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Poultry No. 1573

The replacement value of betaine for DL-methionine and Choline in broiler diets

Key Information

- In broiler diets deficient in sulfur amino acids but adequately supplemented with methyl groups via added choline, there is no evidence for betaine to spare methionine in its functions as an essential amino acid.
- Betaine may have a positive effect on breast meat yield independent of methionine, although this effect was much smaller and less consistent than the effect of DL-methionine on breast meat yield.
- Betaine may replace 50 % of the total Choline requirement in diets sufficient in sulfur amino acids.

Relationship between choline, betaine and methionine

Especially in times of high raw material prices as a result of limited availability of feed ingredients nutritionist look for ways to keep feed cost as low as possible. Part of this discussion is whether certain ingredients can be replaced by others while avoiding impairments of performance. This discussion sometimes includes the question whether supplemental methionine can be replaced by betaine.

Use of supplemental methionine, choline and betaine is common in broiler diets. Biochemically, all three compounds can act as methyl group donors. Figure 1 illustrates metabolic pathways connecting choline, betaine and methionine. This chart shows that choline is transformed to betaine which can then deliver a CH₃-group for methylation reactions. One of those reactions is the methylation of homocysteine to methionine. This reaction occurs as part of the homocysteine cycle, which continues by transferring the methyl group further and yielding homocysteine again. Thus, there is no net yield of methionine from this cycle, since it only functions to transport a methyl group.

Priority of choline metabolism is to form acetyl-choline and phosphor-idyl-choline (Dilger et al, 2007). Further choline will be transformed to betaine. With respect to betaine, it is important to note that it, although containing three methyl groups, can only deliver one group for methylation

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processes (Pesti, 1989). The other two methyl groups undergo oxidation with the final formation of glycine.

From these relations it might be hypothesised that choline, betaine and methionine can replace each other on an equimolar basis as methyl group donors, but there is no evidence for either choline or betaine to deliver methionine for protein synthesis as explained in the following.

Betaine cannot replace choline

Recently, relationship between choline and betaine was investigated by Dilger et al. (2007). In three assays 8 - 17 or 19 days old chicks were fed a choline free basal diet adequate in Methionine in order to meet the Met+Cys requirement. To this basal diet graded levels of choline and betaine were added. In the absence of supplemented choline it was demonstrated that addition of betaine did not improve performance suggesting that betaine could not replace choline. On the other hand, responses to graded levels of choline addition were more pronounced in the presence of betaine (Figure 2). This indicates that in the presence of choline some betaine is transformed and available to meet the methyl requirement of the chicks. It is also seen that the choline requirement in the presence of betaine is half that needed in the absence of betaine (10.5 vs. 20.8). The authors concluded that choline per se must provide at least 50 % of the total Choline requirement. The remaining portion of the choline requirement can be replaced by betaine.

Betaine cannot spare supplemental methionine

More recently, however, it has been suggested in this context that betaine could replace methionine in order to spare supplemental DL-Met and to lower diet cost. The present paper presents the results of feeding experiments that investigated this hypothesis in broilers.

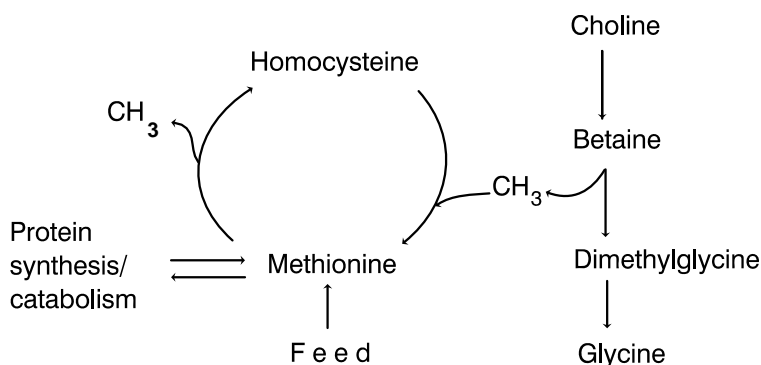


Figure 1: Metabolic pathways relating to methionine and betaine

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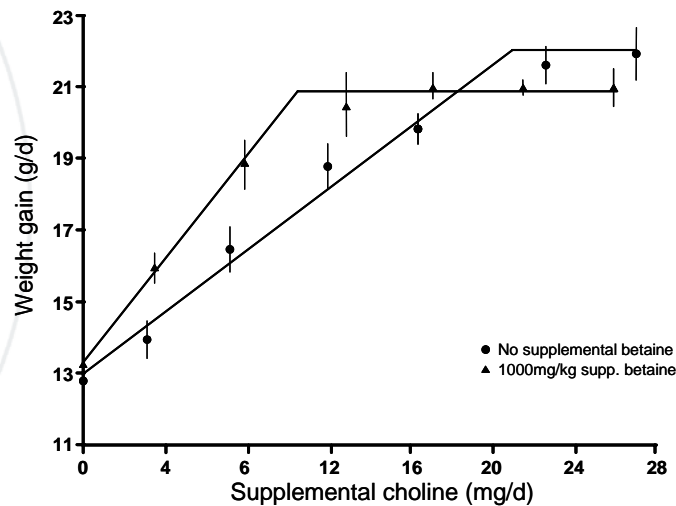


