



LITERATURLISTE: ZEOLITHE ALS FUTTERMITTELZUSATZ

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Diese Literaturliste wurde im März 2009 erstellt und enthält eine Reihe von Publikationen zum Thema "Fütterungsversuche mit Zeolithen". Publikationen, die nur dazu dienen, die Eigenschaften einzelner Markenprodukte zu beschreiben, wurden ausgelassen. Die Sortierung erfolgte alphabetisch nach dem Hauptautor.

Eine Zusammenfassung und einen Kommentar zu dem Thema finden Sie in meinem [Blog](#).

Abad, E., J. J. Llerena, et al. (2002). "Comprehensive study on dioxin contents in binder and anti-caking agent feed additives." *Chemosphere* **46**(9-10): 1417-21.

Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) were determined in some additives widely employed as binder and anti-caking agents in feedstuffs, such as kaolin, bentonite, zeolite, etc. with an special attention on sepiolite samples. Owing to their physico-chemical properties, the little information of these materials reported in the literature, the variability of PCDDs/PCDFs found in a preliminary evaluation and the absence of reference materials highlighted further research needed. Therefore, an extensive study on the analytical procedures based on the classical methods was performed with sepiolite samples. The study includes evaluation of reproducibility and repeatability. To this end, a series of intra-day and nine inter-day analysis were made. The methodolg was also assessed against the sample size and series of 12.5, 25, 37.5 and 50 g were analyzed. In all cases, the results confirmed good correlation with the parameters evaluated.

Bachman, S. E., M. L. Galyean, et al. (1992). "Early aspects of locoweed toxicosis and evaluation of a mineral supplement or clinoptilolite as dietary treatments." *J Anim Sci* **70**(10): 3125-32.

Sixteen crossbred beef heifers were used to determine the efficacy of serum clinical profiles as diagnostic tools for detection of early stages of locoweed toxicity and to test the ability of two mineral supplements for prevention or therapy of toxicosis. Dietary treatments were (DM basis) 1) 100% sorghum sudangrass hay, 2) 80% sorghum sudangrass hay:20% locoweed, 3) 80% sorghum sudangrass hay:20% locoweed plus 100 g of Silent Herder Mineral Mix (a mineral supplement reported to alleviate locoweed toxicity), and 4) 80% sorghum sudangrass hay:20% locoweed plus 100 g of clinoptilolite (a natural zeolite clay). Diets were fed at 1.5% of BW for 28 d, after which heifers had ad libitum access to sorghum sudangrass hay for 14 d. Jugular blood was sampled before feeding every 7 d, and at 2, 4, 6, and 8 h after feeding on d 28. Compared with controls, heifers fed locoweed had elevated (P less than .01) serum alkaline phosphatase activities from d 7 through 35. On d 42, alkaline phosphatase activities in heifers previously fed locoweed were lower (P less than .05) than in control heifers. Serum glutamic oxaloacetic transaminase activities were elevated (P less

than .01) in heifers fed locoweed from d 7 through 42 compared with control heifers. In heifers fed locoweed, serum Fe concentrations were less (P less than .01) on d 7 through 28, but no treatment effects were noted (P greater than .10) on d 35 or 42.(ABSTRACT TRUNCATED AT 250 WORDS)

Ballard, R. and H. M. Edwards, Jr. (1988). "Effects of dietary zeolite and vitamin A on tibial dyschondroplasia in chickens." Poult Sci **67**(1): 113-9.

Four experiments were conducted to determine the effects of dietary zeolites on tibial dyschondroplasia in chicks. All studies used a practical-type corn-soybean meal diet and male broiler chicks from 1 day to 14 or 16 days of age. Vitamin A was added to the diet in the first experiment at levels of 0 or 45,000 IU/kg in addition to full or half required levels of vitamin premix, and in the second experiment at levels of 0, 11,250, 22,500 and 45,000 IU/kg in addition to full requirement levels of vitamin premix. This was done in order to determine if vitamin levels affected expression of tibial dyschondroplasia and, if so, if this expression could be influenced by 1.0% dietary zeolite. A high level of dietary vitamin A caused a lower incidence of tibial dyschondroplasia in Experiment 1 but had no effect in Experiment 2. Zeolite at graded levels of 0, .25, .50, and 1.0% in Experiment 3 and at the 1.0% level in all other experiments consistently caused a higher bone ash and a lower incidence and number of birds exhibiting severe tibial dyschondroplasia. The addition of zeolite to the diet generally had no effect on body weight or gain:feed ratio but reduced tibial dyschondroplasia scores in two of the four experiments. In Experiment 4, the addition of dietary zeolite increased 47Ca absorption but did not influence biological half-life.

Bartko, P., J. Chabada, et al. (1983). "[Supplementation of swine feed rations with zeolite during cage rearing]." Vet Med (Praha) **28**(7): 429-35.

The effect of the addition of zeolite to pig feed ration was studied in the cage rearing system under production conditions. Zeolite was mixed in the COS I and COS II feed mixtures directly in the feed plant, the mixing ratio being 100 kg feed mixture + 5 kg zeolite. The feed mixture was administered in granular form ad libitum. The test group had 648 weanlings and the control group 674 weanlings; the piglets, kept in two-story cages in four sections, were arranged so that the test group could be a mirror-like reflection of the control group. The trial lasted 45 days. The piglets given the fortified feed ration had daily weight gains higher by 0.017 kg and feed consumption lower by 0.234 kg per 1 kg of gain, as compared with the control animals. The costs of the feed ration required for producing a kilogram of gain were 8.55 Cz. crowns in the zeolite group and 9.422 crowns in the control group.

Bartko, P., L. Vrzgula, et al. (1983). "[The effect of feeding zeolite (clinoptilolite) on the health status of sheep]." Vet Med (Praha) **28**(8): 481-92.

Under the experimental conditions of a clinic, zeolite from the N. Hrabovec locality was studied as to its effect on the health condition of sheep. Zeolite was added to the feed mixture at a rate of 0.15 g per 1 kg of live weight daily for

three months. The trials were performed with five sheep of the Merino breed. Five sheep were used as controls. No differences were found in the health condition and general behaviour of sheep fed zeolite and sheep of the control group. Neither were substantial differences observed in the indices of the other parameters under study--actual and total acidity, content of volatile fatty acids in rumen contents, blood picture, content of macroelements and microelements, nor in the transaminase activity of blood serum and acid-base homeostasis in blood. Before the zeolite supplementation of feed ration is introduced in practice, detailed studies should be conducted and the optimum zeolite dose should be determined.

Bogdanov, G. A., A. V. Mikhailov, et al. (2004). "[On the influence of silicate feeding on metabolism of ^{137}Cs in rabbit]." *Radiats Biol Radioecol* **44**(4): 420-5.

The features of ^{137}Cs metabolism in the rabbit's organism when feeding on silicates were investigated. By results of two experiments on rabbits radiosorption by of zeolite, saponit, humolit, vermiculite and palygorskite in the gastrointestinal tract was evaluated. It was found that vermiculite and palygorskite had the strongest influence on processes of accumulation and decorporation ^{137}Cs , when a dose of additives was 5% of the weight of forage.

Bonna, R. J., R. J. Aulerich, et al. (1991). "Efficacy of hydrated sodium calcium aluminosilicate and activated charcoal in reducing the toxicity of dietary aflatoxin to mink." *Arch Environ Contam Toxicol* **20**(3): 441-7.

Mink were fed diets that contained 0, 34, or 102 ppb (micrograms/kg) aflatoxins with or without 0.5% hydrated sodium calcium aluminosilicate (HSCAS) and/or 1.0% activated charcoal (AC) for 77 days. Consumption of the diet that contained 34 ppb aflatoxins was lethal to 20% of the mink, while 102 ppb dietary aflatoxins resulted in 100% mortality within 53 days. The addition of AC to the diet containing 102 ppb aflatoxins reduced mortality and increased survival time of the mink while the addition of HSCAS, alone or in combination with AC, prevented mortality. Histologic examination of livers and kidneys from the mink demonstrated liver lesions ranging from extremely severe in mink fed 102 ppb aflatoxin to mild to moderate in those that received 34 ppb aflatoxins. The addition of HSCAS and/or AC to the diets that contained 102 ppb aflatoxins reduced or essentially eliminated histopathologic lesions in the livers. No histopathologic alterations associated with the dietary treatments were observed in the kidneys.

Bursian, S. J., R. J. Aulerich, et al. (1992). "Efficacy of hydrated sodium calcium aluminosilicate in reducing the toxicity of dietary zearalenone to mink." *J Appl Toxicol* **12**(2): 85-90.

