Pig Research Report

Project title: Live performance of weaner pigs offered dietary zeolite

Research Organisation: NSW Agriculture

Principal Investigator: Dr Roger Giles
Elizabeth Macarthur Agricultural Institute
Woodbridge Road, Menangle NSW
PMB 8, Camden NSW 2570

Telephone: 02 4640 6360
Facsimile: 02 4640 6384
Email: roger.giles@agric.nsw.gov.au

A final report prepared for KLC Environmental Pty Ltd

June 2004

Research Summary

The objective of this study was to test the hypothesis that weaner pig performance is unaffected by dietary zeolite powder (NZ 76: KLC Environmental, Boggabri NSW).

Forty eight male weaner pigs (hybrid, mainly Large White x Landrace) were allocated at 8.9 ± 1.3 kg (mean ± SD) live weight to three diets formulated to contain either zero, 25 or 50 g/kg of zeolite (NZ 76). The pigs were housed in individual wire-mesh cages in one room maintained at 27°C. Feed was offered fresh each day as a mash diet to maintain 500 g of feed in each trough. Water was provided from individual nipple drinkers. The experiment continued for 21 days. Individual pig measurements included live weight at the start and finish of the study and feed intake. Mean treatment differences in daily feed intake, daily live weight gain, feed:gain and diet cost per kg gain were compared by analysis of variance.

The live performance results from this study did not support the hypothesis that weaner pig performance is unaffected by dietary zeolite powder (NZ 76). The main finding from this study was a significant ($P<0.05$) 16% improvement in daily gain for weaner pigs offered 50 g NZ 76 zeolite per kg (660 g) compared to the zero control diet (567 g). This improvement in daily gain was achieved with no increase in diet cost per kg gain (65.4 c).

Live performance of weaner pigs offered dietary zeolite

Background

Zeolites are a family of naturally-occurring aluminium silicate minerals associated with volcanic ash (or tuff) formations. The crystalline structure of zeolite consists of a three-dimensional (tetrahedral) framework. The negative-charge imbalance caused by the presence of aluminium allows the tetrahedral framework to be occupied by positively-charged metal ions or cations (such as sodium, potassium, magnesium and calcium) and water molecules. Crushing and milling of zeolite creates a powder that absorbs cations and water. The cation-exchange capacity of zeolite powder is used commercially to absorb ammonium ions (NH_4^+) from animal effluent and hence reduce odour associated with the release of ammonia gas. Furthermore, a number of studies have shown that application of zeolites to animal effluent leads to the absorption of potassium and zinc ions which in combination with NH_4^+ can enhance plant yields when zeolite-treated animal manure is applied to crops and pastures.

Two of the most common minerals in the zeolite family are known as mordenite and clinoptilolite. These minerals are found in compacted volcanic ash deposits located near Quirindi in north-west NSW. A local company, Castle Mountain Zeolites mines and processes mordenite-clinoptilolite at Quirindi and the commercial product (marketed as NZ 76 high-grade zeolite powder) is distributed by KLC Environmental Pty Ltd, based near Boggabri, NSW.

KLC Environmental Pty Ltd has conducted independent laboratory tests on all commercially-available natural zeolites in Australia, of the same particle size, as part of their Quality Assurance program. The Castle Mountain deposit near Quirindi in NSW was shown to have the highest cation exchange capacity, the lowest bulk density and the highest water holding capacity in the 76 micron particle size product. KLC Environmental has registered NZ 76 with the Australian Pesticide and Veterinary Medicine Authority (Permit No. 6764) for use in animal feed as a feed binder.

The problem

Incorporation of zeolite powder in animal diets provides a convenient method of adding zeolite to animal effluent. Although many studies have demonstrated odour control and plant nutrient benefits when zeolites are applied to animal manure, pig response to dietary zeolite has been equivocal.

Studies conducted at Clay Centre, Nebraska (Pond and Yen, 1982; 1987) indicated that daily live weight gain of weaner pigs increased by 14% when fed 20 g/kg of clinoptilolite and that geographic source and particle size of clinoptilolite affected the growth response. However, other reports from New Zealand (Pearson et al., 1985), Denmark (Poulsen and Oksbjerg, 1995) and Italy (Malagutti et al., 2002) showed that growth was unaffected by dietary clinoptilolite. Similarly, unpublished on-farm studies in Australia by KLC Environmental Pty Ltd have shown no improvement in pig performance when commercial mordenite-clinoptilolite powder (NZ76) was added to existing pig diets at 50 g/kg.