Figure 2: Weight gain of young chicks fed graded levels of supplemental choline in the absence or presence of 1000 mg/kg supplemental betaine in a purified diet devoid of bioavailable choline

In order to verify this hypothesis experimentally, two studies were conducted to investigate the replacement value of betaine for methionine in its function as an essential amino acid. For this purpose, broiler diets deficient in sulfur amino acids, but adequately supplemented with methyl groups from choline chloride, were supplemented with different combinations of DL-methionine (DL-Met) and betaine.

The first study was conducted with growing broilers growing from 1 to 40 days of age (Rostagno and Pack (1995). They received corn-soya diets containing 0.63 % Met + Cys (Starter) or 0.51 % Met + Cys (Grower). To these basal diets, DL-Met was added at 0, 0.06, 0.12 or 0.18 %. In addition, the diets supplemented with 0 or 0.06 % DL-Met were tested with further supplements of 0.05 % or 0.10 % betaine (0.05 % betaine is equimolar to 0.06 % DL-Met).

Growth and feed conversion responses are presented in Figure 3.

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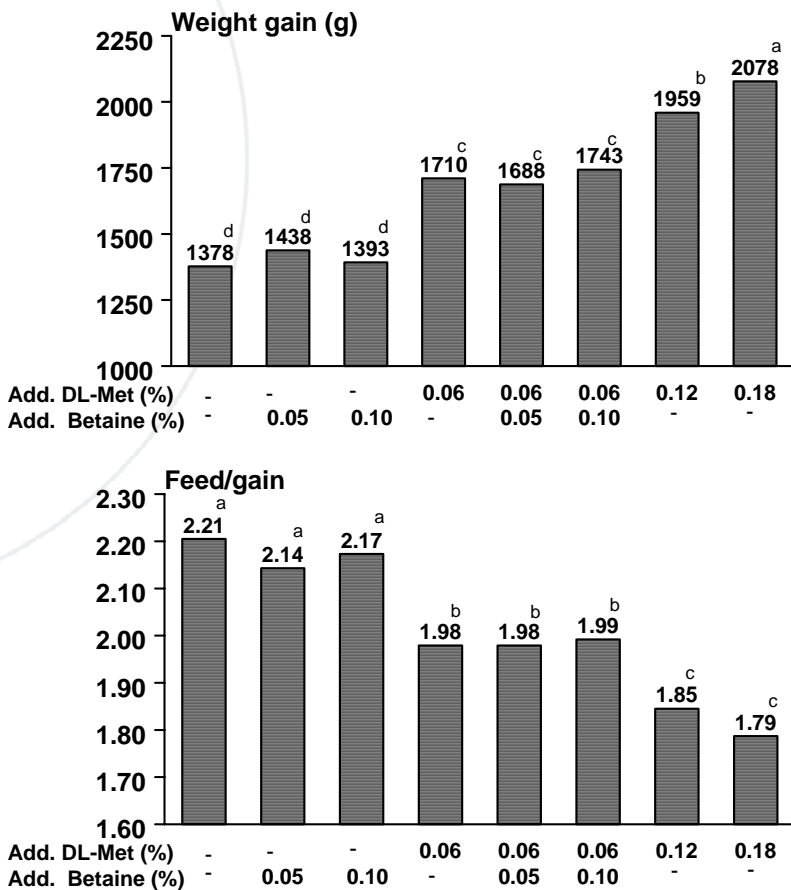


Figure 3: Weight gain and feed conversion as affected by addition of DL-methionine and Betaine (Rostagno & Pack 1995, male Ross broilers 1 to 40 days of age)

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Whereas the birds consistently responded to increasing addition of DL-methionine, there was no response at all to added betaine. Thus, in diets that were very sensitive to detect responses to dietary methionine supply, there was no evidence of any replacement value of betaine for DL-methionine.

A large response to added DL-methionine in breast meat yield was also observed (Figure 4). Betaine addition was again not as efficient as added DL-Met, although there appeared to be a slight improvement from betaine.

