



BEAR RIVER ZEOLITE (BRZ™)

POULTRY RESEARCH: The benefits of clinoptilolite, a volcanic mineral

The research cited in this document used clinoptilolite at or below the purity of Bear River Zeolite BRZ™. Study diets were offered free choice. Benefits from some of the studies cannot be claimed by Bear River Zeolite, Co. due to U. S. and Canadian government restrictions. This document was prepared to provide a compilation of information from world-wide zeolite (clinoptilolite) studies as a resource.

Clinoptilolite stands apart from other additives with beneficial results in a broad range of applications.

POULTRY METABOLISM

- EFFICIENT UTILIZATION OF NITROGEN
- INCREASED BONE DENSITY & EGG SHELL STRENGTH
- MYCOTOXIN BINDING
- PATHOGEN REDUCTION
- ANTIOXIDANT SUPPORT

PRODUCTION PERFORMANCE

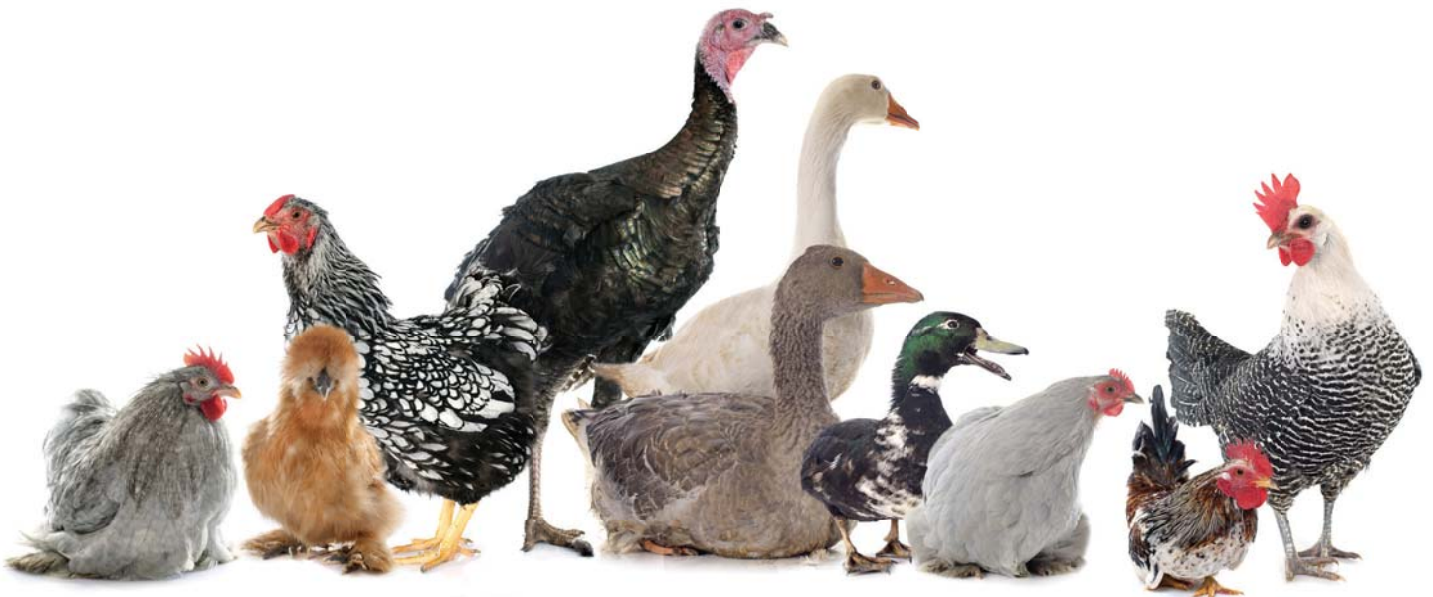
- IMPROVED FEED CONVERSION RATIO (FCR)
- INCREASED WEIGHT GAIN
- ENHANCED MEAT QUALITY
- HIGHER LEVELS OF OMEGA 3 IN MEAT
- INCREASED EGG PRODUCTION