Objective

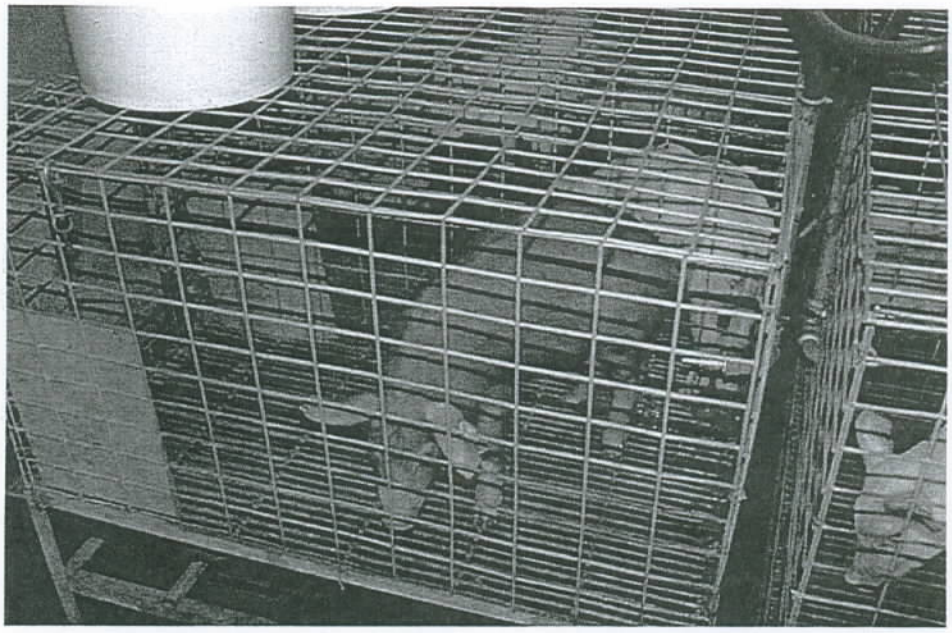
The objective of this study was to test the hypothesis that weaner pig performance is unaffected by dietary zeolite powder (NZ 76).

Experimental procedure

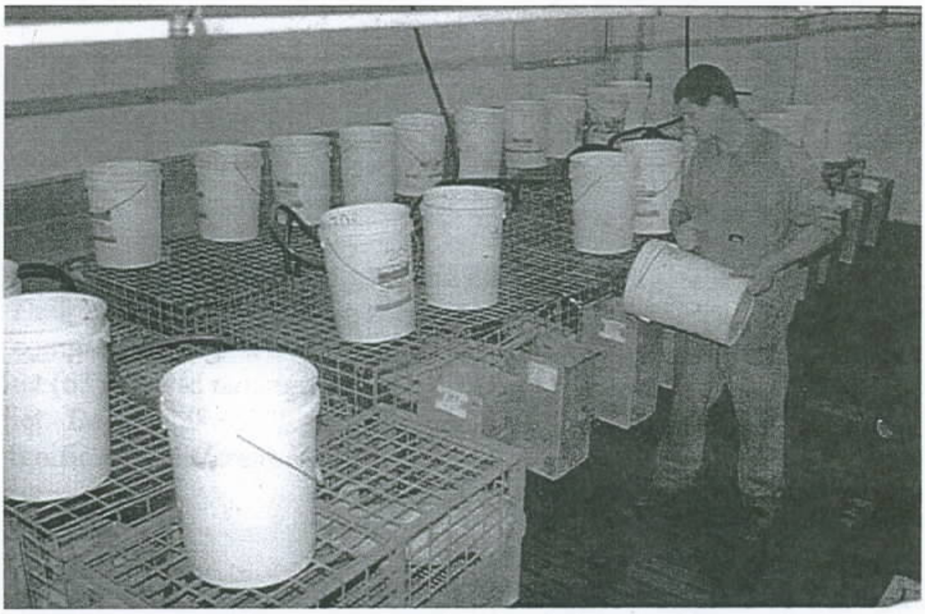
Forty eight male pigs (hybrid, mainly Large White x Landrace) plus two spare animals were sourced at about 28 days of age from a commercial piggery. Each pig was vaccinated on-farm prior to weaning against *M. hyopneumoniae* (Respisure: Pfizer) and *A. pleuropneumoniae, P. multocida* and *S. suis* using a custom vaccine (APS: Allied Animal Health). The study was conducted in the controlled-environment research piggery at Elizabeth Macarthur Agricultural Institute (EMAI), Menangle NSW. On arrival at EMAI each pig was injected with Ivomectin (Ivomec: Merial Australia Pty Ltd) and long-acting penicillin (Benacillin: Illium Veterinary Products) to protect pigs from mange and bacterial infection such as *H. parasuis* (Glasser's disease) respectively.