Ovariectomized mink were fed diets containing zearalenone (ZEN) at concentrations of 0, 10 or 20 ppm with or without 0.5% hydrated sodium calcium aluminosilicate (HSCAS) for 24 days. Zearalenone at 10 and 20 ppm caused a significant increase in uterine weights, while 20 ppm ZEN resulted in significantly higher vulva swelling scores when compared to controls. The presence of HSCAS in the diet did not alter these

hyperestrogenic effects of ZEN. In a second experiment, female mink were provided diets containing 20 ppm ZEN, 20 ppm ZEN plus 0.5% HSCAS or a control diet from 1 January 1989 through whelping (25 April to 15 May 1989). The females were given an opportunity to mate with untreated proven breeder males beginning on 1 March (day 59 of exposure). ZEN did not have an effect on the number of females whelping but there was a significant increase in gestation length, a decrease in litter size and an increase in kit mortality from birth to 3 weeks of age when compared to the control group and the group receiving the combination of ZEN and HSCAS. These results suggest that HSCAS can alleviate some of the reproductive effects of ZEN which are not related to its estrogenic action.

Chestnut, A. B., P. D. Anderson, et al. (1992). "Effects of hydrated sodium calcium aluminosilicate on fescue toxicosis and mineral absorption." J Anim Sci **70**(9): 2838-46.

The possibility of supplementing livestock diets with an aluminosilicate to protect them from fescue toxicosis was investigated. An in vitro study showed that hydrated sodium calcium aluminosilicate (HSCAS) removed greater than 90% of the ergotamine from aqueous solutions at pH 7.8 or lower, indicating a high affinity of ergotamine for HSCAS in vitro. Rats fed diets containing tall fescue seed infested (E+) with the endophytic fungus *Acremonium coenophialum* had lower (P less than .05) feed intakes and weight gains than did rats fed diets containing uninfested (E-) tall fescue seed. When feed intake by rats fed the E- seed diet was limited to that of rats fed the E+ seed diet, weight gains did not differ, but testes weights and serum prolactin (PRL) concentrations were lower (P less than .05 and .10, respectively) in rats receiving E+ seed. Supplementing E+ seed diets with HSCAS did not eliminate effects of E+ seed on intake, PRL, or testes weights. Sheep fed E+ tall fescue hay had higher (P less than .05) rectal temperatures than did sheep fed an equal amount of E- tall fescue hay, but OM and N digestion coefficients did not differ between the two hays. Supplementing E+ hay diets with HSCAS did not eliminate the effect of E+ hay on rectal temperatures. Addition of 2% HSCAS to tall fescue hay diets did not affect apparent absorption by sheep of OM, N, Ca, P, Na, K, or Cu, but it reduced (P less than .05) the apparent absorption of Mg, Mn, and Zn. (ABSTRACT TRUNCATED AT 250 WORDS)

Chung, T. K. and D. H. Baker (1990). "Phosphorus utilization in chicks fed hydrated sodium calcium aluminosilicate." J Anim Sci **68**(7): 1992-8.

Two experiments were conducted to evaluate the effects of hydrated Na Ca aluminosilicate (HSCAS) on P utilization of young broiler chicks. Phosphorus-deficient corn-soybean meal diets containing .36% (.134% available) P and 1% Ca were fortified with 0, .05 and .10% P provided as KH₂PO₄ (22.8% P) or feed-grade dicalcium phosphate (18.9% P). Diets were available ad libitum to chicks receiving 0, .50 or 1.0% HSCAS during the period 8 to 22 d posthatching. Weight of tibia ash, percentage of tibia ash and bone-breaking force were regressed on supplemental P intake to assess P utilization in the absence or presence of HSCAS. Tibia parameters (ash weight, percentage of ash and bone-breaking force) responded linearly (P less than .01) to P supplementation. Regardless of P source (KH₂PO₄ or dicalcium phosphate), .5%

or 1.0% HSCAS had no effect (P greater than .1) on P utilization. With no supplemental P, tibia parameters also were not affected (P greater than .05) by HSCAS. Phosphorus utilization from dicalcium phosphate was estimated to be 87% as efficient as that observed for KH₂PO₄. The results suggest that dietary HSCAS does not impair utilization of either phytate or inorganic P.

Chung, T. K., J. W. Erdman, Jr., et al. (1990). "Hydrated sodium calcium aluminosilicate: effects on zinc, manganese, vitamin A, and riboflavin utilization." *Poult Sci* **69**(8): 1364-70.

Three experiments were conducted to evaluate effects of hydrated sodium calcium aluminosilicate (HSCAS, a phyllosilicate) on Zn, Mn, vitamin A, and riboflavin utilization in young broiler chicks. In Experiment 1, addition of either .5% or 1.0% HSCAS to practical corn-soybean meal diets had no effect (P greater than .05) on total tibia Mn content or total liver vitamin A concentration. Total tibia Zn decreased slightly, but linearly (P less than .05), as level of HSCAS increased. Graded increments of riboflavin (0, .6 and 1.2 mg per kg of diet) were added to a riboflavin-free purified amino acid diet to assess riboflavin utilization as affected by HSCAS in Experiments 2 (.5% HSCAS) and 3 (1.0% HSCAS). Linear growth responses to riboflavin were obtained in the absence and presence of HSCAS. Common intercept multiple-linear regression indicated that riboflavin utilization was not affected (P greater than .05) by .5% or 1.0% HSCAS. The results suggest that .5% or 1.0% dietary HSCAS does not impair Mn, vitamin A, or riboflavin utilization, but that Zn utilization is reduced slightly as a result of HSCAS ingestion.

Danilczuk, M., K. Dlugopolska, et al. (2008). "Molecular sieves in medicine." *Mini Rev Med Chem* **8**(13): 1407-17.

During the last few decades microporous and mesoporous materials have been considered for medical use due to biological properties and stability in biological environment. Zeolites have been investigated as drug carriers, and as adjuvants in anticancer therapy, dietetic supplements or antimicrobial agents. This review gives a brief overview of the major aspects of molecular sieves applications in medicine.

Dwyer, M. R., L. F. Kubena, et al. (1997). "Effects of inorganic adsorbents and cyclopiazonic acid in broiler chickens." *Poult Sci* **76**(8): 1141-9.

Previous studies with cyclopiazonic acid (CPA) have indicated that this mycotoxin strongly adsorbs onto the surface of a naturally acidic phyllosilicate clay (AC). The objective of this study was to determine whether AC (and similar adsorbents) could protect against the toxicity of CPA in vivo. Acidic phyllosilicate clay, neutral phyllosilicate clay (NC, or hydrated sodium calcium aluminosilicate), and a common zeolite (CZ, or clinoptilolite) were evaluated. One-day-old broiler chicks consumed diets containing 0 or 45 mg/kg CPA alone or in combination with 1% AC, NC, or CZ ad libitum from Day 1 to 21. Body weight, feed consumption, feed:gain, hematology, serum biochemical values, and enzyme activities were evaluated. Compared to controls, CPA alone reduced body weight at Day 21 by a total of 26% and resulted in a significantly higher feed:gain ratio. Toxicity of CPA was also expressed through increased relative weights of kidney,

proventriculus, and gizzard. Also, there were some alterations in hematology, serum biochemical values, and enzyme activities. Treatment with inorganic adsorbents did not effectively diminish the growth-inhibitory effects of CPA or the increased weights of organs, although there was some protection from hematological, serum biochemical, and enzymatic changes produced by CPA. The results of this study suggest that *in vitro* binding of CPA to clay does not accurately forecast its efficacy *in vivo*; the reasons for this discrepancy are not clear, but they may be related to differences in clay binding capacity and ligand selectivity for CPA *in vitro* vs *in vivo*. Predictions about the ability of inorganic adsorbents to protect chickens from the adverse effects of mycotoxins should be approached with caution and should be confirmed *in vivo*, paying particular attention to the potential for nutrient interactions.

Edwards, H. M., Jr. (1988). "Effect of dietary calcium, phosphorus, chloride, and zeolite on the development of tibial dyschondroplasia." *Poult Sci* 67(10): 1436-46.

The effect of synthetic zeolite was investigated on the development of tibial dyschondroplasia in young broilers fed diets in which the dietary levels of calcium, phosphorus, and chloride ranged from adequate to deficient. In the first two experiments the calcium level was maintained at .65% and four combinations were fed of .30% and .15% chloride and .75% and .50% phosphorus with and without 1% zeolite. Feeding the high phosphorus diet caused a high incidence of tibial dyschondroplasia that was lowered by feeding 1% zeolite. In both experiments the feeding of zeolite at a low level of dietary phosphorus caused a significant lowering of 16-day weight and bone ash. In the third experiment, when diets containing all combinations of .65% and .80% calcium and .50% and .60% phosphorus were fed, the addition of 1% zeolite caused a significant lowering of the 16-day weight, bone ash, and incidence, score, and percentage severe tibial dyschondroplasia. Once again as in the previous two experiments, there was a significant interaction between dietary phosphorus level and zeolite and 16-day weight and bone ash. Feeding zeolite significantly decreased phytate phosphorus retention.

