

Activated Zeolite - Animal Feed Additive

Summary of Scientific Literature (Compiled by Michael Leu)

What Are Zeolites?

- Zeolites have a high attraction for water and many positively charged ions (K^+ , NH_4^+ , Ca^{2+} , Na^+ and Mg^{2+}) that can be reversibly bound or released depending on the surrounding conditions (Hay 1978). Zeolites are beneficial feed additives for ruminants because of their high affinity for nutritionally vital species.
- Through their ion-exchange selectivity, zeolite minerals may act as sinks for the adsorption of excess rumen ammonia after feeding and gradually release it as the zeolites are regenerated to their natural state by cations from the saliva. Zeolites provide a more stable rumen environment with respect to N availability, that is beneficial to both rumen microbial fermentation and animal performance (Sweeney T. *et al.* 1983).
- Zeolites have a quantitative effect on digestion by influencing rumen retention time (alteration of rumen turnover of fluid and/or particulate phases of digesta).
- Optimum performance.
- Additionally zeolite can improve the physical properties of the feed by increasing flowability, reducing moisture levels, or as an anti-caking agent.

Effect of Feeding Clinoptilolite to Cows

Bergero D., (1997) Universita di Torino, Via Nizza, Italy

- Beneficial effects on the ammonium levels in rumen fluid and blood serum levels.
- Zeolites and ammonium play important roles in nitrogen and protein supply in the rumen. The ammonium level in rumen fluid is an indicator of rumen nitrogen metabolism with particular reference to ruminal protein degradation.
- Reduction in the cost of cow diets can be made by using urea instead of protein in well-balanced diets. Urea can be effectively used by ruminal bacteria to build body protein (that is afterwards digested and used by the cow as a source of amino acids). A diet with a high percentage of soluble nitrogen can release large amounts of ammonium in the rumen fluid, especially in the ammonium peak, during the initial post-prandial time.
- The use of urea or other sources of non-protein nitrogen (NPN) in dairy cows, such as the use of diets containing high percentages of soluble protein, could cause an increase in rumen pH and ammonium concentration and a subsequent increase in the concentration of ammonium in blood serum. Risks of toxicity can be linked to the increase in both the pH of the rumen and the ammonium levels in blood serum.

- Natural Zeolites have the ability retain excess (adsorb) ammonium in the rumen and to subsequently release this cation when the rumen concentration lowers. The zeolite lowers the risk of toxicity by preventing both a pH increase and an increase of ammonium in the blood serum. The ammonium level is maintained constant (buffered) with beneficial effects on the metabolism of ruminal bacteria.
- Urea level in milk decreases at 5 hours post-prandial time.
- Quote Mumpton and Fisherman (1977): 1% zeolite added to rations resulted in a pH decrease in the rumen, probably due to a lower ammonium content and to an increase in volatile fatty acid production.
- Quote Garcia-Lopez *et al.* (1988): 2 wt% zeolite added to dairy cow feed concentrate increased the milk fat percentage and the acid/base balance.

Effect of Clinoptilolite on Lactating Dairy Cows Fed a Diet Containing Urea as a Source of Protein.

Hemken, R. W. *et al.* (1983) Department of Animal Sciences, University of Kentucky.

- Faecal pH was highest for the urea +clinoptilolite diet (5.64). Faecal starch followed the same trend as faecal pH. A high faecal pH is desirable and can indicate improved energy utilisation. Other studies have shown that as faecal pH increases, faecal starch decreases. Lower faecal starch indicates more complete digestion of dietary starch.
- The effects of faecal starch and faecal pH suggest an effect similar to that noted for limestone and magnesium oxide.
- Body weights were not different due to diets, i.e. zeolite (6%) vs. control.
- Rumen ammonia was lowered by the addition of zeolite. Lower rumen ammonia is considered indicative of improved utilisation of protein.
- The data demonstrated that clinoptilolite alters protein metabolism by reducing blood urea-nitrogen and affects pH in the lower gastrointestinal tract; however, these beneficial changes were not accompanied by increased milk yield.
- A soybean meal (protein source) plus 0.5% urea produced a significant increase in milk yield.
- The blood plasma urea-nitrogen (BUN) was not significantly lower with the addition of zeolite. It was significantly lower in the soybean meal diet.
- Milk fat and milk protein concentrations were not affected by diet.
- Serum Ca, Mg, K and Na was not affected by diet.
- Cows past their peak lactation period were used. Recommended trials on dairy cows in an earlier stage of lactation (may be more responsive).
- Trials led to suggested designs for further study involving developing the optimum zeolite/protein diet.