Forty eight pigs were allocated at 8.9 ± 1.3 kg (mean ± SD) live weight to three diets (see Table 1). The diets were formulated to contain either zero, 25 or 50 g/kg of zeolite (NZ 76) powder. Digestible energy and available lysine content of each diet were maintained at 15 MJ per kg and 0.82 g per MJ DE respectively. Free amino acids were added to maintain the balance of amino acids relative to lysine (Baker and Chung, 1992). The wheat sample was analysed by near-infrared reflectance to contain 14.8 MJ DE per kg (air-dry basis).

The pigs were housed in individual wire-mesh cages in one room maintained at 27°C and a minimum of 10 g water per kg of air. Cage dimensions were 0.9x0.4x0.6 m and each cage contained an individual feed trough and nipple drinker (see photograph 1). Feed was offered fresh each day as a mash diet to maintain 500 g of feed in each trough (see photograph 2). Feed spillage was collected each day and uncontaminated feed was re-fed to each pig. The experiment continued for 21 days. Individual pig measurements included live weight at the start and finish of the study and feed intake. Mean treatment differences in daily feed intake, daily live weight gain, feed:gain and diet cost per kg gain were compared by analysis of variance.



Photograph 1. Weaner pig cage



Photograph 2. Room layout and feeding

Table 1. Diet ingredients (g/kg) and nutrient composition

Ingredient	Dietary zeolite (g/kg)		
	0	25	50
Wheat	674.5	623.8	560.7
Feed oil	13.7	27.3	37.1
L-lysine	1.2	1.8	0.9
DL-methionine	0.5	0.5	0.4
L-threonine	0.9	0.9	0.5
Premix	2.0	2.0	2.0
Salt	2.0	2.0	2.0
Zeolite (NZ 76)[1]	0	25.0	50.0
Blood meal	25.1	25.6	30.0
Meat & bone meal	80.1	80.8	81.0
Fish meal	40.0	40.0	40.0
Dried whey powder	20.0	20.0	20.0
Full-fat soya bean meal	78.8	90.4	115.4
Solvent-extracted soya-bean meal	60.0	60.0	60.0
Diet cost (c/kg)	39.5	41.3	43.4
Nutrient composition			
Digestible energy (DE) (MJ/kg)	15.0	15.0	15.0
Available lysine (g/MJ DE)	0.82	0.82	0.82
Crude protein (g/kg)	237.0	235.9	241.0
Crude fibre (g/kg)	27.4	26.7	26.5
Fat (g/kg)	56.1	70.8	84.1
Calcium (g/kg)	11.6	11.6	11.7
Available phosphorus (g/kg)	6.0	6.0	6.0

[1] NZ 76 high grade zeolite powder supplied by KLC Environmental Pty Ltd, Boggabri, NSW.

Results

Mean daily intake, daily gain, feed:gain and diet cost per kg gain are presented in Table 2. Daily gain of pigs fed 50 g zeolite per kg (660 g) increased significantly ($P<0.05$) compared to pigs fed the zero control diet (567 g). Daily gain of pigs fed the 25 g/kg diet (635 g) was not significantly different from either the zero control or the 50 g/kg diet. Daily intake (975 g), feed:gain (1.58) and diet cost per kg gain (65.4 c) was not significantly different for each diet.

Table 2. Mean live performance of 48 male weaner pigs fed one of three wheat-based diets containing either zero, 25 or 50 g of zeolite[1] per kg and housed in individual pens from 9 to 22 kg live weight.

Measurement	Dietary zeolite (g/kg)			SEM[2]	Probability
	Zero control	25	50		
Daily intake (g)	933	993	1000	57.3	0.482
Daily gain (g)	567[a]	635[ab]	660[b]	19.3	0.035
Feed:gain	1.66	1.57	1.52	0.059	0.295
Diet cost[3] (c/kg gain)	65.6	64.8	65.9	2.39	0.939

[1] NZ 76 high grade zeolite powder supplied by KLC Environmental Pty Ltd, Boggabri, NSW.
[2] Standard error of the mean.
[3] Diet cost was 39.5 c/kg (zero control); 41.3 c/kg (25 g/kg); and 43.4 c/kg (50 g/kg).
[a,b] Means sharing the same superscript are not significantly different ($P \leq 0.05$)

Discussion

The live performance results from this study did not support the hypothesis that weaner pig performance is unaffected by dietary zeolite powder (NZ 76). The main finding from this study was a significant ($P<0.05$) 16% improvement in daily gain for weaner pigs offered 50 g NZ 76 zeolite per kg (660 g) compared to the zero control diet (567 g). This improvement in daily gain was achieved with no increase in diet cost per kg gain (65.4 c).