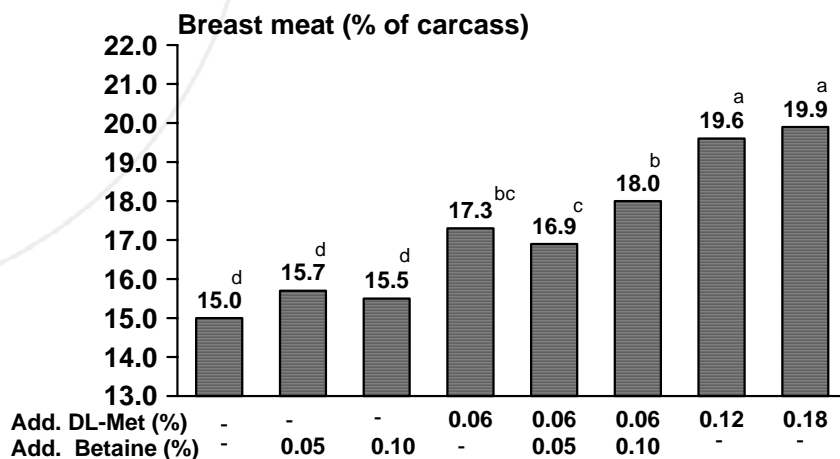


Figure 4: Breast meat yield responses to added DL-methionine and betaine
(Rostagno & Pack 1995 [2], male Ross broilers 1 to 40 days of age)

Similarly Pillai et al. (2006) reported that performance parameters did not respond to supplementation of choline and betaine with the same magnitude of response as they did to methionine, additionally this limited response was only observed in basal diets with no methionine supplementation.

A second study involved two experiments of similar design (Schutte et al., 1995). In broilers grown to 38 days, two types of basal diets (corn-soya or a mixed diet including wheat, tapioca, meat & bone meal and peas) were formulated as Starters (0-21 days, 0.75 % Met + Cys) and Growers (21-38 days, 0.64 % Met + Cys). DL-methionine was added at 0, 0.05 or 0.10 %, and combined with either 0 or 0.04 % betaine.

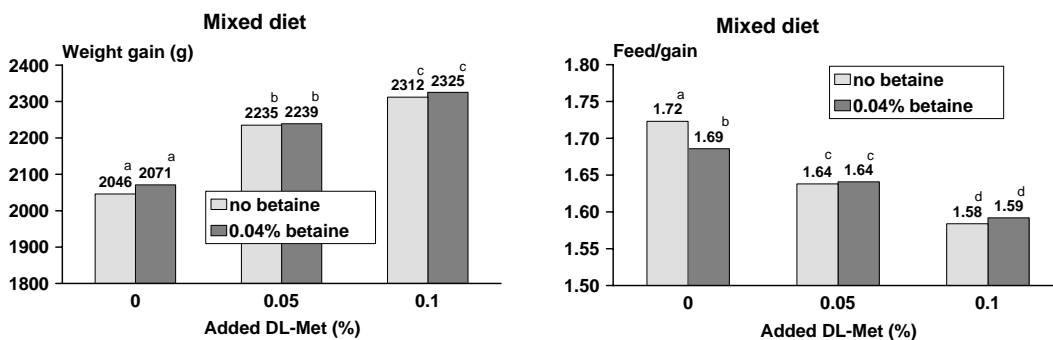
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Figure 5 illustrates growth and feed conversion responses in this study.

Mixed diet



Corn-soya diet

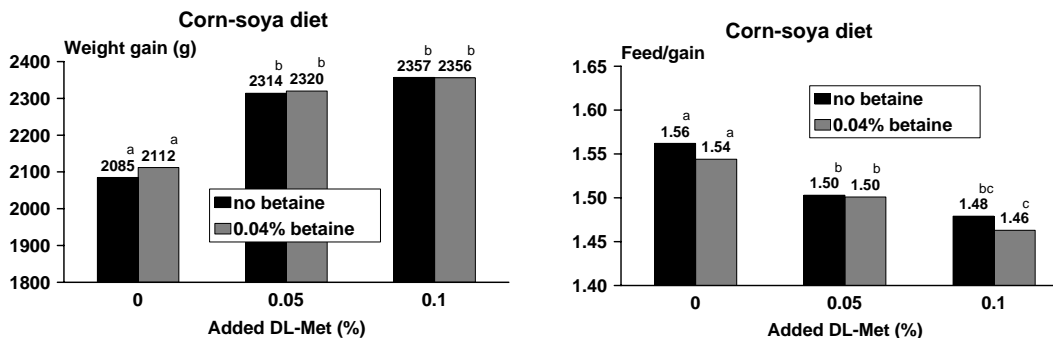


Figure 5: Weight gain and feed conversion as affected by DL-methionine and betaine in two different types of basal diets
(Schutte et al. 1995 [3], male Ross broilers 1 to 38 days of age)

Broilers significantly responded to the two additions of DL-methionine in both diets. Further addition of betaine was ineffective in improving performance, confirming the results of the first study (Figure 5).

