Betaine – an essential nutrient for pigs?

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Betaine is the trimethyl derivative of the amino acid glycine found in many plant and invertebrate species.

Physiologically, betaine has important osmoregulatory properties and can serve as a methyl group donor via S-adenosyl-methionine (SAM). It can be used in trans-methylation reactions for the synthesis of numerous substances such as carnitine and creatine.

In practical pig nutrition, betaine is recommended as an alternative methyl-donor in transmethylation reactions for choline chloride and DL-methionine in the methylation cycle (Fig. 1).

Eklund et al. recently reviewed the role of betaine, and concluded that it has important functional properties, but care has to be taken for the replacement of methionine in diets for pigs. The extent to which methionine can be substituted by betaine may depend on the dietary supply of cysteine as well. Methionine will be mainly used for protein synthesis when the animal's cystine requirement is met.

Otherwise, part of the methionine will be irreversibly degraded to cysteine. With regard to choline, commonly used raw materials in pig diets provide sufficient endogenous choline to cover the essential needs for functions such as membrane synthesis or formation of acetylcholine.

At least part of the supplemented choline can be substituted by betaine.

Although many studies focused on betaine as a potential substitute of methionine and choline, more evidence is coming up that betaine may be seen as a key nutrient by itself.

Especially in stressful conditions and at high performance levels, betaine supplementation has shown to improve performance of pigs fed choline and methionine adequate diets.

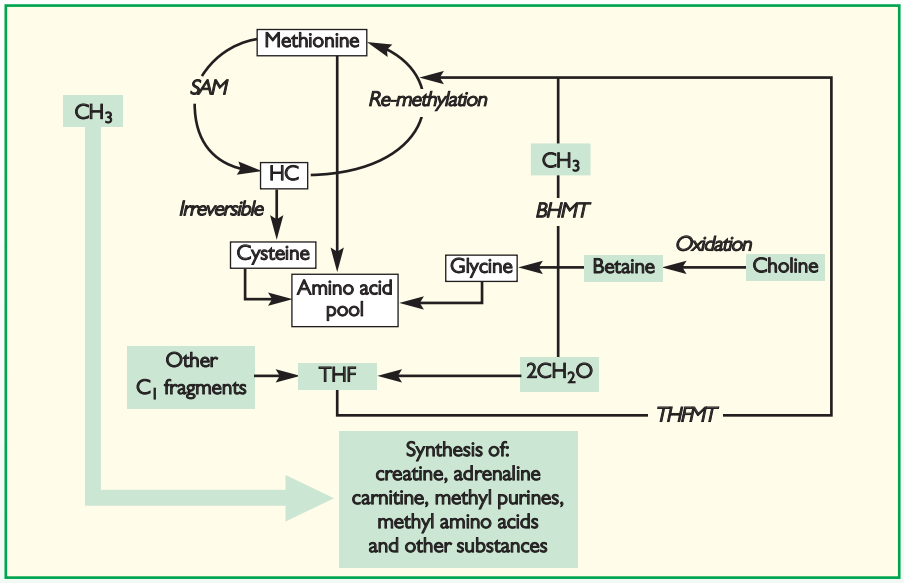

Fig. 1. Methyl group (CH3) metabolism. SAM, S-adenosyl methionine; HC, homocysteine; BHMT, betaine-homocysteine-methyltransferase; THF, tetrahydrofolate; THFMT, tetrahydrofolate-methyltransferase; CH2O, formaldehyde group (Eklund et al., 2005a).

Gut health in piglets

Recent literature reports have indicated that betaine may improve gut integrity in weaned piglets and broiler chickens because of its osmoregulatory and immune-modulating properties.

Betaine supplementation improved gut tensile strength in piglets and broiler chickens, modulated small intestinal weight in weaned piglets, increased villus height in the duodenum of weaned piglets and reduced the decrease in villus height in chicks infected with coccidia.

Eklund et al. suggested that since the use of in-feed antibiotics is restricted, there is a growing interest in using betaine as a bioactive compound for improving gut health.

To study the hypothesis that betaine may improve performance and health of weaned piglets, a study was carried out at the Nutreco Swine Research Centre.

In total 192 piglets were allocated to four treatments in a 2 x 2 factorial design, with

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Table 1. Main effects of ™Betain96 and protein level on performance and diarrhoea of weaned piglets challenged with poor hygiene conditions from weaning to four weeks postweaning.

Treatment	Betaine		Crude protein		Overall mean	CV [2]	Significance		
	-	+	LP	HP			Bet	CP	Bet x CP
Growth	298	298	292	304	298	14.3	0.995	0.222	0.369
Feed intake	459	446	461	443	455	13.1	0.336	0.202	0.445
Feed efficiency	0.650	0.675	0.639	0.686	0.661	8.2	0.048	0.001	0.491

**For the level of significance see P-value.*

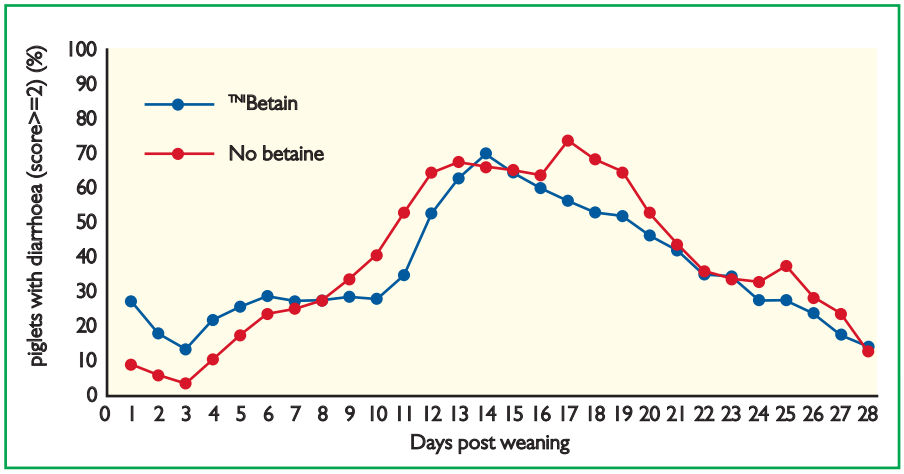

Fig. 2. Main effects of TNIBetain96 on incidence of diarrhoea of weaned piglets challenged with poor hygiene conditions from weaning to four weeks postweaning.