Edwards, H. M., Jr., M. A. Elliot, et al. (1992). "Effect of dietary calcium on tibial dyschondroplasia. Interaction with light, cholecalciferol, 1,25-dihydroxycholecalciferol, protein, and synthetic zeolite." *Poult Sci* 71(12): 2041-55.

A series of experiments was conducted to investigate interactions of dietary calcium levels with ultraviolet light, cholecalciferol (D3), 1,25-dihydroxycholecalciferol [1,25-(OH)2D3], dietary protein, and a synthetic zeolite on the development of tibial dyschondroplasia in broilers. A basal diet low in calcium, high in phosphorus and chloride, and known to promote a high incidence of tibial dyschondroplasia was used. The chicks received ultraviolet radiation from fluorescent lights in addition to 1,100 ICU/kg (27.5 micrograms/kg) of D3 in the basal diet when these were not experimental variables. Regardless of whether the calcium level was low (.65%) or adequate (.95%), the incidence of tibial dyschondroplasia was significantly lower in chicks receiving ultraviolet radiation or dietary vitamin D3 levels well above the required amounts. The addition of 10 micrograms/kg of 1,25-(OH)2D3 to the diet when calcium

levels varied from .45 to .95% resulted in a reduction in the incidence of tibial dyschondroplasia and increased tibial bone ash when dietary protein levels were 18 or 22%. The addition of 1% synthetic zeolite to the diet did not influence the incidence of tibial dyschondroplasia when the diet contained widely varying dietary calcium levels (.65 to 1.81%) and .73% phosphorus.

Eljarrat, E., J. Caixach, et al. (2002). "Determination of PCDDs and PCDFs in different animal feed ingredients." *Chemosphere* 46(9-10): 1403-7.

As result of a study to control feedstuff, analyses were carried out to evaluate the contamination caused by PCDDs and PCDFs in different animal feed ingredients. Thirty two samples were selected, including ingredients of animal and mineral origin. For samples of mineral origin, some additives widely employed as binder and anticaking agents, such as bentonite, damoline, kaolin, magnesite, sepiolite and zeolite were selected. And, for ingredients of animal origin, samples of hemoglobin, animal fat, fish oil, fish meal and meat and bone meal were analyzed. The levels ranged from 0.52 to 9.08 pg WHO-TEQ/g fat for samples of animal origin, and from 0.05 to 460.59 pg WHO-TEQ/g for samples of mineral origin. The higher concentrations were observed for the kaolin samples that presented high levels of dioxin contamination.

Elliot, M. A. and H. M. Edwards, Jr. (1991). "Comparison of the effects of synthetic and natural zeolite on laying hen and broiler chicken performance." *Poult Sci* 70(10): 2115-30.

Three experiments were conducted to investigate the effect of zeolites on laying hens (Experiments 1 and 2) and broiler chickens (Experiment 3). Each experiment used corn and soybean meal-based practical diets. Experiment 1 was a 90-day trial and used 200 40-wk-old laying hens. The basal diet contained 2.75% calcium and .7% total phosphorus. The dietary treatments were the basal diet and the basal diet plus 1.5% synthetic zeolite (SZ; Ethacal). Experiment 2 was a 56-day trial and used 360 36-wk-old laying hens. The dietary treatments were .12, .22, .32, and .42% nonphytin phosphorus with and without 1.0% SZ and 1.0% natural zeolite (NZ; Zar-Min). All diets contained 3.5% calcium. Experiment 3 utilized 240 broiler cockerels from 1 to 16 days. The dietary treatments were two calcium levels (.65 and 1.0%) with and without 1.0% supplementary SZ and NZ. In Experiment 1, egg specific gravity was significantly increased with SZ supplementation. Egg weight and egg production were unaffected. Phytin phosphorus retention and plasma dialyzable phosphorus were significantly reduced by SZ. In Experiment 2, egg specific gravity was not affected by SZ or NZ. Egg weight, egg production, plasma dialyzable phosphorus, and the retention of phosphorus and phytin phosphorus were significantly reduced by SZ with the effect on egg weight and egg production being the most severe at the lower levels of dietary nonphytin phosphorus. Natural zeolite had no effect on egg weight, egg production, plasma calcium, plasma phosphorus, or on the retention of calcium, phosphorus, and phytin phosphorus. In Experiment 3, weight gain and percentage tibia bone ash were significantly reduced by SZ. The SZ had no effect on the incidence and severity of tibial dyschondroplasia. Weight gain, feed efficiency, and the incidence and severity of tibial dyschondroplasia were significantly reduced and the percentage bone ash

significantly increased by 1.0% calcium. Natural zeolite significantly improved feed efficiency and had no effect on any other parameter measured.

Elmore, A. R. (2003). "Final report on the safety assessment of aluminum silicate, calcium silicate, magnesium aluminum silicate, magnesium silicate, magnesium trisilicate, sodium magnesium silicate, zirconium silicate, attapulgite, bentonite, Fuller's earth, hectorite, kaolin, lithium magnesium silicate, lithium magnesium sodium silicate, montmorillonite, pyrophyllite, and zeolite." *Int J Toxicol* 22 Suppl 1: 37-102.

This report reviews the safety of Aluminum, Calcium, Lithium Magnesium, Lithium Magnesium Sodium, Magnesium Aluminum, Magnesium, Sodium Magnesium, and Zirconium Silicates, Magnesium Trisilicate, Attapulgite, Bentonite, Fuller's Earth, Hectorite, Kaolin, Montmorillonite, Pyrophyllite, and Zeolite as used in cosmetic formulations. The common aspect of all these claylike ingredients is that they contain silicon, oxygen, and one or more metals. Many silicates occur naturally and are mined; yet others are produced synthetically. Typical cosmetic uses of silicates include abrasive, opacifying agent, viscosity-increasing agent, anticaking agent, emulsion stabilizer, binder, and suspending agent. Clay silicates (silicates containing water in their structure) primarily function as adsorbents, opacifiers, and viscosity-increasing agents. Pyrophyllite is also used as a colorant. The International Agency for Research on Cancer has ruled Attapulgite fibers >5 microm as possibly carcinogenic to humans, but fibers <5 microm were not classified as to their carcinogenicity to humans. Likewise, Clinoptilolite, Phillipsite, Mordenite, Nonfibrous Japanese Zeolite, and synthetic Zeolites were not classified as to their carcinogenicity to humans. These ingredients are not significantly toxic in oral acute or short-term oral or parenteral toxicity studies in animals. Inhalation toxicity, however, is readily demonstrated in animals. Particle size, fibrogenicity, concentration, and mineral composition had the greatest effect on toxicity. Larger particle size and longer and wider fibers cause more adverse effects. Magnesium Aluminum Silicate was a weak primary skin irritant in rabbits and had no cumulative skin irritation in guinea pigs. No gross effects were reported in any of these studies. Sodium Magnesium Silicate had no primary skin irritation in rabbits and had no cumulative skin irritation in guinea pigs. Hectorite was nonirritating to the skin of rabbits in a Draize primary skin irritation study. Magnesium Aluminum Silicate and Sodium Magnesium Silicate caused minimal eye irritation in a Draize eye irritation test. Bentonite caused severe iritis after injection into the anterior chamber of the eyes of rabbits and when injected intralamellarly, widespread corneal infiltrates and retrocorneal membranes were recorded. In a primary eye irritation study in rabbits, Hectorite was moderately irritating without washing and practically nonirritating to the eye with a washout. Rats tolerated a single dose of Zeolite A without any adverse reaction in the eye. Calcium Silicate had no discernible effect on nidation or on maternal or fetal survival in rabbits. Magnesium Aluminum Silicate had neither a teratogenic nor adverse effects on the mouse fetus. Female rats receiving a 20% Kaolin diet exhibited maternal anemia but no significant reduction in birth weight of the pups was recorded. Type A Zeolite produced no adverse effects on the dam, embryo, or fetus in either rats or rabbits at any dose level. Clinoptilolite had no effect on female rat reproductive performance. These ingredients were not genotoxic in the Ames bacterial test

system. In primary hepatocyte cultures, the addition of Attapulgite had no significant unscheduled DNA synthesis. Attapulgite did cause significant increases in unscheduled DNA synthesis in rat pleural mesothelial cells, but no significant increase in sister chromosome exchanges were seen. Zeolite particles (<10 microm) produced statistically significant increase in the percentage of aberrant metaphases in human peripheral blood lymphocytes and cells collected by peritoneal lavage from exposed mice. Topical application of Magnesium Aluminum Silicate to human skin daily for 1 week produced no adverse effects. Occupational exposure to mineral dusts has been studied extensively. Fibrosis and pneumoconiosis have been documented in workers involved in the mining and processing of Aluminum Silicate, Calcium Silicate, Zirconium Silicate, Fuller's Earth, Kaolin, Montmorillonite, Pyrophyllite, and Zeolite. The Cosmetic Ingredient Review (CIR). The Cosmetic Ingredient Review (CIR) Expert Panel concluded that the extensive pulmonary damage in humans was the result of direct occupational inhalation of the dusts and noted that lesions seen in animals were affected by particle size, fiber length, and concentration. The Panel considers that most of the formulations are not respirable and of the preparations that are respirable, the concentration of the ingredient is very low. Even so, the Panel considered that any spray containing these solids should be formulated to minimize their inhalation. With this admonition to the cosmetics industry, the CIR Expert Panel concluded that these ingredients are safe as currently used in cosmetic formulations. The Panel did note that the cosmetic ingredient, Talc, is a hydrated magnesium silicate. Because it has a unique crystalline structure that differs from ingredients addressed in this safety assessment, Talc is not included in this report.

