WP

COCCIDIOSIS

Betaine improves performance of coccidia-challenged birds

The methionine-sparing effect of betaine has been known for many years. However, possibly of greater importance is betaine's role as an osmolyte. Trials have shown that betaine can have positive effects at the intestinal level, improving the integrity of the intestinal epithelium and a likely mode of action is related to betaine's osmolyte function. The improved intestinal integrity may help to minimise the effects of coccidia, resulting in a more robust and efficient intestinal epithelium.

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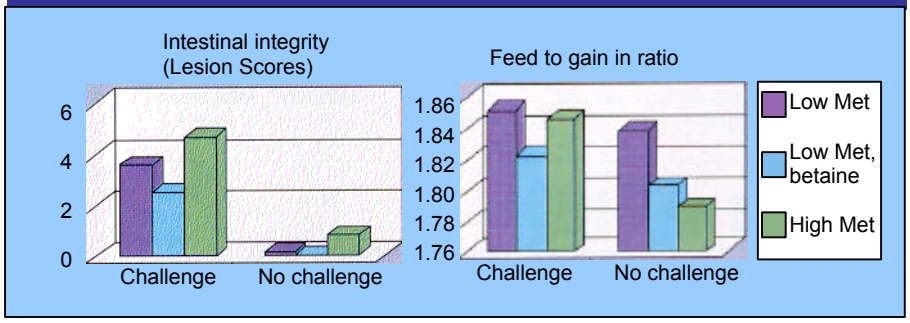
Figure 1. Gut integrity (total lesion scores) and feed to gain ratio with or without coccidia challenge when broilers were fed low methionine diets, with or without betaine, or diets with adequate methionine.



Betaine is a naturally occurring substance that is isolated from sugar beet and has osmoregulatory properties involved in water balance within the cells of plants. A series of trials have shown that the osmoprotectant properties of betaine, when combined with ionophore coccidiostats, reduced the negative effects on bird performance in broilers inoculated with a mixture of *Eimeria* sp. isolates. It is likely that betaine helps re-establish the osmotic balance in the gut that may be disrupted by both coccidia infection and the use of some coccidiostats.

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What is betaine?

Betaine, or trimethylglycine, is a natural product produced by most living organisms. Sugar beet concentrates large amounts of betaine and it is extracted in an industrial process. The interest of the poultry industry in betaine is due to its three reactive methyl groups and its bipolar structure. The bipolar nature of betaine makes it important for osmoregulation, which assists in the balance of water within cells, generated by changing the concentration of charged particles in solution. This property has recently led to betaine being investigated for its effects on performance in coccidia infected birds.

Betaine in coccidia challenged birds

In a coccidiosis outbreak, oocysts infect the cells of the intestinal lining, replicate, and cause them to burst. Coccidia infection changes the gut morphology, reducing gut length, and truncating the intestinal villi. Coccidiosis also changes the osmolarity of the gut by inducing diarrhoea, and leading to reduced nutrient absorption. There are several species of coccidia, each infecting a different area of the intestinal tract and producing different symptoms. For experimental purposes it is appropriate to use a mixture of species. In the experimental work described here, a mixture of three species (*Eimeria acervulina*, *E. maxima* and *E. tenella*) was used for inoculation. Two trials were conducted at the Georgia Poultry Research centre to investigate the effect of feeding betaine on the intestinal environment of young broilers. In each trial, 10 pens of 60 broilers per treatment were infected with coccidia via the feed at 15 days of age. A basal diet deficient in methionine was fed as is with 0.15% methionine, or 0.075% betaine added. A coccidiostat and growth promoter was supplemented at commercial levels in both the starter and grower diets. *Table 1* shows that in each trial, body weights were reduced when feeding the low methionine diets which resulted in poor feed conversion, ratios (FCRs). Supplementation with either methionine or betaine resulted in increased body weights and significantly improved FCR at 42 days of age. In a trial at Colorado Quality Research (USA) betaine was able to compensate for low methionine levels for performance without a coccldia challenge, while in the presence of a coccidia challenge betaine produced better performance than methionine (*Figure 1*). The same trial also showed that in coccidia-challenged broilers, betaine may help improve intestinal integrity (measured as lesion scores), while higher levels of supplemental methionine appeared to have no effect. In this trial, the diets included two coccidiostats and a growth promotant.