Effect of Dietary Clinoptilolite on Digestion and Rumen Fermentation in Steers.

Sweeney T. F. *et al.* (1983) Pennsylvania State University

- The ability of zeolites to release ammonium ions gradually is beneficial for microbial synthesis in the rumen, especially in diets containing a high level of nonprotein nitrogen.
- Carried out tests to determine if 5% dietary zeolite (<50 mesh), by nature of its affinity for water and osmotically active cations, affects the rate of passage of liquid digesta from the rumen.
- No differences in the growth rate or average daily intake due to the use of clinoptilolite were noted.
- Zeolite added to a high N-solubility (HNS) diet resulted in increases in both apparent protein and organic matter digestion.
- The zeolite had an affect on acid-detergent fibre (a major component of organic-matter) digestion, increasing fibre digestibility possibly due to the maintenance of suitable levels of NH₃ for enhanced microbial growth in the rumen.
- Faecal dry matter was increased by the addition of clinoptilolite to the diet. The increased faecal dry matter percentage improves environmental conditions in highly confined feedlot situations. Decreases in moisture available for microbial growth in faeces contributes to improved animal health through cleaner air and reduced disease communication.
- Blood urea-N (BUN) was reduced when clinoptilolite was added to the high HNS diet.
- Zeolite has affinity for cations other than NH₄⁺ and it was noted blood K was reduced by the presence of zeolite in the diets.
- It is well documented that feeding high roughage diets to ruminants is not commonly associated with high incidences of diarrhoea.
- Trial 2: No effect of dietary clinoptilolite was found on rumen pH or NH₃.
- Organic-matter digestibility (3.5% - 4.5%) was increased by the addition of clinoptilolite to the diet. This response may be related to a physical and/or chemical interactions between clinoptilolite, rumen microbes and forage fibre particles.
- Noted no differences in fluid digesta flow from the rumen.
- Improved digestion and metabolism. Improved fibre digestion and rumen fermentation.
- Zeolites promoted an increase rumen acetate production (the precursor of milk fat); feed additive for lactating dairy cattle.

Influence of Zeolite on Growth and Metabolism in the Ruminant.

Sweeney T. F. *et al.* (1980) Ph. D. Dissertation, University of Kentucky.

- Determined clinoptilolite could be used to conserve free ammonia for rumen microbial fermentation and thereby improve nutrient utilisation by ruminant animals.
- Demonstrated improved nitrogen, organic matter, and acid-detergent fibre digestibility when 5% clinoptilolite was added to a high-solubility protein diet of growing steers and heifers.

Addition of Clinoptilolite to the Diets of Feeder Cattle.

Hutcheson, D. P. (1983) Texas Agricultural Experiment Station

- Clinoptilolite (-40 mesh) was added to replace 3% and 5% of diets.
- An adaptation period of two weeks appeared to be required for animals on a diet containing 3% clinoptilolite before intake levels become stabilised. Differing percentages of zeolite, variable results, most nil and some reduced weight gains relative to controls.
- Serum Na was significantly lower after 56 days and whole blood K and serum P increased significantly at 7 days for the animals on the C20 diet. Na and K are not stored by the body and must be supplied daily in the diets. Thus, shifts in serum Na and whole blood K indicate that Na and K levels in the diet must be controlled when feeding clinoptilolite.

The Effect of Zeolite (Clinoptilolite) on the Post-feeding Dynamics of N Metabolism in the Portal Vein, Jugular Vein and the Rumen fluid of Bulls.

Jacobi, U. *et al.* (1984)

- Bulls, live weight 300kg, Urea application 0.2g per kg liveweight, zeolite 2.5% per kg dry matter. After urea administration, Zeolite reduced the ammonia concentration in the rumen by 20 – 40% and in the v. portae by 60 – 70% in comparison with the control group.
- In v. jugularis in the 90th minute after feeding significant hyperammonemia was observed in bulls with no zeolite supplement.