Enemark, J. M., A. M. Frandsen, et al. (2003). "Aspects of physiological effects of sodium zeolite A supplementation in dry, non-pregnant dairy cows fed grass silage." Acta Vet Scand Suppl 97: 97-117.

The objective of the present study was to monitor serum and urine biochemical changes in dairy cows during and after oral administration of a synthetic sodium aluminium-silicate (zeolite A). A prospective longitudinal study involving four non-pregnant and non-lactating cows was chosen. Cows were randomly allocated to either a control or experimental group. The period of observation was three weeks. During the first week (period 1) cows were maintained on basic ration for the purpose of recording baseline values. During the second week (period 2) control cows were fed a basic diet (grass silage), while cows in the experimental group were fed the basic diet and supplemented with 1 kg zeolite pellets once daily. During the third week (period 3) both groups were fed the basic ration only and observed for any persistent effects after zeolite withdraw. Daily sampling included blood and urine. Selected physiological parameters were compared between groups during period 2 and 3, whereas mean values from period 1, 2 and 3 were compared within the groups. Zeolite supplementation revealed a significant influence on calcium homeostasis. A slight decrease in serum Ca and in renal excretion of calcium was observed in the experimental group at initiation of supplementation, whereas an increment in these parameters was recorded after withdrawal of zeolite supplementation. It is assumed, that zeolite caused a reduction in the availability of dietary calcium during supplementation, which possibly elicited an activation of

calcium mobilisation. The influence of zeolite on calcium homeostasis was not evident from monitoring serum concentration of calcium regulating hormones (PTH, 1,25(OH)2D3, 25(OH)VitD) or renal excretion of markers of bone resorption. Enhanced active intestinal calcium absorption and bone resorption was therefore considered insignificant in the calcium mobilisation under the conditions of this experiment. The origin of the increased amount of Ca, which was observed in serum and urine after zeolite withdraw, is at present unknown, but it is suggested, that the readily mobilized Ca-pool in bone was a contributing factor. An effect of zeolite on phosphate and magnesium homeostasis in the experimental group was evidenced from the values of serum concentration and fractional excretion, which during supplementation were significant lower than in the control group. The influence of zeolite on phosphorus and magnesium is presumed to result from a combination of interference of zeolite with intestinal absorption and a marginal dietary supplementation of these minerals.

Enemark, J. M., C. N. Kirketerp-Møller, et al. (2003). "Effect of prepartum zeolite A supplementation on renal calcium excretion in dairy cows around calving and evaluation of a field test kit for monitoring it." *Acta Vet Scand Suppl* **97**: 119-36.

In a prospective, longitudinal study ten pregnant dry cows were randomly assigned as either experimentals or controls. The experimental period was from 28 days before expected calving until calving. Experimental cows were allocated 800 g of zeolite A daily during week 2 and 3 before expected calving. The zeolite A was given continuously via a feed dispenser. The daily calcium intake was calculated to be 60 g. Daily urine samples were obtained before, during and after the period of zeolite A supplementation. Urine pH was measured immediately whereas the remaining of samples was stored at C until analysis for calcium and creatinine. Urinary calcium/creatinine ratio was used as a measure of renal calcium excretion. Zeolite A supplementation did not affect urine pH. Renal calcium excretion peaked at the first day of supplementation, whereupon it decreased steadily to a level comparable to pre-exposure level. This could be explained by a sudden draw of calcium from the readily mobilizable pool in the bone. A commercial available water hardness test kit was evaluated as a possible cow-side test for monitoring renal calcium excretion. The repeatability of the analysis was acceptable ($CV = 9.3$). The accuracy of the test was good. When compared to laboratory derived urinary calcium/creatinine ratios of the same samples, a distinct linear relationship could be shown ($Y = 7.9E-7 + 1.9E-8$). It was therefore concluded that the water hardness test was able to monitor renal calcium excretion with an acceptable accuracy.

Fethiere, R., R. D. Miles, et al. (1990). "Influence of synthetic sodium aluminosilicate on laying hens fed different phosphorus levels." *Poult Sci* **69**(12): 2195-8.

Two 28-day experiments were conducted utilizing 360 and 180 Leghorn-type hens, 60 and 40 wk of age in Experiments 1 and 2, respectively. In both experiments, a corn-soybean meal basal diet containing no supplemental P was formulated. Dicalcium phosphate was added to the basal diet to supply 0, .05, and .13% supplemental P in Experiment 1 and 0, .13, and .35% supplemental P in Experiment 2. In both

experiments, diets were fed with 0 and .75% synthetic sodium aluminosilicate (SAS). The basal diet was calculated to contain .30% P. In Experiment 1, egg production was significantly increased by the addition of .13% supplemental P. When SAS was added to each diet, a decline in egg production and feed consumption was observed. Egg specific gravity increased and egg weight decreased in the presence of SAS. In Experiment 2, egg production was significantly depressed by SAS in the absence of supplemental P and returned to normal with supplemental P. Feed consumption was significantly depressed by adding SAS to diets containing 0 to .13% supplemental P but not to diets containing .35% supplemental P. Egg weight decreased and specific gravity increased when SAS was supplemented to the diet. Data from these two experiments indicate that adequate P intake is advised when using SAS because feed consumption, egg production, and egg weight were decreased in the presence of SAS.

Fethiere, R., R. D. Miles, et al. (1994). "The utilization of sodium in sodium zeolite A by broilers." Poult Sci 7 (1): 118-21.

Two identical experiments were conducted with 1-d-old broiler chicks to determine whether the Na in sodium zeolite A (SZA) was utilizable. Three male and three female chicks were randomly assigned to each of eight replicate pens per treatment. A corn-soybean meal basal diet was formulated to contain supplemental levels of 0, .02, .04, .06, .08, and .16% Na from either SZA or NaCl. The diets were isocaloric and isonitrogenous. The Cl level within each dietary Na level was kept constant. Feed and deionized water were offered for ad libitum consumption throughout each 21-d experiments. In both experiments, broiler body weight was increased with each addition of Na from either NaCl or SZA. In Experiment 1, the addition of Na, whether from NaCl or SZA, resulted in an improvement in feed consumption and feed conversion compared with birds fed the control diet. In Experiment 2, body weights of birds fed .04 to .08% Na from SZA were heavier than those fed the same levels from NaCl. Overall the addition of Na from SZA or NaCl resulted in an improvement in body weight, increased feed consumption, and improved feed conversion. Data from these experiments indicated that the Na in SZA was able to be utilized by broilers as efficiently as the Na from NaCl.

Firling, C. E., G. L. Evans, et al. (1996). "Lack of an effect of sodium zeolite A on rat tibia histomorphometry." J Bone Miner Res 11(2): 254-63.

