THE EFFECT OF DL-METHIONINE AND BETAINE SUPPLEMENTATION ON GROWTH PERFORMANCE AND CARCASS COMPOSITION IN MALE BROILERS

R.M. MCDEVITT¹, S. MACK² and I.R. WALLIS³

Summary

We measured growth performance and carcass characteristics of male broiler chickens fed a series of diets containing betaine or DL-methionine (met) or a combination of both to see whether betaine could replace part of the methionine in broiler rations.

Supplementation with DL-met increased feed intake, weight gain and decreased FCR compared to birds fed control diets; however, the addition of betaine to these diets had no effect. Birds fed DL-met supplemented diets had relatively more breast muscle than birds fed diets with no DL-met. Addition of betaine to the DL-met diets improved the relative breast muscle yield. The addition of DL-met or betaine to the diet decreased relative abdominal fat pad mass. Birds fed 0.12% DL-met had lighter relative viscera masses, with or without added betaine.

Our data do not support the hypothesis that betaine can successfully substitute for methionine in broilers fed diets that are marginally deficient in methionine plus cystine.

I. INTRODUCTION

Methionine has three crucially important roles in vertebrate metabolism. Firstly it is an essential amino acid, secondly it is a precursor of cysteine and thirdly, methionine plays a key role as a methyl group donor. When methionine acts as a methyl donor it produces the compound homocysteine that together with serine ultimately produces cystine. In order for homocysteine to then be subsequently converted back to methionine, another methyl donor, such as betaine or choline, is required (Baker et al., 1983; Finklestein and Martin, 1984).

The methyl donor betaine is a naturally occurring methylated derivative of glycine and is found in most organisms. In poultry, the methylation properties of betaine may also be important during lipid metabolism. In this role, betaine may reduce and redistribute carcass fat (Saunderson and MacKinlay, 1990). Carcasses with less fat could also result if betaine spared methionine, leaving more of the available essential amino acid for protein synthesis. This means that better use of dietary nutrients would leave fewer amino acids for deamination and eventual synthesis into adipose tissue.

There is some evidence that betaine has a sparing effect in broiler (Virtanen and Rossi, 1995) and in layer (Lowry et al., 1987) diets; however, there is also evidence to the contrary (Rostagno and Pack, 1996; Schutte et al., 1997). The objective of this study was to determine whether betaine could either spare methionine or enhance the effect of methionine in terms of growth and carcass composition of male broiler chickens. We therefore measured several indices of growth performance; live weight gain, feed intake and feed conversion efficiency (FCR), and the yields of breast meat and abdominal fat depots in male broiler chickens fed diets supplemented with either DL-methionine (DL-met) or betaine or a combination of both.

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II. METHODS

Male Cobb 500 day-old chicks (n=432) were group brooded at 31°C for one week, with gradual reduction to 21°C at 21 days. The lighting pattern throughout the experiment was 21.5 h per day. At 7 days of age the birds were individually weighed, wing-tagged and assigned to treatments using a stratified randomisation procedure. Birds were kept 12 to a pen (1.0 m X 2.0 m) in deep litter and there were 6 replicates per treatment. Each pen had a tube feeder and a bell drinker. The birds were vaccinated as per standard broiler commercial practice in Britain. The diets used in the feeding programme during the experiment were; day 0-7 (commercial starter) day 7-21 (experimental grower) and day 21-42 (experimental finisher). Both of the experimental diets consisted mainly of wheat, peas and soya bean meal, and were adequate in energy and all nutrients except methionine. There were 6 experimental treatments (Table 1).

Table 1. Levels of methionine and cystine in the basal diet and the supplemented levels of DL-methionine and betaine per dietary treatment.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>DL-methionine (g/kg)</td>
<td>0.0</td>
<td>0.0</td>
<td>0.6</td>
<td>0.66</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Betaine (g/kg)</td>
<td>0.0</td>
<td>0.5</td>
<td>0.0</td>
<td>0.5</td>
<td>0.0</td>
<td>0.5</td>
</tr>
</tbody>
</table>

1Basal diet contained 6.3 g methionine + 5.7 g methionine/kg

Body weight was recorded on days 7, 21 and 42, and feed intake (per pen) was measured on a weekly basis. At day 42, the birds were killed by stunning and allowed to bleed out and the weights of the following carcass composition parameters were recorded; plucked and bled carcass, eviscerated carcass, breast muscle (BRM) and abdominal fat pad (AFP).