Table 1. The methionine sparing effect of betaine with coccidiosis inoculation (1 to 42 days)

	Body weight (g)	*FCR*
Trial 1		
Low methionine	1.994	1.974[a]
Plus methionine (0.15%)	2.029	1.948[b]
Plus betaine (0.075%)	2.027	1.946[b]
Trial 2		
Low methionine	2.110[b]	1.932[a]
Plus methionine (0.15%)	2.170[a]	1.902[b]
Plus betaine (0.075%)	2.165[a]	1.905[b]

[a,b] Within a column within each trial, means with no common superscript differ significantly (p<0.05}

Two further trials at Colorado Quality Research, USA, investigated the role of betaine's osmoprotectant properties on the effects of coccidiosis on broiler performance. The first trial (*Table 2*) evaluated the intestinal integrity (measured by lesion scores) in broilers fed either betaine, choline or methionine, with or without a coccldiostat, and with a mild or heavy coccidia challenge. Intestinal integrity (total lesion scores) was improved in birds fed betaine in all cases, especially under heavy coccidia-challenge

Table 2. Effect of betaine, coccidiostat, and coccidia challenge on intestinal integrity (lesion scores - scored as 0 to 4 per area analysed)

Challenge	*Coccidiostat*[1]		*No Coccidiostat*[1]	
	0 Betaine	*0.15% Betaine*	*0 Betaine*	*0.15% Betaine*
Mild	1.85	1.57	3.04[a]	2.48[b]
Heavy	3.00[a]	1.82[b]	6.45[a]	4.35[b]

[a,b]Means within each comparison between level of betaine supplementation having no common superscript differs significantly (P<0.05)
*sum of four areas analysed using a 0-4 pt system in each area (4 is severe)
[1]Salinomycin

Table 3. Effect of betaine and methionine on intestinal integrity (lesion scores) and feed conversion when broilers were vaccinated against coccidiosis

Diets	*Betaine (%)*	*Total Lesion score**	*FCR*
Positive Control	0.00	2.90[b]	1.984[b]
Negative Control	0.00	4.08[a]	1.995[b]
Negative +	0.15	1.50[c]	1.967[a]

[a,b]Means within each comparison between level of betaine supplementation having no common superscript differs significantly (P<0.05)
*sum of four areas analysed using a 0-4 pt system in each area (4 is severe)
**Birds were not vaccinated and received salinomycin and roxarsone

Table 4. Effect of coccidiostat[1] and betaine on performance of broilers to 21 days of age

Coccidiostat[1] *(ppm)*	*Betaine (%)*	*Body weight (g)*	*FCR*	*Mortality (%)*	*Total lesion score**
0	0.00	580[d]	1.443[a]	16.62[a]	3.63[a]
0	0.15	592[c]	1.397[b]	14.06[a]	3.47[a]
66	0.00	617[b]	1.349[c]	4.69[b]	2.34[b]
66	0.15	640[a]	1.311[c]	2.70[b]	1.81[c]

[a-d]Means having no common superscript differs significantly (P<0.05)
*sum of four areas analysed using a 0-4 pt system in each area (4 is severe)
[1]Salinomycin

Table 5. Effects of betaine in the presence of eight different coccidiostats (only main effect of coccidiostat was shown)

Coccidiostat[1] *(ppm)*	*Betaine (%)*	*Body weight (g)*	*FCR*	*Mortality (%)*	*Total lesion score**
0	0.00	592	1.456	34.2	5.88
+	0.00	619[b]	1.399[a]	11.7[a]	2.08[a]
+	0.15	627[a]	1.378[b]	7.9[b]	1.30[b]

[a,b]Means having no common superscript differs significantly (P<0.05)
Comparisons are only with coccidiostat
[1]Coccidiostats were; Salinomycin (66ppm), Monensin (110ppm), Narasin (79ppm), Nicarbazin (199ppm), Diclazuril (1.1ppm), Robenidine (33ppm), Zoalene (125ppm) and Maduramicin (5ppm)
*sum of four areas analysed using a 0-4 pt system in each area (4 is severe)

(as the effects of choline and methionine were inconsistent these results were not shown). It would appear that the benefit of feeding betaine under a coccidia challenge indicates the importance of osmoprotection and the maintenance of water balance under cellular invasion.