Cell culture studies suggest that the aluminum silicate polymer sodium Zeolite A (SZA) increases bone cell proliferation and extracellular matrix production. This study in rats investigated the short-term (2 weeks) and long-term (18 weeks) *in vivo* effects of SZA on growth rate (weight gain) and tibia histomorphometry. In separate short-term experiments, female (experiment 1) or male (experiment 2) Sprague-Dawley rats grown and maintained on normal calcium diets were gavaged daily during a 2 week treatment period with 30 mg/kg, 100 mg/kg, or 500 mg of SZA/kg of rat body weight. In the long-term study (experiment 3) ovariectomized (OVX) rats were fed a low calcium diet containing 0, 1.80, and 9.00 g of SZA/kg of diet (0, 125, and 617 mg/kg of body weight, respectively). Short- and long-term treatment of growing rats with SZA resulted in a dose-dependent increase

in bone aluminum. In the first experiment, growing intact female rats showed no significant SZA dose-dependent response in growth rate (weight gain) or histomorphometry of cortical bone in the tibial diaphysis or cancellous bone in the secondary spongiosa of the tibial metaphysis. In the second experiment, growing male rats, with right hind limbs immobilized by unilateral sciatic neurotomy, showed no SZA dose-dependent response in growth rate. The longitudinal growth of cancellous bone in the tibia of the denervated limb and the intact contralateral limb were not influenced by sciatic neurectomy and/or by treatment with SZA. Histomorphometry demonstrated that cortical bone mass and formation was reduced in the sciatic-sectioned limb when compared with the contralateral intact limb of vehicle-treated rats, as evidenced by significant reductions in static measurements of cortical bone area (-8.5%) and cross-sectional area (-4.8%) and in calculations of the periosteal formation rate (-33.8%) and mineral apposition rate (-31.6%), and the endocortical formation rate (-35.5%) and mineral apposition rate (-37.9%). The cancellous bone mass of denervated limbs of vehicle-treated rats was also deficient, as evidenced by decreased cancellous bone area (-39.1%) and perimeter (-31.9%). The bone mineral apposition rate was decreased (-26.7%) indicating reduced osteoblast activity. Treatment with SZA did not influence these indices in the tibiae of either sciatic-sectioned limbs or contralateral intact limbs. In the long-term experiment, OVX resulted in a dramatic 88% decrease in cancellous bone volume which was prevented by treatment with 17 beta-estradiol and not influenced by treatment with Zeolite A. The increases in osteoblast and osteoclast number following OVX were not influenced by SZA. The results indicate that SZA treatment has no anabolic effect on cortical and cancellous bone formation and mass in normal growing female rats and that this compound does not protect against osteopenia due to reduced load bearing in the growing male rat or gonadal hormone deficiency in adult female rats.

Frost, T. J., D. A. Roland, Sr., et al. (1992). "The effect of sodium zeolite A and cholecalciferol on plasma levels of 1,25-dihydroxycholecalciferol, calcium, and phosphorus in commercial Leghorns." *Poult Sci* 71(5): 886-93.

Three experiments were conducted to determine possible mechanisms involved in improving eggshell quality with sodium zeolite A (SZA) (trade name Ethacal feed component), and cholecalciferol (vitamin D3) by studying the effect of dietary supplementation of SZA and vitamin D3 on plasma 1,25-dihydroxycholecalciferol [1,25-(OH)2 D3], ionic calcium (Ca++), normalized calcium (nCa++), total calcium (TCa), percentage Ca++ to TCa (PCa++), pH, and phosphorus (P). In Experiment 1 (2 x 2 factorial arrangement of treatments), two levels of SZA (0 and .75%) and two levels of vitamin D3 (0 and 175 ICU/kg) were fed. In Experiment 2, five levels of vitamin D3 (100 to 500 ICU/kg) and two levels of SZA (0 and .75%) were fed using a 2 x 5 factorial arrangement of treatments. In Experiment 3, hens were fed two levels of SZA (0 and .75%). Blood samples were collected at 0 (Experiments 1, 2, and 3), 7, 14, and 21 h (Experiment 3) postoviposition (POP). In Experiments 1 and 2, decreasing vitamin D3 decreased plasma 1,25-(OH)2 D3 and P. Plasma TCa decreased when 0 ICU vitamin D3 was fed (Experiment 1), but was not affected by vitamin D3 level in Experiment 2. Supplemental SZA had no effect on plasma 1,25-(OH)2 D3, TCa, or P in Experiments 1 and 2. In Experiment 3, plasma 1,25-(OH)2 D3 and P peaked at

14 h POP, but Ca++ was lowest at 14 h POP. Circadian rhythms for plasma 1,25-(OH)2 D3, Ca++, and P were not affected by SZA. There were no significant effects due to dietary SZA on plasma 1,25-(OH)2 D3, TCa, Ca++, PCa++, nCa++, pH, or P.
(ABSTRACT TRUNCATED AT 250 WORDS)

Gajewska, J., M. Fabijanska, et al. (2002). "Microbiological studies of feed and faeces of fatteners fed mixtures containing naked oat and permutite." *Acta Microbiol Pol* 1 (1): 63-9.

Quantitative and qualitative microbiological studies of feed mixtures and faeces of fatteners with body weight approximately 70 kg receiving complete mixtures: group I (control)--55% barley, II--55% naked oat, III--55% naked oat + 3% permutite were conducted. All mixtures were supplemented with the same protein concentrate for fatteners. It was found that feeding the fatteners with mixtures containing naked oat had a favourable effect on the composition of the faecal microflora, with increased participation of Lactobacillus spp. bacteria. The addition of permutite did not visibly affect the composition of the microflora and the observed differences between the groups can be attributed to the species of cereal in the feed mixture, with naked oat being far more favourable than barley. The addition of permutite seems to have a beneficial effect on the condition of the faecal matter of these animals, which contained a larger number of Saccharomyces spp. cells.

Galyean, M. L. and R. C. Chabot (1981). "Effects of sodium bentonite, buffer salts, cement kiln dust and clinoptilolite on rumen characteristics of beef steers fed a high roughage diet." *J Anim Sci* 2(5): 1197-1204.

Five ruminally cannulated Hereford steers (average weight 340 kg) were used in a 5 x 5 Latin square design experiment to examine the influences of dietary sodium bentonite (SB), McDougall's buffer salts (MB), cement kiln dust (KD) and clinoptilolite (CLN) on rumen liquid dilution rate, fermentation patterns and roughage intake. Treatments were administered as 350-g additions to a basal protein/energy supplement of 2.62 kilograms. The basal diet of cottonseed hulls was offered ad libitum. Mineral analyses of the four treatment substances revealed fairly high levels of potentially toxic trace minerals (e.g., Pb, Cd and F) in the KD. Intake of cottonseed hulls was not significantly affected by treatment but tended to be higher for MB-supplemented steers (7.19 kg) than for those given the control or other treatments (average 6.72 kg). Some rejection of supplements containing MB and KD was noted. At e hr after supplement feeding rumen pH of MB-treated steers (6.68) was higher (P less than .05) than that of steers fed KD (6.50) and CLN (6.44) but was not different from that od control or SB-treated steers (6.56). Seven hours after supplement was offered rumen pH of MB steers (6.74) was higher (P less than .05) for steers fed MB, KD and CLN than for SB-an control-fed steers. Volatile fatty acids, rumen ammonia, osmolality and protein and ash contents of a crude bacterial fraction were not significantly influenced by mineral compounds, nor was rumen liquid volume. Values for rumen liquid volume were as follows: MB (60.27 liters), SB (50.43 liters), CLN (45.53 liters), control (43.14 liters) and KD (41.81 liters). Liquid dilution rate (percentage per hour) was high for steers on all treatments (average of 9.11) and was not significantly altered by mineral supplementation.

Gerasev, A. D., G. A. Sviatash, et al. (2003). "[Effect of natural zeolites on renal functions and water-salt metabolism in rats]." *Ross Fiziol Zh Im I M Sechenova* **89**(7): 879-87.

In vivo experiments on adult Wistar rats, it has been found that intake of natural zeolites resulted in temporary decrease of renal water, sodium and potassium excretion. At the same time, reabsorption of water and electrolytes increased. This effect was due to the stimulation of Na⁺, K(+)-ATPase activity in thick ascending limb of Henle loop and hormonal changes: increase of insulin, thyroxin and aldosterone concentration in plasma. The water and ion content in most of the tissues under study was higher in the experimental group than in control. It has been suggested that renal response in rats with zeolites intake was compensatory lower as a result of gastrointestinal losses of ions and ion accumulation in tissues.

Goetsch, A. L., D. L. Galloway, Sr., et al. (1993). "Effects of various supplements on voluntary intake and performance by growing cattle consuming forage moderate to high in crude protein." *Arch Tierernahr* **44**(2): 163-74.

