



BEAR RIVER ZEOLITE

SWINE RESEARCH REVIEW

The benefits of clinoptilolite, a volcanic mineral

This document was prepared to provide a compilation of data from world-wide zeolite (clinoptilolite) studies to be used as an informational resource. Benefits from studies cannot be claimed by Bear River Zeolite, Co. due to U. S. and Canadian government restrictions.

Research articles report numerous benefits from clinoptilolite inclusion in swine nutrition at all stages of growth. The improvements in the health status of animals, litter sizes, weight gains, survival rates and meat quality have increased profits. Clinoptilolite is also excellent for odor control and the conservation of nitrogen in manure for soil additive use.



HEALTH AND PRODUCTIVITY



MANURE MANAGEMENT



FINANCIAL GAINS



“The performance of clinoptilolite is related to purity, physiochemical properties, particle size and inclusion rate.” Bujnak 2015

PURITY

- High clinoptilolite content will reduce the inclusion rate needed to return optimum benefits.
- Less material reduces freight and labor costs, and reduces the space required for storage.

PHYSIOCHEMICAL PROPERTIES

- Higher CEC (cation exchange capacity) enhances ammonium adsorption.
- Clinoptilolite can hold up to 60% of its weight in water.
- Higher Ca (calcium) acts as a buffer and enhances bone development.
- Low Na (sodium) levels are beneficial when manure is applied to soil, because sodium is toxic to plants and creates hard pan in clay soil.

PARTICLE SIZE

- Small particles of clinoptilolite provide more surface area and better adsorption than larger particles.

INCLUSION RATE

- Clinoptilolite is approved by the FDA and CFIA for use as a flow/anti-caking agent in feed at up to 2% inclusion of the total mixed ration.
- The piglet inclusion rate is 0.5%.

HEALTH AND PRODUCTIVITY

BENEFITS FOR ALL STAGES OF GROWTH

Papaioannou 2002, Stojic 2003, Sardi 2002, Defang 2009, Bujnak 2015, Papaioannou 2004, Kyriakis 2002, Tomasevic-Canovic 2003

- Binds ammonium in the animal to prevent toxic level build up that causes intestinal epithelial damage.
- Increases energy available for growth, resulting in higher bodyweight.
- Maintains or restores the digestive enzyme activity required to break down and digest feed.
- Slows intestinal transit rate of feed for increased nutrient assimilation.
- Increases survival rate.
- Clinoptilolite is compatible with antibacterial medication (chlortetracycline, enrofloxacin, salinomycin).
- Dietary use of clinoptilolite has been shown to sequester mycotoxins, which reduces the gastrointestinal absorption of ochratoxin, aflatoxins and ZEA (zearalenone).
- Clinoptilolite reduces the detrimental effects of ZEA toxicosis for reproductive performance, larger litter sizes, higher birth weights, and a reduction of piglet birth defects.



Zearalenone (ZEA)

BENEFITS SPECIFIC TO EACH STAGE OF GROWTH

GESTATION (conception to parturition)

Papaioannou 2002, Kyriakis 2002

Reproductive performance was significantly improved with clinoptilolite

- Higher mating and farrowing rate: 92.5% for the clinoptilolite group versus 85.8% for the control group.
- Increases litter size.
- Increases number of piglets born alive.
- Clinoptilolite increases piglet birth weight.
- Improved sow feed efficiency for energy and nutrients to support farrowing and lactation for healthier piglets.





FARROWING (birth to weaning, at approximately 13 - 15 lbs.)

Devillers 2011, Stojic 2003

Pre-weaning mortality rates as high as 50% can occur within 3 days after birth. Colostrum intake in the first hours of life transfers passive immunity (IgG [immunoglobulin]) that is essential for the survival and development of nursing piglets and has long term effects on their growth.

- Clinoptilolite inclusion in colostrum showed a 60% increase in IgG absorption in newborn piglets at 24 hours postpartum, which reduces the mortality rate with increased immunity.
- 20% increase in blood insulin levels with clinoptilolite inclusion, partly due to an increase in insulin absorption in the intestine.



NURSERY (weaning, to approximately 50 - 60 lbs.)

Papaioannou 2004

Post Weaning Diarrhea Syndrome (PWDS) occurs when high levels of enterotoxin *Escherichia coli* (*E. coli*) develop in the intestine. Weanlings are susceptible to PWDS during the first 14 days due to stressors from changes in environment, nutrition and growth.

- Clinoptilolite added to weaning feed is beneficial for the control of PWDS.
- Reduced weaning mortality rate by 28.7%.
- Adsorbs *E. coli* enterotoxin to control PWDS.
- Reduction of PWDS occurrences.
- PWDS was less potent and had a shorter duration when it did occur.



GROWING AND FINISHING (to approximately 240 to 280 lbs. market weight)

Defang 2009, Yannakopoulos 2000, Sardi 2002

- Lower feed conversion ratio (FRC) and 9% greater feed efficiencies.
- Increases daily weight gain – more efficient conversion of feedstuff to animal protein.
- Reduces days to market weight.