Sorption Characteristics of Natural Zeolite (Clinoptilolite) in Biological Material in Vitro.

Vrzgula, L. and Seidel, H. (1989)

- The sorption by clinoptilolite of arsenic, cadmium, and lead ion from the rumen and abomasum juice was investigated in laboratory conditions.
- Zeolite was found to sorb 91% of lead and 45% of cadmium from rumen fluid in 24 hours. The sorption effectiveness was even higher from abomasum juice where zeolite sorbed 98% lead in 24 hours.

Effect of Clinoptilolite on Rumen Fermentation, Digestion and Feedlot Performance in Beef Steers Fed High Concentrate Diets.

McCollum, F. T. and Galyean, M. L. (1983)

- Obtain a copy.

Kondo *et al.* (1969)

- Reported that clinoptilolite added to the feed of young calves improved growth rate decreased the incidence of diarrhoea (cited by Mumpton and Fishman, 1977).

Homo-Immuno Parameters in Newborn Calves

Nik-Khan A., (2002) Faculty of Agriculture, Tehran University, Iran, Zeolite '02.

- Neonatal calves are born with no immunoglobulins in blood serum and rely on immunoglobulin from colostrum through passive immunity transfer.
- Male and female Holstein calves were fed maternal colostrum plus zeolite (0.5, 1.0, 1.5 and 2.0 grams per kg of bodyweight per day).
- 1gram clinoptilolite per kg of body weight per day had the best effects on increasing serum immunoglobulins, vitamin A adsorption, average daily weight gain, reduction of faecal score and reduction of morbidity and mortality.

Calves in the Postnatal Period

Vrzgula L., (1988) Veterinary University, Czechoslovakia; Jacobi. U. Animal Production and Veterinary Medicine, Humboldt University, Germany.

- Health problems such as alimentary diarrhoea can cause the death of calves up to the second week of life. Treatment with antibiotics is not always effective.
- Zeolite (clinoptilolite) was added (1gram per kg of body weight at every feed) to the colostrum of newly born calves up to the 15th day of life.
- The zeolite decreased the occurrence of both diarrhoea of alimentary origin and an associated respiratory syndrome in comparison to the control. This treatment offers a possibility to decrease the use of expensive antibiotics.
- The zeolite fed calves had a statistically significant increase in the concentration of immunoglobulins in the blood serum.
- The zeolite improved the absorption of immunoglobulins, total proteins and some microelements, especially iron and copper.
- Mechanisms for the positive protective effect of zeolite on the incidence and course of diarrhoea in the alimentary canal: increase in adherency of enteropathogenic *E. coli*; alteration of metabolic acidosis through effects on osmotic pressure in the lumen of intestines.

Nitrogen Nutrition of Cattle in the Southern NT.

Phillips A., (2000) Senior Animal Production Officer, Department of Business, Industry and Resource Development, Alice Springs.

- Nitrogen is an essential animal nutrient required for protein formation (major component of muscle, skin and hair). The N is contained in amino acids, the building blocks of proteins. Amino acids and therefore proteins contain 16% nitrogen. To calculate the crude protein content of a feed multiply the N content by 6.25. Plant protein levels are highest in actively growing tissue and in seeds.
- Mature cattle require 6 – 8% crude (plant) protein in the diet to maintain liveweight.
- Cattle: on entry to the rumen, plant protein is broken down by microbes, that use the protein to grow and reproduce. These microbes are then passed from the rumen and digested in the abomasum (fourth stomach). The majority of protein digested and used by cattle is microbial protein.

- Some nitrogen from plant protein broken down in the rumen is absorbed across the rumen wall as the gas ammonia. The ammonia is absorbed into the bloodstream, converted to urea in the liver and recycled in saliva. Excess urea is excreted in urine.
- Some proteins escape microbial breakdown in the rumen and are passed to the abomasum. These are called bypass proteins. Bypass protein is more efficiently digested than microbial protein because there is less nitrogen loss as ammonia. Protein can be protected from breakdown in the rumen by plant substances called tannins, resulting in bypass protein. High tannin can result in some protein escaping digestion altogether, reducing feed value.
- Protein levels often fall below maintenance requirement in dry feed. This slows rumen microbial activity because microbes cannot grow and reproduce as quickly as normal. Slower feed breakdown results, and less microbial protein passes to the fourth stomach. Feed intake is reduced because the time feed spends in the rumen is increased.