Growing cattle were supplemented with substances to lessen or increase ruminal ammonia level to determine if consumption of moderate- to high-crude protein (CP) forage is limited by high ruminal ammonia absorption. In Experiment 1 (5 x 5 Latin square), five Holstein steers (198 kg) had ad libitum access to alfalfa cubes (17% CP) without supplementation or with corn at 0.25 or 0.75% body weight (BW) alone (LC or HC) or with 0.06% BW of zeolite (chabazite; LC-Z and HC-Z). Total daily organic water (OM) intake was not affected by treatment (6.08, 6.14, 6.11, 6.19 and 6.09 kg for control, LC, LC-Z, HC and HC-Z, respectively; SE 0.25). In Experiment 2, Simmental crossbred beef calves grazed fescue-clover paddocks in the spring (clipped forage: 21 to 27% CP) for 84 days and were supplemented with 0.25 or 0.75% BW corn alone or with added zeolite (0.06% BW) or lasalocid (0.5 mg/kg BW). Daily gain did not differ among treatments (1.24 to 1.31 kg/day). In Experiment 3 (6 x 6 Latin square), six Holstein steer calves (168 kg) had ad libitum access to medium-quality, orchardgrass-clover hay (15% CP). Steers received one of the following six treatments: no supplement (Control), 0.35% BW ground corn (C), corn plus 0.049% BW urea (C-U), 0.35% BW soybean meal (S), 0.205% BW feather meal (F) or 0.103% BW feather meal, 0.052% BW blood meal and 0.067% BW corn gluten meal (F-BG). Total daily OM intake was 5.00, 5.14, 5.00, 5.11, 4.84 and 4.70 kg for control, C, C-U, S, F and F-BG, respectively (SE 0.13). In Experiment 4 (6 x 6 Latin square), six Holstein steer calves (226 kg) were fed 0.75% BW of alfalfa cubes (19% CP) plus ad libitum access to medium- to high-quality orchardgrass hay (16% CP). Steers received one of the following six treatments: no supplement (Control), corn at 0.25% BW alone (c) or mixed with 0.12% BW peanut skins (C-PSK), a mix of high-CP feedstuffs high in ruminal escape protein (0.029% BW blood meal, 0.038% BW corn gluten meal and 0.028% BW feather meal; C-REP), 0.139% soybean meal (C-S) or soybean meal plus peanut skins (C-PSK-S). Total daily OM intake was 6.16, 6.25, 6.13, 6.52, 6.50 and 6.60 kg for control, C, C-PSK, C-REP, C-S and C-PSK-S, respectively (SE 0.10). (ABSTRACT TRUNCATED AT 400 WORDS)

Grabherr, H., M. Spolders, et al. (2008). "[Influence of zeolite A supplementation during the dry period of dairy cows on feed intake, on the macro and trace element metabolism around calving and milk yield in the following lactation]." Berl Munch Tierarztl Wochenschr 121(1-2): 41-52.

The object of the present study was to determine the influence of zeolite A, a calcium binder from the group of the aluminosilicate, on feed intake, macro and trace element metabolism as well as the milk yield in the following lactation in dairy cows. 46 cows were allotted to 2 groups (A--control group and B--experimental group). They were fed a total mixed ration (TMR) ad libitum 2 weeks before calving. Additionally the cows in group B received 90 g zeolite A/kg dry matter (DM). The individually feed intake was registered daily. The serum was analysed for Ca, Mg, and Pi (inorganic phosphate), Fe, FFA (free fatty acid) and beta-HB (hydroxybutyrate) and the plasma for the trace elements Cu, Zn, and Mn. After calving the milk yield (FCM) and the milk composition (fat, protein, lactose and urea) were analysed. Feed intake of group B, amounting to 6.2 +/- 1.3 kg DM/d was around 48% lower as compared to 12.0 +/- 1.4 kg DM/d for group A. The zeolite addition into the TMR showed a stabilizing effect on the average Ca concentration in the serum around calving. This effect led to a significantly lower Mg concentration on the day of calving and 1 day post partum. The Pi concentration was significantly lower already after the 1st week of zeolite supplementation and on the day of calving as compared to group A. There was no essential effect of zeolite A on the trace element concentration. The depression of feed intake for group B led to a significant increase of FFA one week after beginning zeolite supplementation and of beta-HB around calving. The feed intake post partum as well as the milk yield were not affected by zeolite supplementation. Because decreased feed intake of group B after zeolite supplementation and the occurred hypophosphatemia, it is not acceptable to use zeolite A in the proved dose for preventing milk fever.

Harvey, R. B., L. F. Kubena, et al. (1993). "Efficacy of zeolitic ore compounds on the toxicity of aflatoxin to growing broiler chickens." Avian Dis 7(1): 67-73.

Commercially available zeolitic ore compounds, when incorporated into the diets at 0.5%, were evaluated for their ability to reduce the deleterious effects of 3.5 mg aflatoxin/kg feed on growing broiler chickens from 1 day to 3 weeks of age. In a series of four experiments, the compounds used included the following: mordenite (particle size of -20 mesh; Zeomite); clinoptilolite (particle size of -20 mesh; Zeobrite); SC Zeolite (particle size of -20 mesh); and clinoptilolite (particle size of -35 mesh; Clino 1) or clinoptilolite (particle sizes of -20 plus +35 mesh; Clino 2). Results demonstrated that 0.5% Zeobrite, Clino 1, or Clino 2 added to aflatoxin-contaminated diets did not significantly ($P < 0.05$) diminish the toxicity of high concentrations of aflatoxin to growing broiler chicks. Zeomite mordenite ore reduced the toxicity of aflatoxin to growing chicks by 41%, as indicated by weight gains, liver weight, and serum biochemical measurements, which compares favorably with its in vitro binding capacity to aflatoxin. SC Zeolite reduced weight-gain toxicity of aflatoxin by approximately 29%.

Harvey, R. B., L. F. Kubena, et al. (1993). "Evaluation of aluminosilicate compounds to reduce aflatoxin residues and toxicity to poultry and livestock: a review report." Sci Total Environ Suppl 2: 1453-7.

The aflatoxins (AFs) are reported to be hepatotoxic, mutagenic, immunosuppressive, and carcinogenic. Methods to prevent, reduce, or remediate AF toxicity and residues in the environment are in great demand. Various AF-detoxification procedures are reviewed with particular emphasis on ammoniation and the use of adsorbent compounds to bind AF. A series of in vivo experiments by the authors are reviewed that evaluated the ability of a specific hydrated sodium calcium aluminosilicate (HSCAS) adsorbent to reduce the toxicity of AF to poultry and livestock and to reduce AF residues in milk. These studies showed that HSCAS forms stable bonds with AF in vitro, and when added to AF-contaminated poultry and livestock feeds, HSCAS is able to protect chickens, swine, and lambs from the deleterious toxic effects of AF and to reduce AF residues in milk of dairy cows and goats. These results indicate that HSCAS, when used in conjunction with other mycotoxin management practices, may prove effective for the preventive management of AF-contaminated feedstuffs in livestock and poultry and may reduce AF residues in the food-chain.

Harvey, R. B., L. F. Kubena, et al. (1991). "Diminution of aflatoxin toxicity to growing lambs by dietary supplementation with hydrated sodium calcium aluminosilicate." Am J Vet Res 2(1): 152-6.

Hydrated sodium calcium aluminosilicate (HSCAS), an anticaking agent for mixed feed, was added to the diets of growing wethers (mean body weight, 34.0 kg) and was evaluated for its ability to diminish the clinical signs of aflatoxicosis. The experimental design consisted of 4 treatment groups of 5 wethers each, consuming concentrations of 0 g of HSCAS and 0 g of aflatoxin (AF)/kg of feed (control; group 1); 20 g of HSCAS/kg (2.0%; group 2), 2.6 mg of AF/kg (group 3); or 20 g of HSCAS (2.0%) plus 2.6 mg of AF/kg (group 4). Wethers were maintained in indoor pens, with feed and water available ad libitum for 42 days. Lambs were observed twice daily and weighed weekly, and blood samples were obtained every 2 weeks for hematologic and serum biochemical analyses and for measurement of mitogen-induced lymphocyte-stimulation index. At the termination of the study, wethers were euthanatized and necropsied. Body weight gain was diminished significantly (P less than 0.05) by consumption of 2.6 mg of AF/kg of feed, whereas body weight of lambs consuming HSCAS plus AF did not differ from that of control wethers. The AF-alone treatment increased serum aspartate transaminase and gamma-glutamyltransferase activities, prothrombin time, and cholesterol, uric acid, and triglyceride values and decreased albumin, glucose, and urea nitrogen values, and urea-to-creatinine ratio. (ABSTRACT TRUNCATED AT 250 WORDS)

Harvey, R. B., L. F. Kubena, et al. (1989). "Prevention of aflatoxicosis by addition of hydrated sodium calcium aluminosilicate to the diets of growing barrows." Am J Vet Res 0(3): 416-20.