MANURE MANAGEMENT

ODOR CONTROL *Ndegwa 2008, Sakrabani*

Ammonium generates ammonia gas, which is lighter than air and rises as an aerosol to distribute odors.

- Top Dress Rate: 1 to 2%
- Clinoptilolite used as a top dress for manure, captures ammonium (NH_4^+) before it generates ammonia gas (NH_3) and has been reported to reduce emissions as high as 71%.
- Reduces fly attraction by reducing odor.*
- Improves the air quality in swine facilities, resulting in healthier conditions for animals and workers.

MANURE QUALITY *Bujnak 2015, Sardi 2002*

- Higher total nitrogen retention in manure (crude protein [CP], ammonia [NH_3], dry matter [DM] and volatile fatty acids [VFAs]).
- Reduces moisture in manure because clinoptilolite is a desiccant.

FINANCIAL GAINS

INCREASED MARKET VALUE *Defang 2009, Yannakopoulos 2000, Sardi 2002*

- Increased total gross margin by \$9.83 per clinoptilolite fed pig.
- Higher rate of finished hogs to market.
- Increased carcass length and yield (+3.34% increase in final bodyweight)
- Increased loin and leg yields (clinoptilolite group 12.08% compared to the control group 4.79%)
- Fat content of meat was 33.87% lower (2 lbs. of fat gain requires about three times as much food as 2 lbs. of lean gain).
- Improved lean to fat ratio of cuts; ham, loin and shoulder yield.
- Clinoptilolite pigs had heavier neck, loin and belly.



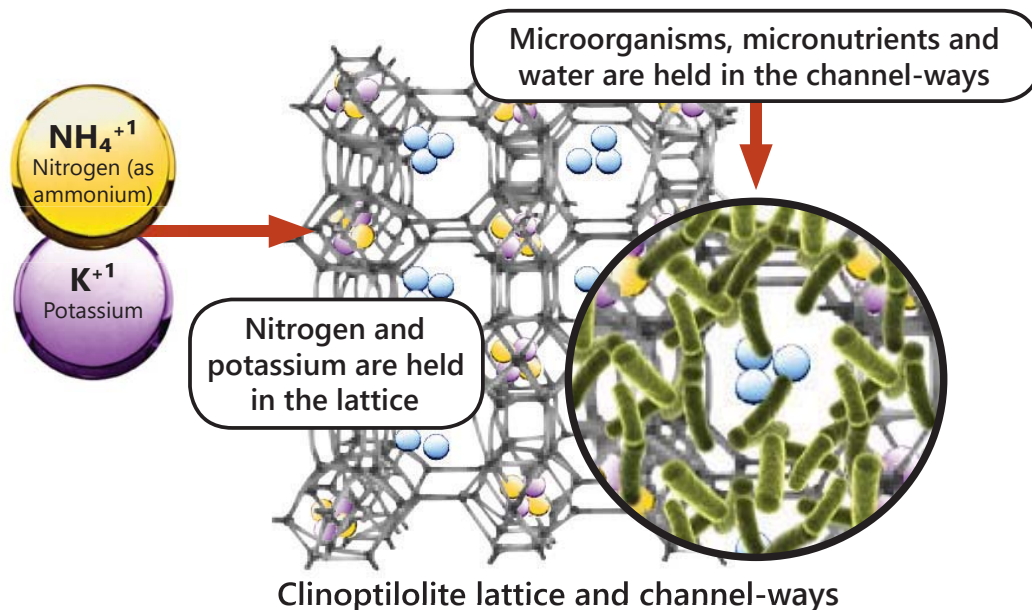
REDUCED PRODUCTION COSTS *Yannakopoulos 2000, Sardi 2002, Papaioannou 2004*

- Reduced feed cost per pig by 5.69%.

How Clinoptilolite Works

Clinoptilolite has the ability to exchange ammonium (NH_4^{+1}) into its lattice through its cation exchange capacity (CEC).*

The clinoptilolite lattices are negatively charged and are able to hold positively charged ammonium (NH_4^{+1}) and potassium (K^{+1}), which are accessible to microorganisms as needed for growth but not water soluble.

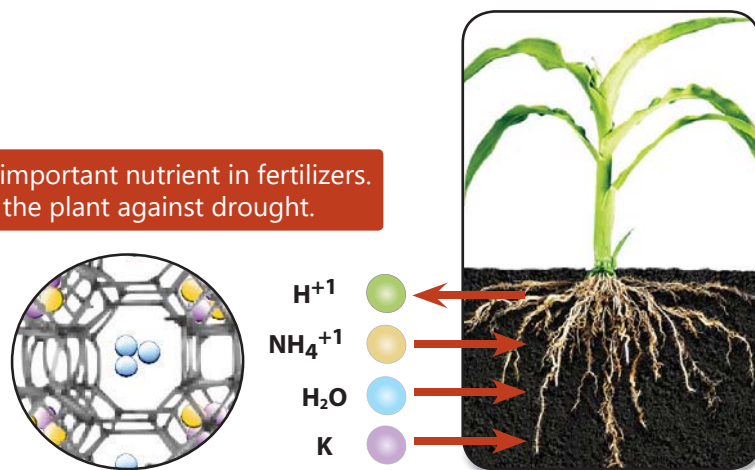


HOW CLINOPTILOLITE WORKS IN THE SOIL*

BRZ™ contains approximately 3.47% potassium, which is an important nutrient in fertilizers. BRZ™ holds at least 55% of its weight in water that protects the plant against drought.