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12 replicates per treatment. The experimental diets contained either (LP) low (18%) or (HP) high (20%) crude protein (CP) levels of which two diets were supplemented with 2g/kg TNIBetain96 (Bet) in crystalline form (anhydrous betaine).

All experimental diets were adequate in methionine and choline, according to NRC (1998) recommendations.

The piglets were subjected to poor hygiene conditions in order to create challenge conditions. The experiment was performed from weaning to four weeks postweaning.

The results demonstrate that betaine improved feed efficiency significantly and tended to reduce the incidence of diarrhoea. The latter effect was more pronounced in the high protein diet. Average daily gain was not influenced.

Part of the explanation for the observed improvement in feed efficiency and incidence of diarrhoea may have been positive effects of betaine on nutrient digestibility.

In weaned piglets, improvements have been reported in digestibility of dry matter, crude protein and crude fat.

A recent study of Eklund et al. demonstrated that dietary supplementation of betaine increased significantly ileal and faecal digestibilities of the complex carbohydrate fraction (NDF, ADF) in weaned piglets of 9kg body weight.

The authors suggest that betaine may be a potent stimulator of intestinal microbial fermentation.

Nutrient partitioning

When incorporated into pig diets, betaine has been reported to reduce the maintenance requirement for energy of pigs with about 5%.

The quantitative effect is of economic interest, because betaine will raise the level of energy available for nutrient partitioning. Moreover, betaine may improve carcase quality and extra revenues may be obtained by the farmer from the quality payments. Betaine increased protein deposition and carcase leanness, and decreased backfat.

The most consistent effects of betaine on growth performance and carcase quality have been reported in lean genotypes or sexes with restricted dietary energy intakes.

It suggests that betaine especially offers the potential to improve lean body growth when protein deposition is limited by energy

intake. Suster et al. (2004), recently tested this hypothesis with finisher boars fed either restricted or ad libitum diets, with or without betaine, and either or not treated with porcine somatropin (pST).

They observed that the effects of betaine on growth performance and tissue deposition were evident only when dietary energy was limiting.

Dietary betaine increased protein and lean tissue deposition, lean content in the half-carcase, and daily gain. There was in this study no effect on fat deposition. Importantly, the betaine response was additive to the effects of pST.

Thus, these studies with growing pigs suggest that betaine included at levels of 0.1 to 0.2% improves significantly the utilisation of dietary energy.

This will especially benefit the leaner animals with a high daily protein deposition. It can be expected, therefore, that with the increased genetic progress in lean meat deposition, the functional role of betaine in nutrition of lean modern genotypes will become increasingly important.

Fertility of sows

The improved utilisation of dietary energy by the supplementation of betaine may also benefit sows.

Campbell et al. (1997) studied the effect of betaine (0.2%) during a 25 days lactation period in lactating sows on piglet performance and subsequent reproductive performance.

Betaine had no effect on sow feed intake or piglet growth rate during lactation, but improved the litter size in the subsequent reproductive cycle.

The mechanism behind this effect remains to be elucidated and warrants further investigation.

In conclusion, recent studies suggest that the functional role of betaine in pig nutrition becomes increasingly important. Betaine supplementation proved to be beneficial in weaned piglets, growing pigs and reproductive sows, also in methionine and choline adequate diets.

The improved utilisation of dietary energy may play a central role in the reported effects. In addition, betaine may, as osmoprotectant and methyl-donor, promote critical metabolic functions. ■

References are available from the author on request

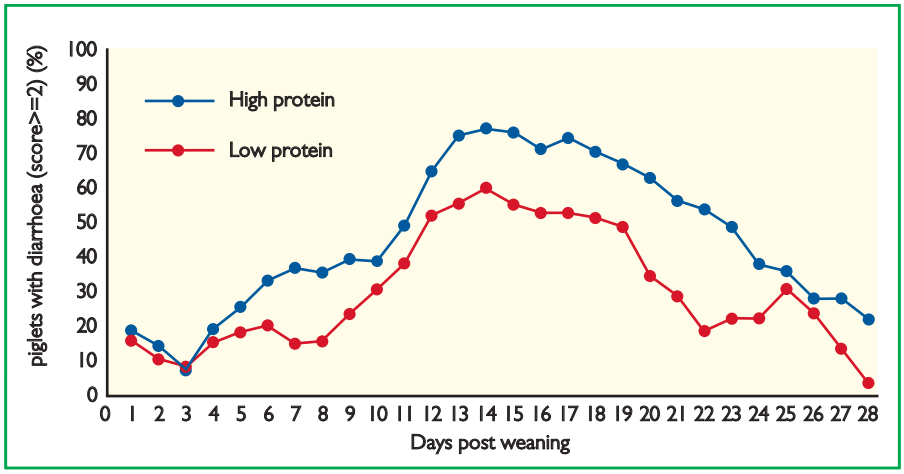

Fig. 3. Main effects of protein level on incidence of diarrhoea of weaned piglets challenged with poor hygiene conditions from weaning to four weeks postweaning.