Hydrated sodium calcium aluminosilicate (HSCAS), an anticaking agent for mixed feed, was added to the diets of

growing barrows and was evaluated for its potential to ameliorate the clinical signs of aflatoxicosis. The experimental design consisted of 6 treatments of 5 barrows each at concentrations of 0 g of HSCAS and 0 g of aflatoxin (AF)/kg of feed (control), 5 g of HSCAS/kg of feed (0.5%), 20 g of HSCAS/kg of feed (2.0%), 3 mg of AF/kg of feed, 5 g of HSCAS (0.5%) plus 3 mg of AF/kg of feed, or 20 g of HSCAS (2.0%) plus 3 mg of AF/kg of feed. Barrows were maintained in indoor concrete-floored pens, with feed and water available ad libitum for 28 days (from the age of 7 to 11 weeks). Barrows were observed twice daily and were weighed weekly, and blood samples were obtained weekly for hematologic and serum biochemical measurements. At the termination of the study, barrows were euthanatized and necropsied. Body weight gains were diminished significantly (P less than 0.05) by consumption of 3 mg of AF/kg of feed, whereas body weight gain in barrows consuming diets containing HSCAS or HSCAS plus AF did not differ from that in control barrows. Serum enzymatic activities of alkaline phosphatase and gamma-glutamyl transferase and prothrombin time were increased in barrows consuming 3 mg of AF/kg of feed, but not in those consuming HSCAS or HSCAS plus AF. (ABSTRACT TRUNCATED AT 250 WORDS)

Harvey, R. B., T. D. Phillips, et al. (1991). "Effects on aflatoxin M1 residues in milk by addition of hydrated sodium calcium aluminosilicate to aflatoxin-contaminated diets of dairy cows." *Am J Vet Res* 2(9): 1556-9.

Hydrated sodium calcium aluminosilicate (HSCAS), an anticaking agent for agricultural feeds, was added to aflatoxin (AF)-contaminated diets of 3 lactating dairy cows and evaluated for its potential to reduce aflatoxin M1 (AFM1) residues in milk. During phase I, cows were fed alternating diets that consisted of 200 micrograms of AF/kg of feed for 7 days, 0.5% HSCAS plus 200 micrograms of AF/kg of feed for 7 days, and feed with the HSCAS removed for a final 7 days. The AFM1 milk concentrations from the intervals with HSCAS added to diets were compared with those times when HSCAS was absent. The presence of 0.5% HSCAS in feed containing 200 micrograms of AF/kg reduced AFM1 secretion into the milk by an average of 0.44 micrograms/L (from pretreatment of 1.85 micrograms/L to 1.41 micrograms/L with HSCAS, a 24% reduction). Following a 10-day period of noncontaminated feed consumption and no AFM1 residues in the milk, phase II of the study was begun. The same experimental design as phase I was used, but the dosages of HSCAS and AF were changed to 1.0% and 100 micrograms/kg of feed, respectively. The addition of 1.0% HSCAS in feed containing 100 micrograms of AF/kg decreased AFM1 content in the milk by an average of 0.40 micrograms/L (from a pretreatment of 0.91 micrograms/L to 0.51 micrograms/L when HSCAS was present, a 44% reduction). These findings suggest that HSCAS, a high-affinity sorbent compound for AF in vitro, is capable of reducing the secretion of AFM1 into milk.

Huff, W. E., L. F. Kubena, et al. (1992). "Efficacy of hydrated sodium calcium aluminosilicate to reduce the individual and combined toxicity of aflatoxin and ochratoxin A." *Poult Sci* 71 (1): 64-9.

A $2 \times 2 \times 2$ factorial arrangement of treatments consisting of dietary aflatoxin (3.5 micrograms/g), ochratoxin A (2.0 micrograms/g), and hydrated sodium calcium aluminosilicate

(HSCAS, .5%) was used to evaluate the individual and combined effects of these treatments. There were six replicate pens of 10 broilers per pen for each of the eight treatments. The broilers were maintained on these treatments from 1 day to 3 wk of age with feed and water available for ad libitum intake. Aflatoxin and ochratoxin A each significantly decreased body weight, serum protein, albumin, and cholesterol and increased the relative weight of the liver, kidney, and proventriculus. Aflatoxin increased the relative weight of the heart and decreased serum aspartate aminotransferase activity and ochratoxin A increased serum uric acid. The toxicity resulting from the combination of aflatoxin and ochratoxin A was more severe than when either of these mycotoxins were present alone. Addition of HSCAS alone did not alter any of the parameters evaluated. The HSCAS reduced the toxicity of aflatoxin, but had little effect on either the toxicity of ochratoxin A alone or the toxicity resulting from the combination of aflatoxin and ochratoxin A.

Jacobi, U., L. Vrzgula, et al. (1984). "[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]." *Vet Med (Praha)* **29**(4): 207-16.

If easily digestible saccharides are deficient in the feed ration of bulls with the live weight of 300 kg and at simultaneous single application of urea at a rate of 0.2 g per 1 kg live weight, zeolite (with 50.6% clinoptilolite content) administered at a rate of 2.5% per 1 kg dry matter influenced significantly (P less than 0.05) the ammonia concentration in rumen, v. portae and v. jugularis. The rumen contents and blood were sampled at the intervals of 0, 15, 30, 60, 90, 120, 180 and 360 minutes after feeding. Basal feed ration consisted of 1 kg feed mixture and 3 kg meadow hay. After urea administration, zeolite reduced the ammonia concentration in rumen by 20-40% in comparison with the control group and in v. portae by 60-70%. In v. jugularis in the 90th minute after feeding significant hyperammonemia was observed in bulls with no zeolite supplement. Zeolite administration did not influence urea concentration in plasma.

Jain, S. K. (1999). "Protective role of zeolite on short- and long-term lead toxicity in the teleost fish *Heteropneustes fossilis*." *Chemosphere* **9**(2): 247-51.

The high ion-exchange capacity of zeolite (sodium aluminium silicate) enhances the removal of lead from water, thus decreasing its availability to fish. Zeolites are very important in the field of environmental preservation due to the low cost and ecological compatibility. Zeolites can adsorb metallic ions by cation exchange reactions. Continuous exposure of the teleost fish *Heteropneustes fossilis* to sublethal concentrations of lead nitrate in water solution for short (35 days) and long (120 days) periods decreased both the soluble protein, RNA and glycogen contents in the liver and the body weight, but increased the cholesterol content. The presence of zeolite in the exposure solution decreased all of the adverse effects. In fish exposed to zeolite as feed additive, all the parameters improved in comparison to control fish, indicating that zeolites can be used safely in biological systems.

Jandl, J. and J. Novosad (1995). "[In vivo reduction of radiocesium with modified clinoptilolite in sheep]." Vet Med (Praha) **40**(8): 237-41.

The efficiency of the sorbent prepared by immobilization of [Iron(II)hexacyanoferrate(II)] on clinoptilolite--marked as ZEOFe--in reduction of the radiocaesium Cs-137 has been in vivo investigated in sheep. It was found that an application of this modified clinoptilolite affected both primary and secondary resorption of Cs-137 also by interrupting the enteral cycle of radiocaesium in sheep. It was proved that ZEOFe accelerated approx. twice the excretion of Cs-137 from sheep's body. The whole effect resulted in 15 to 50 times lowering of the equilibrium concentration of radiocaesium in the case of constant intake of the contaminated feed and simultaneous application of 50 grams of ZEOFe daily. The actual reduction depends mainly on the way of administration. The reduction of Cs-137 by non-modified clinoptilolite--ZEO--has been investigated, too. More than 10x lower sorption efficiency has been observed in comparison with ZEOFe.

Johnson, M. A., T. F. Sweeney, et al. (1988). "Effects of feeding synthetic zeolite A and sodium bicarbonate on milk production, nutrient digestion, and rate of digesta passage in dairy cows." J Dairy Sci **71**(4): 946-53.

Four rumen-cannulated Holstein cows were fed synthetic zeolite A and NaHCO₃ to evaluate their affect on milk production, nutrient digestibility, rumen fermentation, and rate of digesta passage. Treatments were allocated in a 2 x 2 factorial arrangement within a 4 x 4 Latin-square design. Treatments consisted of control; 1.0% NaHCO₃; 2.0% zeolite; and 1.0% NaHCO₃ plus 2.0% zeolite. A total mixed ration with 50:50 concentrate to forage (80% corn silage, 20% haylage) DM was fed. Intake of DM was lower for cows receiving zeolite (18.7 vs. 20.7 kg/d). Decreases were noted in daily milk (26.3 vs. 28.9 kg/d), 4% FCM (23.6 vs. 25.6 kg/d); milk fat yield (.86 vs. .93 kg/d); milk protein yield (.85 vs. .95 kg/d); and milk protein percent (3.21 vs. 3.34) with zeolite. Digestibilities of DM, organic matter, and crude protein were also decreased by zeolite but ADF digestion was unaffected. Rumen pH was increased, ruminal propionate decreased, and acetate:propionate ratio increased by zeolite. All other VFA plus rumen NH₃ were not affected by treatment. Decreases due to zeolite were observed in liquid fractional rate of passage and liquid flow rate when measured by Cr-EDTA in the feces. No treatment differences were found in fractional rate of passage of feed particles. Addition of NaHCO₃ had no significant effects.