Betaine in vaccinated birds

In recent years vaccines have been developed against intestinal Eimeria sps. as potential alternatives to coccidiostats. Vaccination induces a low level of infection to build up the birds' natural resistance to coccidiosis. A second trial was conducted at Colorado Quality Research, USA, to investigate the effect of betaine on birds vaccinated against coccidiosis (*Table 3*).

Betaine supplementation resulted in significant improvements in feed conversion compared to both control groups. This effect may be attributed to the osmoprotectant effect that betaine elicits at the intestinal level (measured as a reduction in lesion scores).

In a study conducted by Augustine and co-workers (1997) young broilers were challenged with coccidia and fed diets supplemented without or with coccidiostat, and/or 0.15% betaine. A growth promotant was used in all diets. Betaine supplementation resulted in better performance whether a coccidiostat was fed or not (*Table 4*). In birds that were not fed a coccidiostat, betaine appeared to have no effect on intestinal integrity (no significant reduction in total lesion score). The observed improvement in broiler performance in these birds may have been more related to improved nutrient absorption from the intestinal lumen. In later trial work the same researchers found that betaine improved the digestibility of several essential nutrients (e.g. amino acids)

The trials reported above generally focused on the effect of betaine in the presence of one specific coccidiostat. A further trial was conducted to evaluate bird performance responses to betaine in the presence of several different coccidiostats. *Table 5* shows data from a trial at the PARC Institute in Maryland, USA, which demonstrates the effect of coccidiostats and betaine on performance and intestinal integrity. In the absence of coccidiostat, bird performance was unchanged by betaine supplementation (data not shown). In contrast, when fed in the presence of a coccidiostat, betaine had a positive effect on bird performance. Betaine resulted in a significant effect on bird performance in the presence of all of the coccidiostats, with the exception of two chemical coccidiostats.

Ionophore coccidiostats disturb the osmotic regulation of the coccidia organism by facilitating the transport of ions across biological membranes, thus interfering with the first stages of coccidial infection. VVhile ionophore coccidiostats are remarkably effective in controlling coccidiosis, they may also affect the ionic balance in the gut, which has been shown to reduce feed consumption and therefore broiler performance. It follows, therefore, that the osmoregulatory effects elicited by betaine may be responsible for the beneficial effects on bird performance when fed in the presence of different coccidiostats. Data from a recent publication (Walden-stedt *et al.*1999), appears at first glance to conflict with these data. These authors found that betaine improved broiler body weight, but there was no change in intestinal integrity (lesion score). The coccidiostat alone, however, similarly improved growth but did not affect intestinal integrity (lesion score).

The authors concluded that the lack of effect on intestinal integrity was due to a possible severe reinfection by *Eimeria tenella* in the caeca combined with a lack of coccidial sensitivity to the coccidiostat. It appears, therefore, that in order for a significant effect on intestinal integrity, there needs to be some sensitivity of the coccidia to the coccidiostat used.

Proven benefits

The methionine-sparing effect of betaine has been known for many years. However a more important role of betaine may be related to its osmolyte function which helps in maintaining water balance at the intestinal level under commercial conditions, especially in the presence of ionophore coccidiostats. Both coccidiosis infection and the coccidiostats used to control the disease may disturb the ionic balance in the gut, which the osmoregulatory function of betaine helps to re-establish.

Key words
Betafin (poultry), Betafin, betaine, coccidiosis, coccidiostat, gut lesion, osmolyte, broiler