Mycotoxins

Surfactant Modified Zeolites. New Efficient Adsorbents for Mycotoxins. Tomasevic-Canovic, M. *et al.* (2002), Belgrade, Yugoslavia and College of Veterinary Medicine, University of Missouri.

- Mycotoxins are toxic secondary metabolites produced by certain fungi in a number of agricultural products. Mycotoxins contamination may affect as much as 25% of the world's food crops.
- The prevention of mycotoxicosis in livestock can be achieved by the inclusion of mineral adsorbents to bind mycotoxins, thereby decreasing their bioavailability.
- Zeolites effectively absorb mycotoxins containing polar groups, such as aflatoxins.
- Organic modification with amines (surfactant) enables the zeolite to adsorb less polar mycotoxins.

Prevention of Aflatoxicosis in Farm animals by Means of Hydrated Sodium Calcium Aluminosilicate Addition to Feedstuffs: a Review Ramos, A. J. and Hernandez E. (1997), Spain.

- Mycotoxins are a wide group of fungal toxins that have been associated with severe toxic effects (mycotoxicosis) in man and animals. Aflatoxins are the most dangerous of these secondary metabolites.
- There is no definitive way to achieve complete detoxification of food and feed contaminated with mycotoxins.
- Some natural zeolites have a high affinity to absorb aflatoxins, thereby having a protective effect against the development of aflatoxicosis in farm animals.
- Paper postulates a mechanism for the protective effect against aflatoxicosis generated by a sorbent compound obtained by from a natural zeolite.

Minerals for Animal Feed, in a Stable Market.

Loughbrough R., (1993) Assistant Editor, Industrial Minerals

- The use of clays as carriers allows the addition of vitamins; minerals, antibiotics and other active compounds to the feed mix in concentrations under 0.1%.
- Perlite and vermiculite also remove pesticides present in feedstuffs by adsorption and excretion, thus reducing the level of pollutants in both the animal's body and milk.
- Perlite slows the progress of feed through the digestive tract and controls the release of nutrients in the gut. It is also capable of absorbing microorganisms and other components during the process of fermentation in a ruminant's gut.
- Zeolites can be used as binding agents in animal feeds.
- Zeolite's primary values are as growth promoters and carriers of nutrients.
- As growth promoters zeolites appear to act as a buffer in the animal's digestive system, storing nitrogen in the form of ammonium and releasing it gradually by ion exchange with sodium and potassium. The animal receives greater benefit from the same quantity of feed.
- The ammonium absorbing characteristics result in drier faeces and an improved atmosphere in the stables.
- 1993: the US market for zeolites is only 3,000 short tons. A major obstacle to its use in feed is that zeolite would be classified as a drug by the Federal Drug Administration (FDA). Before any claims of its beneficial qualities can be made, it must be approved by the FDA. This process takes several years and costs millions of dollars.

Bentonite.

Negatives

- Bentonite can absorb vitamin A in the animal's gut, so measures have to be taken to ensure ruminants continue to receive the required amount of this material. However some beef producers have found that bentonite's absorption of vitamin A is not a problem and in fact is a benefit. This is because the clay also absorbs carotene (a precursor to vitamin A in the animal's gut) that can cause yellow fat in cattle – an undesirable characteristic (Loughbrough R., 1993).
- Sodium and calcium bentonites are used in animal feeds in Australia. Sodium ****

Other

- ZeoconiX technology: Should be able to load zeolite with animal nutrients (macro, micro), vitamins and anti-biotics. Load or blend with magnesium, calcium and sodium to replace sodium bicarbonate, sodium sesquicarbonate and magnesium oxide in dairy and beef cattle feeds (as per Zeo Inc's Zeo-Carb and Zar-Min); develop effective licks.

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