				diets with 2.5% oil				SE
Replacement level (%)	0	33	66	100	0	33	66	100	
Abdominal fat	2.33[a]	2.33[a]	1.89[b]	2.22[a]	2.27[a]	2.20[a]	2.16[a]	2.29[a]	0.253
Thigh	19.90	19.59	19.39	20.28	19.60	20.10	19.28	19.35	0.569
Breast	18.55[a]	18.71[a]	19.05[a]	19.20[a]	19.02[a]	19.04[a]	19.08[a]	20.27[b]	0.708
Liver	2.35	2.32	2.36	2.28	2.23	2.22	2.19	2.21	0.121
Liver fat	13.87	14.05	14.13	13.90	14.52	14.52	14.39	14.61	3.224
Cholesterol	137.75	144.00	141.00	138.50	135.25	133.50	130.75	138.25	7.97
Triglycerides	48.50	48.25	54.50	50.25	52.25	51.50	49.50	46.25	8.33
LDL	95.05	102.55	100.15	97.25	93.75	96.30	91.45	97.85	6.02
VLDL	9.73	9.70	10.85	10.65	10.35	10.44	9.62	9.79	1.64
HDL	28.00	33.75	34.25	30.20	31.50	28.50	29.00	32.75	2.20

[ab]Means with common superscripts do not differ significantly ($P < 0.05$).

Blood lipoproteins were not affected by dietary treatments (*Table 2*). There is a noticeable variation in the published literature regarding to the efficacy of betaine and choline for methylation. It is reported that the betaine methylates homocysteine to methionine roughly three times more efficient than choline (Saunderson and Mackinlay, 1990). Conversely, other experiments showed that betaine, choline and methionine appear to be equivalent as sources of methyl group (Rostango and Pack, 1996). Garcia Neto and his co-workers (2000) using a chick growth model concluded that the sparing of methionine by methylation of homocysteine to methionine is increased by adding choline or betaine to chick diets.

In conclusion, the results of this study indicate little or no positive benefit in terms of body weight gain and feed conversion ratios from the addition of betaine to the corn-soybean meal based diets of broiler chicks. Betaine supplementation improved body weight gain and feed conversion ratio at 0 to 21 and 22 to 42 days of age but not at 42 to 49 days of age. Therefore, for use of these supplements in broiler diets, the bird age should be considered, thus birds marketed at younger ages might be more responsive to these nutrients. Further studies are needed to evaluate potential effect of age on response to choline and betaine supplementation.

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