ODOR CONTROL & LITTER QUALITY

- AIR QUALITY CONTROL
- MOISTURE REDUCTION
- IMPROVED LITTER QUALITY

COMPOST & SOIL AMENDMENT

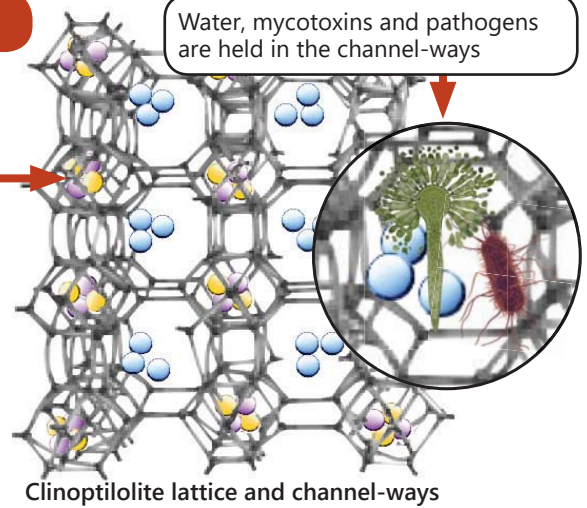
- INCREASED COMPOST VALUE
- IMPROVED SOIL COMPONENTS
- FACILITATED PLANT GROWTH
- HOLDS NITROGEN IN THE GROWTH ZONE
- ABSORBS AND HOLDS MOISTURE



POULTRY METABOLISM



NH_4^{+1}
Nitrogen (as ammonium) is held in the lattice



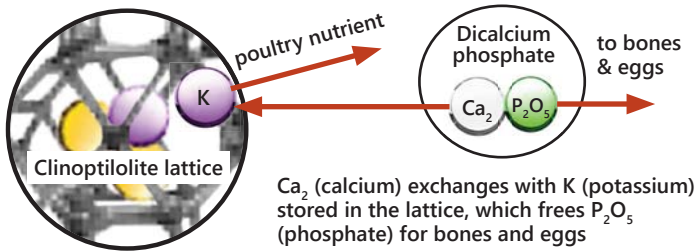
Clinoptilolite lattice and channel-ways

EFFICIENT UTILIZATION OF NITROGEN ^{*,7}

Clinoptilolite has the ability to capture ammonium from feed through its cation exchange capacity (CEC). The lattice structure has a negative charge and holds positively charged ammonium until digestive sodium releases it as an energy source. The gradual release increases the assimilation of nitrogen.

INCREASED BONE DENSITY & EGG SHELL STRENGTH ^{4,6}

The potassium in clinoptilolite exchanges with the calcium in "di-cal" to help solubilize phosphate. The net effect is that the di-cal ration can be reduced because the phosphate is better utilized and bone growth is enhanced.

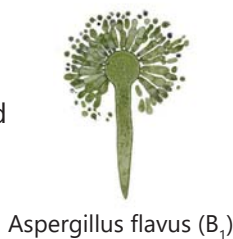


- Clinoptilolite added to the feed mixture resulted in a positive effect on bone health with the absorption of Ca, P, Mg and crude protein in the femur and tibiotarsus.
- Increased tibia density with a 1.5% inclusion rate.
- **Strong leg bones (no rubber legs) and egg shells.**

MYCOTOXIN BINDING ^{4,10,13,14}

Feeding mycotoxin contaminated feed to poultry results in productivity declines, organ damage, a compromised immune system and higher mortality rates.

- Mycotoxin species number over 200, with aflatoxin B₁ considered the most toxic and carcinogenic for animals and humans.
- Mycotoxins can be passed to the consumer through contaminated meat and eggs.



Clinoptilolite is very beneficial as a mycotoxin binder when used as a feed additive in poultry.

- Mycotoxins were bound in open clinoptilolite channel-ways during digestion and safely passed through the bird.
- Clinoptilolite's ability to absorb water reduced the development of fungi and spores in feed.
- As little as 0.5% inclusion rate in broiler diets reduced the toxic effects of aflatoxin B₁ and aflatoxin A.

PATHOGEN REDUCTION ^{1,8,15}

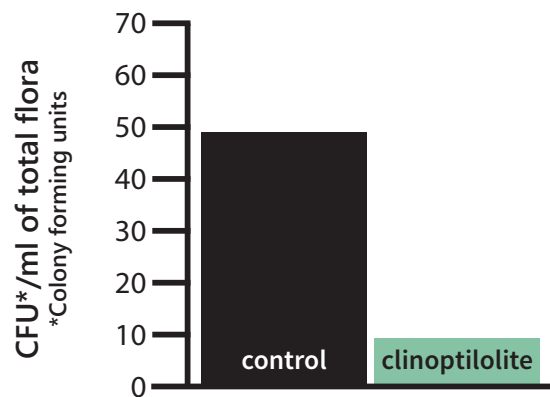
At the processing plant, broilers are often rejected due to visual signs of septicemia infection in organs and membranes (910,595 chickens reported for September 2016, USDA/ NASS Slaughter Report).