Multifactorial general linear model analysis of variance (ANOVA) and where appropriate (to correct for differences in body mass), analysis of covariance (ANCOVA) were used to analyse the data. To control the alpha level for multiple comparisons between means, and keep the error probability at alpha (5%), the Bonferroni correction was used (Bolton, 1997). Data are means and the SEM per measurement is given. The data presented here are for the overall growth period (7-42 d).

III. RESULTS

(a) Growth performance

Dietary treatment had a significant effect on live weight gain over the whole growth period (P≤0.05). Weight gain (Table 2) increased significantly with increasing levels of DL-met (0.0 to 1.2 g/kg) supplementation. The addition of betaine to the DL-met supplemented diets did not cause an improvement in weight gain. The birds with the greatest weight gain (2347 g) were those supplemented with 1.2 g DL-met alone, and this was 600 g heavier than the birds fed the control diet and those supplemented with only 0.5g/kg betaine.

Addition of DL-met, at both levels of inclusion, to the control diet caused a significant increase in feed intake over the whole growth period compared to birds fed the control diet and the control diet supplemented with 0.5 g betaine (P≤0.05). The further addition of betaine to any of the diets had no additional effect on feed intake (Table 2). Over the whole
35 d measurement period, birds fed DL-met supplemented diets had similar feed conversion ratios (FCR) at both the 0.6 and the 1.2 g/kg inclusion level. The FCR in birds fed diets unsupplemented with DL-met was significantly higher compared to those whose diets were supplemented with DL-met (P≤0.05). The addition of betaine to the diets did not significantly improve FCR.

Table 2. Performance in male broilers fed varying levels of DL-met and betaine (g/kg). Viscera, abdominal fat pad (AFP) and breast muscle (BRM) masses are corrected for the effect of body mass (g, C)

<table>
<thead>
<tr>
<th>Diet (DL-met, betaine)</th>
<th>Weight gain (g)</th>
<th>Feed intake (g)</th>
<th>FCR (g/g)</th>
<th>Viscera (g, C)</th>
<th>AFP (g, C)</th>
<th>BRM (g, C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (0.0, 0.0)</td>
<td>1748&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3770&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.15&lt;sup&gt;b&lt;/sup&gt;</td>
<td>518&lt;sup&gt;a&lt;/sup&gt;</td>
<td>39.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>258&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>B (0.0, 0.5)</td>
<td>1673&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3651&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.18&lt;sup&gt;b&lt;/sup&gt;</td>
<td>517&lt;sup&gt;a&lt;/sup&gt;</td>
<td>38.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>260&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>C (0.6, 0.0)</td>
<td>2191&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4256&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.94&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>521&lt;sup&gt;a&lt;/sup&gt;</td>
<td>37.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>289&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>D (0.6, 0.5)</td>
<td>2225&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4328&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.95&lt;sup&gt;b&lt;/sup&gt;</td>
<td>511&lt;sup&gt;a&lt;/sup&gt;</td>
<td>32.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>324&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>E (1.2, 0.0)</td>
<td>2347&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4509&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.92&lt;sup&gt;a&lt;/sup&gt;</td>
<td>493&lt;sup&gt;b&lt;/sup&gt;</td>
<td>30.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>333&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>F (1.2, 0.5)</td>
<td>2277&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>4450&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.96&lt;sup&gt;a&lt;/sup&gt;</td>
<td>493&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>29.8&lt;sup&gt;b&lt;/sup&gt;</td>
<td>354&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Pooled SEM</td>
<td>27.6</td>
<td>64.4</td>
<td>0.033</td>
<td>7.52</td>
<td>1.53</td>
<td>7.25</td>
</tr>
</tbody>
</table>

<sup>a</sup>Means within columns without a common letter are significantly different (at P≤ 0.05).