Breast meat yield was determined in birds of those groups receiving no supplement, or 0.05 % DL-Met, or 0.04 % betaine, or both supplements. Added DL-Met improved breast meat yield in both diets by 1.5 %-points, while betaine added to the unsupplemented basal diets or to the diets containing 0.05 % DL-Met only slightly enhanced breast meat yield by about 0.5 %-points (Figure 6). Betaine was clearly inefficient in replacing DL-Met, although it may have some positive effect on breast meat yield independent of methionine.

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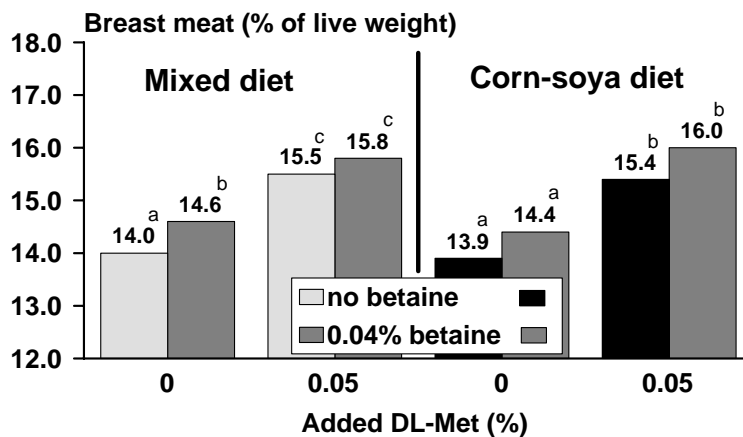


Figure 6: Breast meat yield responses to added DL-methionine or betaine
 (Schutte et al. 1995 [3], male Ross broilers 1 to 38 days of age)

Further trials confirmed that betaine cannot replace methionine.

Further trials were reported in literature all confirming the above made conclusions. McDevitt et al. (2000) included six dietary treatments and fed broilers starter (d1-21) and grower diets (d22-42). Similar to the above shown experiments, McDevitt et al.'s (2000) set up consisted of a methionine deficient diet but being adequate in choline (diet 1) and two diets with 0.06% (diets 2,3). Three further diets were included which were diets 1-3 each supplemented with 0.05% betaine (equivalent to 0.06% DL-Met). Responses of broilers were exactly the same as in the studies by Rostagno and Pack (1995) and Schutte et al. (1995). Only, supplementation of DL-Met produced a clear dose-dependent response on body weight gain and feed conversion whereas added betaine did not. Betaine had a positive effect on breast meat yield but was by far not as effective as DL-Met. Esteve-Garcia and Mack (2000) not only used exactly the same experimental design with the same inclusion levels of betaine and DL-Met but came also to exactly the same conclusions.

In 2006 Waldroup et al, reported that addition of either choline or betaine to a nutritionally adequate corn-soybean meal diet had little or no sparing effect on methionine. Finally, Maurice's (1998) applied the same experimental set up but did not evaluate carcass composition both he and Rama Rao et al. (2008) reported the similar findings.

All together, seven experiments are available in which the hypothesis that supplemental betaine can replace supplemental DL-Met and thus reduce diet costs was tested. Results of all trials suggested that betaine does not have this potential although betaine as such did have a positive effect on breast meat yield.

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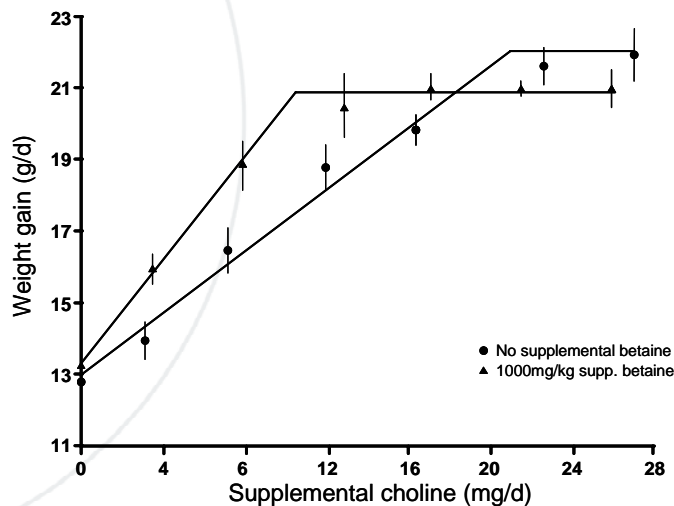


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