Pathogen reduction results in healthy birds and healthy meat and eggs for the consumer.

Clinoptilolite reduces food borne pathogens in broilers and layers. Pathogens are captured on the large surface area of the clinoptilolite channel-ways. The addition of clinoptilolite in feed has returned positive results in poultry studies.

- Feeding 1% clinoptilolite reduced total intestinal flora contamination by over 50%.
- 2% dietary clinoptilolite inclusion significantly reduced flora levels, including *salmonella*.



Clinoptilolite significantly reduced intestinal flora at 45 days with a 1% inclusion rate.

ANTIOXIDANT SUPPORT ¹⁷

Antioxidants are molecules or compounds that neutralize free radicals before they can cause cellular damage. Clinoptilolite is an effective antioxidant when added to the feed ration at 2%.

- Free radicals were inactivated and eliminated when bound in the clinoptilolite lattice.
- Clinoptilolite increased levels of antioxidant enzymes that protect against oxidative stress.

PRODUCTION PERFORMANCE

IMPROVED FEED CONVERSION RATIO (FCR) ^{1,3,4,6,11,12,13,18}

- The high CEC of clinoptilolite enhanced the utilization of nitrogen (energy) from feed during digestion.
- Clinoptilolite particles ground feed within the gizzard and increased digestibility and available nutrients.
- Water was absorbed during digestion and slowed the passage rate of feed increasing nutrient assimilation.
- The dietary inclusion of 2% clinoptilolite lengthened intestinal villi, increasing their capacity to absorb nutrients.
- Fewer adverse effects from mycotoxins and pathogens leaves more energy available for the production of eggs and meat.

Broilers	Efficient feed conversion ratio with 1.5% clinoptilolite inclusion in feed, as shown through the significant increase in body weight gain combined with a marked feed intake decrease.
Laying hens	Results from two additional studies showed that the inclusion of 1% clinoptilolite reduced consumption of feed per egg (4.1 g lower).

INCREASED WEIGHT GAIN ^{8,11}

- Improved weight gain .20 kg / .44 lb at 45 days with 1% inclusion.

	Control	1% Clinoptilolite
Body weight	2.24 (kg) / 4.94 (lb)	2.44 (kg) / 5.38 (lb)



ENHANCED MEAT QUALITY ^{3,8}

- 2% inclusion produced leaner meat.
- 1% inclusion increased the tenderness of broilers, due to water binding in the protein gel network, resulting in less compaction.

HIGHER LEVELS OF OMEGA 3 IN MEAT ⁸

- Increased Omega 3 poly-unsaturated fatty acids in meat when 1% clinoptilolite was added to the ration.

Poly-unsaturated fatty acids	Control %	Clinoptilolite %
Omega 6 (linoleic acid)	19.40	22.77
Omega 3 (linolenic acid)	0.57	0.80



INCREASED EGG PRODUCTION ^{4,13}

- Clinoptilolite added to feed at a 2% inclusion rate showed increased egg shell strength.
- Marked decrease in manure moisture, which resulted in cleaner eggs.
- 1% clinoptilolite inclusion **increased egg production by 5.6 eggs per laying hen** during a 30 week monitored period.

ODOR CONTROL & LITTER QUALITY

AIR QUALITY CONTROL ^{*2, 12,15}

Airsacculitis is the second highest cause for poultry rejection by processing plants. Airsacculitis occurs in facilities with high levels of ammonia, causing inflammation of the air sacs. Airsacculitis leads to infection and compromised immune systems. In one month 452,678 chickens were rejected due to airsacculitis at U.S. processing plants.

The high cation exchange capacity (CEC) of clinoptilolite captures and holds ammonium before it vaporizes to ammonia (gas).

Feeding clinoptilolite is the most effective way to control odors and moisture in the litter and in deep pit manure containment systems by adsorbing the ammonium and absorbing water during digestion.

- Decreased ammonia and volatile organic compound (VOC) emissions with 0.5% Bear River Zeolite BRZ™ added to field study rations.
- BRZ™ reduced VOCs and odor by 51% - 67% in a simulated study when applied on fresh poultry manure.