(b) Carcass composition

The masses of the plucked and bled carcass and the eviscerated carcass were affected by dietary treatment in the same way. The carcasses from the birds fed the control diet and the betaine (0.5 g) diet were significantly lighter than those of the birds on the other treatments (P≤0.05). The carcasses of those birds fed the highest level of DL-met (1.2 g) were significantly heavier than those fed diets with less DL-met (0.6 g). The addition of betaine to any of the diets did not result in a significant increase in carcass mass. Birds fed diets containing DL-met also had significantly heavier viscera (P≤0.001) than birds fed diets without DL-met. However, after correcting for treatment differences in carcass mass, the birds fed the two diets with 1.2 g DL-met had lighter viscera than the birds fed all the other diets (P ≤ 0.01) (Table 2).

Dietary treatment had a significant effect on both breast muscle (BRM) and abdominal fat pad (AFP) masses. The addition of DL-met to the diet had a significant positive effect on absolute BRM mass (P≤0.001) and there was evidence of a positive interaction between DL-met and betaine (P≤0.05). At 1.2 g DL-met, the addition of betaine to the diet had no significant effect on BRM, but, at the 0.6 g DL-met/kg, betaine did have a significant effect, resulting in a mean increase in BRM of 40 g. However, when BRM was corrected for the effect of body mass (Table 2) both DL-met and betaine did have a significant effect on BRM (P≤0.01). As the dietary concentration of DL-met increased so did corrected breast mass; likewise the addition of betaine to the diet in the presence of DL-met promoted synthesis of breast muscle. The fact that betaine had no effect, in the absence of DL-met, but a positive effect, in the presence of DL-met, suggested an interaction between the two additives (P = 0.065).

Supplementary DL-met increased the absolute mass of the AFP (P<0.001). Adding 0.6 g DL-met to the basal ration led to carcasses with heavier AFPs, but a further increase in DL-met from 0.6 g to 1.2 g kg had no additional effect. Correcting for treatment differences in body mass (Table 2) showed that adding either DL-met (P<0.05) or betaine (P<0.05)

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makes a smaller relative AFP. Birds fed diets with 1.2 g DL-met or 0.6 g DL-met and 0.5 g betaine had smaller AFPs than those fed diets with no DL-met or with 0.6 g DL-met but no betaine.

IV. DISCUSSION

The results of this experiment suggest that betaine cannot substitute for DL-met in diets that are marginally deficient in methionine plus cystine. Adding betaine alone to the basal ration, which contained 2.9 g and 2.6 g DL-met in the grower and finisher phases, respectively, did not significantly improve body mass, feed intake, FCR, or body composition of male broiler chickens. In contrast, adding DL-met to the basal ration stimulated food intake, increased weight gain and improved FCR compared to control or betaine only diets.

The improved balance of dietary amino acids changed the carcass composition too, by increasing both the absolute and relative amounts of breast meat and by decreasing the deposition of abdominal fat. However, there were clear indications of a synergistic relationship between DL-met and betaine. As expected from the requirement for methionine (3.8 - 5.0 g/kg; NRC, 1994), adding 1.2 g DL-met to the basal diet generally resulted in a larger response than adding 0.6 g DL-met/kg.

From a wider energetics perspective, an interesting biological finding in this study was the reduction in relative visceral mass in birds fed diets with 1.2 g DL-met. Considering that relative food intake, after removing treatment differences in body mass, was similar across treatments, one would expect all birds to have similar masses of metabolically active tissue. Instead, it seems that birds fed diets that were deficient in methionine were attempting to compensate by maintaining more viscera in an attempt to maximise nutrient intake (Konarzewski et al., 1990). However, when supplied with sufficient methionine, visceral mass no longer needed to compensate in the same way.

V. CONCLUSION

Our data demonstrate that betaine cannot replace DL-met with regard to improving growth performance in diets that are marginally deficient in methionine. However, betaine may have a role in poultry feeding with regard to its ability to modify carcass composition.

REFERENCES