The plant releases hydrogen (H^{+1}) during growth, which exchanges with ammonium (NH_4^{+1}) held in the clinoptilolite lattice, which is plant accessible but not water soluble.

Available water (H_2O) is held in the open pore spaces of the clinoptilolite in the growth zone.



REFERENCES:

Alexopoulos, C., Papaioannou, D.S., Fortomaris, P., Kyriakis, C.S., Tserveni-Goussi, A., Yannakopoulos, A., and Kyriakis, S.C. 2007. *Experimental study on the effect of in-feed administration of a clinoptilolite-rich tuff on certain biochemical and hematological parameters of growing and fattening pigs*. *Livestock Sci.* 111: 230-241.

Bujnak, L., Bindas, L., Maskalova, I., and Vajda, V. 2015. *Effects of zeolite supplementation on some fermentation process characteristics of growing pigs*. *Acta fytotechn. zootechn.* 18 (3): 63-65.

Defang, H.F. and Nikishov, A.A. 2009. *The effect of dietary inclusion of zeolite on performance and carcass quality of grower-finisher pigs*. *Livestock Research for Rural Development* 21(6).

Devillers, N., Le Dividich, J., and Prunier, A. 2011. *Influence of colostrum intake on piglet survival and immunity*. *Animal Consortium*, 5 (10): 1605-1612.

Kyriakis, S.C., Papaioannou, D.S., Alexopoulos, C., Polizopoulou, Z., Tzika, E.D., and Kyriakis, C.S. 2002. *Experimental studies on safety and efficacy of the dietary use of a clinoptilolite-rich tuff in sows: a review of recent research in Greece*. *Microporous and Mesoporous Materials* 51: 65-74.

Laine, T.M., Lyytikäinen, T., Yliaho, M., and Anttila, M. 2008. *Risk factors for post-weaning diarrhoea on piglet producing farms in Finland*. *Acto Vet. Scandinavica* 50 (21).

Ndegwa, P.M., Hristov, A.N., Argo, J., and Sheffield, R.E. 2008. *A review of ammonia emission mitigation techniques for concentrated animal feeding operations*. *Biosystems Engineering* 100: 453-469.

Papaioannou, D.S., Kyriakis, C.S., Papasteriadis, A., Roubies, N., Yanakopoulos, A., and Alexopoulos, C. 2002. *A field study on the effect of in-feed inclusion of a natural zeolite (clinoptilolite) on health status and performance of sows/gilts and their litters*. *Research in Vet. Sci.* 72: 51-59.

Papaioannou, D.S., Kyriakis, C.S., Alexopoulos, C., Tzika, E.D., Polizopoulou, Z.S., and Kyriakis, S.C. 2004. *A field study on the effect of the dietary use of a clinoptilolite-rich tuff, alone or in combination with certain antimicrobials, on the health status and performance of weaned, growing and finishing pigs*. *Research in Vet. Sci.* 76: 19-29.

Sakrabani, R. *Evaluation of zeolite as a binding agent to mitigate ammonia loss from pig slurry and manure*. *Depat. of Natural Resources, School of Applied Science, Cranfield Univ. UK*.

Sardis, L., Martelli, G., Parisini, P., Cessi, E., and Mordenti, A. 2002. *The effects of clinoptilolite on piglet and heavy pig production*. *Italian J. of Ani. Sci.* 1 (2): 103-111.

Stojic, V., Gvozdic, D., Nikolic, J.A., Samanc, A., Jovanovic, I., Tomasevic-Canovic, M., and Vujanac, I. 2003. *The serum levels of insulin and IGF-1 in newborn piglets treated with clinoptilolite*. *Acta Veterinaria (Beograd)*. 53 (4): 219-228.

Tomasevic-Canovic, M., Dakovic, A., Rottinghaus, G., Matijasevic, S., and Duricic, M. 2003. *Surfactant modified zeolites - new efficient adsorbents for mycotoxins*. *Microporous and Mesoporous Materials*. 61: 173-180.

Yannakopoulos, A., Tserveni-Goussi, A., Kassoli-Fournaraki, A., Tsirambides, A., Michailidis, K., Filippidis, A., and Lutat, U. 2000. *Effects of dietary clinoptilolite-rich tuff on the performance of growing-finishing pigs*. in *Natural Zeolites for the third millennium*. Italy, 471-481

*Additional references for background information on file at Bear River Zeolite Co.