MOISTURE REDUCTION ^{*4,5,8,11}

Clinoptilolite reduces moisture when fed or applied to litter. **Litter has less liquid and is easier to handle.**

- 2% clinoptilolite in broiler feed reduced moisture and organic content in broiler litter.
- Decreased manure moisture with 1% to 3% clinoptilolite added to the diet of laying hens.

IMPROVED LITTER QUALITY ^{5,8,11}

- **Clinoptilolite decreased organic content (excreta, feed, feathers)** and moisture with 2% dietary supplementation.
- The addition of 1.5% clinoptilolite in a commercial ration reduced turkey footpad lesions and the degree of severity when they did occur.



Turkey foot lesions rated 1 to 4, with 4 the most severe.

Relative value of nutrient content in one ton of broiler and stockpiled litter.⁷

Nutrient	Fertilizer cost (\$/lb)	Broiler house value (\$/ton)	Stockpiled value (\$/ton)
Nitrogen ^a	0.51	18.36	9.18
Phosphate ^b	0.41	27.18	27.88
Potash ^b	0.41	16.03	11.85
Calcium	0.02	0.92	1.22
TOTAL		62.49	50.13

^aAssumes a 0.50 efficiency factor for nitrogen relative to commercial fertilizer.
^bAssumes a 0.85 efficiency factor for phosphate and potash relative to commercial fertilizer.

Poultry manure is a valuable fertilizer with high concentrations of ammonium, phosphorus and potassium. Economic and environmental losses result when nutrients are lost to water supplies and to the atmosphere as ammonia (gas) during composting.^{7,9}

INCREASED COMPOST VALUE^{7,9,16}

One goal of composting is to convert organically bound nitrogen to usable nitrogen compounds, such as ammonium.

- Clinoptilolite adsorbed and held ammonium (NH₄⁺) in its lattice, reducing generation to ammonia (gas) and ground water contamination from nitrates and nitrites.
- Clinoptilolite prevented fly development by reducing compost moisture, and odor from ammonia and VOCs.
- Clinoptilolite absorbs and holds water, which supports compost digesting microbes by reducing moisture overloads that limit essential oxygen.

IMPROVED SOIL COMPONENTS^{9,16,*}

Clinoptilolite keeps the soil loose, mediates pH, holds water and stores nutrients through CEC. Nutrients held by clinoptilolite in the soil are protected from leaching during heavy rains (especially important in areas that have sandy soils). Clinoptilolite holds ammonium through CEC and frees organically bound nitrogen (energy) to plants instead of oxidizing to water soluble nitrates and nitrites that pollute the ground water and to the atmosphere as ammonia (gas).

- High cation exchange capacity (CEC) of BRZ™ allows nitrogen loading of 2.1%.
- BRZ™ has less than 0.5% non-water soluble sodium (a toxin to plants)
- Calcium component of BRZ™ gives it an 8.64 pH, which is a buffer for soils.
- BRZ™ contains 1.6% calcium (worth \$0.91/ton) and 3.47% potassium (a plant nutrient worth \$27.00/ton). **The total value is \$27.91 per ton.**
- BRZ™ holds 55% of its weight in water.
- Low clay content makes BRZ™ hard and resistant to attrition.



FACILITATED PLANT GROWTH^{9,16}

Clinoptilolite's CEC, high surface area and porosity facilitate the gradual release of nutrients and water to support plant production.

- **Water and nutrients are held in clinoptilolite near the root system and available to the plant.**
- As the plant matures it exchanges increasing levels of hydrogen (H⁺) for nitrogen (NH₄⁺) held in the clinoptilolite lattice through CEC.

Bear River Zeolite BRZ™ is 85% to 95% clinoptilolite and contains no significant concentrations of toxic trace elements (none are water soluble). BRZ™ has a general formula of (Na, K, Ca)₂₋₃Al₃(Al, Si)₂Si₁₃O₁₂H₂O. The balance is primarily opaline or non-crystalline silica. Bear River Zeolite BRZ™ is approved by the FDA and CFIA for use as a flow/anti-caking agent in feed at up to 2% inclusion in the ration and is GRAS classified (generally regarded as safe).*