The mode of action of NZ 76 zeolite on pig growth is unclear. The improvement in daily gain was directly associated with an increase in feed oil in the control (1.4 %), 25 g/kg (2.7 %) and 50 g/kg (3.7 %) diets. Addition of feed oil to weaner pig diets often causes a mild laxative effect. We observed no laxative effect in pigs offered the zeolite diets despite an increase in dietary feed oil. One possible explanation for the increase in gain is the reduction in viscosity of digesta which could increase the energy utilisation of feed oil in weaner pig diets with a concomitant increase in growth. However the absorbent nature alone of dietary zeolite is unlikely to improve pig performance since other absorbent feed additives, such as bentonite has been shown to have no effect on pig growth (Tavener et al., 1984).

A recent study conducted in Yugoslavia (Stojic et al., 2003) may provide an interesting insight into the growth promoting effect of dietary zeolite. These authors investigated serum levels of insulin and insulin-like growth factor I (IGF-I) with new-born piglets treated orally with a 10 ml suspension containing 15% clinoptilolite. Serum IGF-I increased significantly following clinoptilolite treatment and there was a non-significant 20% increase in serum insulin associated with a high variation in insulin levels between piglets. These findings suggest that dietary clinoptilolite may be associated with an increase in endogenous growth hormone production in young piglets with a concomitant increase in growth. The mechanism underlying an increase in serum IGF-I following ingestion of clinoptilolite is uncertain but further studies with dietary NZ 76 zeolite should examine circulating IGF-I levels in weaner pigs.

The current study highlighted the need to reformulate diets when feeding additives such as NZ 76 zeolite. Dietary DE level was maintained at 15 MJ with additions of feed oil and full-fat soya bean meal. In addition amino acid levels were maintained relative to lysine at 0.82 g/MJ DE with additions of free amino acids and protein sources, such as blood and soya bean meal. This method of diet formulation differed from previous investigators (Malagutti et al., 2002; KLC Environmental – unpublished) who added zeolite directly to existing diets. Hence experimental design was confounded by dilution of dietary amino acid and DE content which appears to have compromised any growth improvement associated with dietary zeolite.

This study provided the first evidence in Australia of a positive growth response when NZ 76 zeolite powder was fed to weaner pigs. Despite an increase in diet cost when formulating diets containing zeolite, this study found that the improvement in daily gain was achieved with no increase in diet cost per kg of live weight gain. Provided diets containing zeolite are reformulated to maintain DE and amino acid content, this study suggests that NZ 76 zeolite provides a cost-effective means of improving live weight gain in weaner pigs. Further independent studies are warranted to repeat the current study and to examine the growth response to dietary NZ 76 zeolite when pigs are maintained in group pens in a commercial environment.

Acknowledgements

My particular thanks to Mr Lachlan Barker and Mr Kerry James for their skilled technical assistance during this study. My thanks also to Ken and Sue Crawford from Boggabri NSW who provided the diets, pigs and the pig transport to and from EMAI. The diets were formulated by Mr Chris Brewster, NSW Agriculture, Yanco Agricultural Institute, Yanco NSW and feed preparation was conducted by Peter Pryde and staff of Prydes Stockfeeds at Gunnedah.

References

BAKER, D.H. and CHUNG, K.T. 1992. Ideal protein for swine and poultry. Biokyowa Technical Review. No. 4, p 16. (Biokyowa, Inc.: Chesterfield, Mo, USA)

MALAGUTTI, L., ZANNOTTI, M. and SCIARAFFIA, F. 2002. Use of clinoptilolite in piglet diets as a substitute for Colistine. *Italian Journal of Animal Science.* **1:** 275-280.

PEARSON, G., SMITH, W.C. and FOX, J.M. 1985. Influence of dietary zeolite on pig performance over the liveweight range 25-87 kg. *New Zealand Journal of Experimental Agriculture.* **13:** 151-154.

POND, W.G. and YEN, J.T. 1982. Response of growing swine to dietary clinoptilotlite from two geographic sources. *Nutrition Reports International.* **25:** 837-848.

POND, W.G. and YEN, J.T. 1987. Effect of supplemental carbadox, an antibiotic combination, or clinoptilolite on weight gain and organ weights of growing swine fed maize or rye as the grain sources. *Nutrition Reports International.* **35:** 801-809.

POULSEN, H.D. and OKSBJERG, N. 1995. Effects of dietary inclusion of zeolite (clinoptilolite) on performance and protein metabolism of young growing pigs. *Animal Feed Science and Technology.* **53:** 297-303.

STOJIC, V., GVOZDIC, D., NIKOLIC, J.A., SAMANC, H., JOVOANOVIC, I., TOMOASEVIC-CANOVIC, M. and VUJANAC, I. 2003. The serum levels of insulin and IGF-I in newborn piglets treated with clinoptilolite. *Acta Veterinaria Beograd.* **53:** 219-228.

TAVERNER, M.R., CAMPBELL, R.G. and BIDEN, R.S. 1984. A note on sodium bentonite as an additive to grower pig diets. *Animal Production.* **38:** 137-139.