REFERENCES CITED

1. Al-Nasser, A. Y., Al-Zenki, S.F., Al-Saffar, A.E., Abdullah, F.K, Al-Bahouh, M.E. and Mashaly, M. 2011. Zeolite as a Feed Additive to Reduce Salmonella and Improve Production Performance in Broilers. Intl. J. Appl. Poult. Sci.10 (6): 448-454.
2. Cai, L., Koziel, J.A., Liang, Y., Nguyen, A.T. and Hongwei, X. 2007. Evaluation of Zeolite for Control of Odorants Emissions from Simulated Poultry Storage. Animal Industry Report: AS 653, ASL R2212.
3. Christaki, E.V., Florou-Paneri, P.C., Fortomaris, P.D., Tseveni-Gousi, A.S. and Yannakopoulos, A.L. 2006. Effects of Dietary Inclusion of Natural Zeolite and Flaxseed on Broiler Chickens' Body Fat Deposition in an Extended Fattening Period. Arch.Geflügelk., 70(3): 106-111.
4. Herzog, I., Strakova, E. and Suchy, P. 2008. Long-Term Application of Clinoptilolite Via the Feed of Layers and Its Impact on the Chemical Composition of Long Bones of Pelvic Limb (Femur and Tibiotarsus) and Eggshell. Veterinarni Medicina. 53 (10): 550-554
5. Kampf, D. and Bohr, B. 2013. Impact of Clinoptilolite on Litter Quality and Footpad Lesions in Turkeys. 19th European Symposium on Poultry Nutrition. Manuscript of the Poster Presentation no. 260.
6. Kavan, B.P., Shargh, M.S., Hassani, S. and Mostafalo, Y. 2013. Comparison of the Effects of Clinoptilolite and Sodium Zeolite A on Tibia Bone Mineralisation and Calcium and Phosphorus Utilisation in Broiler Chicks. Intl. Res. J. of Appl. and Basic Sci. 4 (11): 3389-3395.
7. Lemus, R. 2016. Using Poultry Litter as a Fertilizer Source in Forage Systems. Mississippi State Extension, February Forage News. 9 (2).
8. Mallek, Z., Fendri, I., Khannous, L., Hassena, A.B., Traore, A.I., Ayadi, M. and Gdoura, R. 2012. Effect of Zeolite (Clinoptilolite) as Feed Additive in Tunisian Broilers on the Total Flora, Meat Texture and the Production of Omega 3 Polyunsaturated Fatty Acid. Lipids in Health and Disease. 11:35.
9. Omar, L., Ahmed, O.H., Majid, N.M. 2015. Improving Ammonium and Nitrate Release from Urea Using Clinoptilolite Zeolite and Compost Produced from Agricultural Wastes. Scientific World Journal.
10. Ortatatli, M., Oğuz, H., Hatipoğlu, F. and Karaman, M. 2005. Evaluation of Pathological Changes in Broilers During Chronic Aflatoxin (50 and 100 ppb) and Clinoptilolite Exposure. Res. Veterinary Sci. 78: 61-68.
11. Parizadian, K.B., Shams, S.M., Hassani, S. and Mostafalo, Y. 2013. Effects of Physical Size of Clinoptilolite on Growth Performance, Serum Biochemical Parameters and Litter Quality of Broiler Chickens in the Growing Phase. Poult. Sci. J. 1(2): 93-104
12. Rhodes, S. 2003. Field Trial: Chicken Odor Control Test. Unpublished research using Bear River Zeolite BRZ™.
13. Straková, E., Suchy, P., Herzog, I., Šerman, V. and Mas, N. 2008. The Long Term Administration of a Clinoptilolite Supplemented Feed to Layers and Its Effects on Performance, Haematological Parameters and Metabolic Profile. Czech J. Anim. Sci. 53 (5): 212-218.
14. Tomašević - Čanović, M., Daković, A., Marković, V. and Stojić, D. 2001. The Effect of Exchangeable Cations in Clinoptilolite and Montmorillonite on the Absorption of Aflatoxin B₁. J. Serb. Chem. Soc. 66 (8): 555-591
15. NASS / USDA. October 2016. Poultry Slaughter. United States Department of Agriculture, National Agricultural Statistics Service. ISSN 1949-158.1
16. Walker, F. On-Farm Composting of Poultry Litter. Univ. Of Tennessee Agricultural Extension Service. P&SS Info # 319.
17. Wu, Q.J., Wang, Y.Q., Zhou, Y.M. and Wang, T. 2015. Dietary Clinoptilolite Influences Antioxidant Capability and Oxidative Status of Broilers. J. Appl. Poul. Res. 00:1-6.
18. Wu, Q.J., Wang, Y.Q., Zhou, Y.M. and Wang, T. 2013. Intestinal Development and Function of Broiler Chickens on Diets Supplemented with Clinoptilolite. Asian Australas. J. Anim. Sci. 26 (7): 987-994.

* Data on file at Bear River Zeolite, Co.