Kartashev, A. G. and A. K. Baskurian (1995). "[Changes in the blood system of white mice with long-term zeolite administration]." Fiziol Zh **41**(1-2): 14-9.

The biological effectiveness of zeolites in the postnatal ontogeny was investigated according to the red blood shoot of white mice during prolonged permanent addition of them to the common ration of food. The use of zeolites in the juvenile period of development induces slight changes in the erythron system. The more prolonged use of zeolites in the involutionary period causes disturbances in adaptation systems of the red blood shoot. In our view the use of zeolites

necessitates elaboration of the time regulation depending on the age state and zeolite feeding of animals.

Katsoulos, P. D., N. Panousis, et al. (2006). "Effects of long-term feeding of a diet supplemented with clinoptilolite to dairy cows on the incidence of ketosis, milk yield and liver function." Vet Rec 19(13): 415-8.

Fifty-two clinically healthy Holstein cows were randomly assigned to one of three groups according to their age and parity. The first group (A) consisted of 17 cows that were fed a concentrate ration supplemented with 1.25 per cent clinoptilolite, the second group (B) consisted of 17 cows fed a ration supplemented with 2.5 per cent clinoptilolite, and the third group (C) consisted of 18 cows, which were fed the basal ration containing no clinoptilolite. The rations were fed from four weeks before the cows' expected parturition dates until the beginning of the next dry period. Blood samples were collected from each animal at the start of the experiment, on the day of calving and then monthly, and analysed for serum glucose, ketone bodies, liver enzymes, blood urea nitrogen (BUN) and total proteins. The milk yield of each cow was recorded monthly. The cows in group B had significantly fewer cases of clinical ketosis during the first month after calving and a higher total milk yield. Feeding the cows with clinoptilolite for a long period had no apparent adverse effects on their liver function, and did not significantly affect the concentrations of glucose, ketone bodies, BUN and total proteins in their serum.

Katsoulos, P. D., N. Panousis, et al. (2005). "Effects on blood concentrations of certain serum fat-soluble vitamins of long-term feeding of dairy cows on a diet supplemented with clinoptilolite." J Vet Med A Physiol Pathol Clin Med 2(4): 157-61.

The objective of the experiment was to investigate the effect of clinoptilolite (a natural zeolite) supplementation in the ration of dairy cows on serum beta-carotene, vitamins A and E concentrations. Fifty-two clinically healthy Holstein cows were randomly assigned to one of three groups according to their age and parity. The first group (group A, n = 17), was offered a concentrate feed supplemented with 1.25% clinoptilolite. The second group (group B, n = 17), was offered a concentrate feed supplemented with 2.5% clinoptilolite. The third group (group C, n = 18), which served as controls, was offered the same concentrate feed without clinoptilolite supplementation. All cows were fed the above concentrates continuously starting 30 days before the expected parturition up to the end of lactation. Blood samples from individual animals were collected just before the start of experiment, at the day of calving and, thereafter, at monthly intervals. All samples were tested for serum beta-carotene, vitamins A and E concentrations. The results showed that the 1.25 and 2.5% supplementation of clinoptilolite had no adverse effect on serum concentrations of beta-carotene, vitamins A and E.

Katsoulos, P. D., N. Roubies, et al. (2005). "Effects of long-term dietary supplementation with clinoptilolite on incidence of parturient paresis and serum concentrations of total calcium, phosphate, magnesium, potassium, and sodium in dairy cows." Am J Vet Res 66(12): 2081-5.

OBJECTIVE: To determine whether dietary supplementation with clinoptilolite affects the incidence of parturient paresis and serum concentrations of total calcium (tCa), inorganic phosphorus (PO₄) (2), magnesium (Mg²⁺), potassium (K⁺), and sodium (Na⁺) in dairy cattle. **ANIMALS:** 52 dairy cows. **Procedure-**Cows were placed into 3 groups. The first 2 groups (group A [n = 17] and group B [17]) were offered a concentrate supplemented with 1.25% and 2.5% clinoptilolite, respectively. The third (group C [n = 18]) served as a control and was offered the concentrate alone. The experiment started 1 month before parturition and lasted until the beginning of the next nonlactating period. Around the time of calving, all cows were monitored for the development of parturient paresis. Blood samples were taken at the commencement of the experiment, on the day of calving, and thereafter at monthly intervals to measure serum tCa, PO₄ (2), Mg²⁺, K⁺, and Na⁺ concentrations. **Results-**The incidence of parturient paresis in group B cows was significantly lower, compared with group C cows. However, serum concentrations of tCa, P(O₄) (2), Mg²⁺, K⁺, and Na⁺ were not significantly affected by long-term supplementation with clinoptilolite. **CONCLUSIONS AND CLINICAL RELEVANCE:** In the context of this experiment, clinoptilolite supplementation at 2.5% appeared to have reduced the incidence of parturient paresis in dairy cows, suggesting that its effectiveness depends on the amount incorporated in the ration of cows. Addition of clinoptilolite in the concentrate of dairy cows during the nonlactating period could be used as a cost-effective preventive treatment for parturient paresis.

Kayongo-Male, H. and X. Jia (1999). "Silicon bioavailability studies in young rapidly growing rats and turkeys fed semipurified diets: a comparative study." *Biol Trace Elem Res* **67**(2): 173-86.

Two experiments were conducted using completely randomized designs to study the bioavailability of Si from three sources to growing rats and turkeys fed semipurified diets. The basal diets were dextrose-egg albumin for rats and dextrose-casein for turkeys. The Si sources were tetraethylorthosilicate (TES), sodium silicate (NaSil), and sodium zeolite A (NaZA). Rats and turkeys were supplemented at 500 and 270 ppm Si, respectively, from each source. A control group of unsupplemented rats and turkeys was included in each experiment. In general, irrespective of Si source, Si supplementation slowed ($p < 0.05$ or $p < 0.01$) growth rates in both rats and turkeys. Although dietary Si supplementation reduced ($p < 0.05$) plasma Mg levels and liver Zn concentrations in rats, it increased ($p < 0.05$) plasma P and reduced ($p < 0.05$) plasma Cu levels in turkeys. Rats on TES had significantly slower ($p < 0.05$ or $p < 0.01$) growth rates (5-10%) than those on NaSil or NaZA. In rats, NaZA and TES reduced ($p < 0.05$) hemoglobin concentrations and plasma Zn, respectively. However, plasma Mg levels were higher ($p < 0.05$) in TES than NaSil- or NaZA-fed rats. The source of the dietary Si did not affect ($p < 0.05$) the organ weights of rats and their mineral concentrations. Turkeys on TES diets grew at a significantly faster ($p < 0.05$) rate (15%) than those on NaSil or NaZA diets during the first 2 wk of experimentation. However, after 4 wk, there were no significant ($p > 0.05$) differences in growth between the Si sources. In turkeys, NaZA increased ($p < 0.05$) hematocrit levels and plasma Mg levels. Turkeys on NaZA diets had larger ($p < 0.05$) hearts and livers than those on NaSil but not TES. Liver Mn content was higher ($p < 0.05$) in turkeys on NaSil than TES or NaZA. Heart

Zn was lower ($p < 0.05$) in turkeys on NaSil than TES, but not NaZA.

Kececi, T., H. Oguz, et al. (1998). "Effects of polyvinylpolypyrrolidone, synthetic zeolite and bentonite on serum biochemical and haematological characters of broiler chickens during aflatoxicosis." *Br Poult Sci* **9**(3): 452-8.

1. Polyvinylpolypyrrolidone (PVPP), synthetic zeolite (SZ) and bentonite (BNT), when incorporated into the diets at 3, 5 and 5 g/kg respectively, were evaluated for their ability to reduce the deleterious effects of 2.5 mg aflatoxin (AF; 83.06% AFB1, 12.98% AFB2, 2.84% AFG1, and 1.12% AFG2,)/kg diet on growing broiler chickens from 1 day to 3 weeks of age. A total of 210 chicks were divided into 10 treatment groups (control, AF, PVPP, AF plus PVPP, PVPP plus SZ, AF plus PVPP plus SZ, PVPP plus BNT, AF plus PVPP plus BNT, AF plus SZ and AF plus BNT) each consisting of 21 chicks. 2. When compared to control, the AF treatment significantly decreased serum total protein, albumin, inorganic phosphorus, uric acid and total cholesterol, and the values of haematocrit, haemoglobin, mean corpuscular haemoglobin, thrombocyte counts, percentage of lymphocyte and monocyte counts; increased values of white blood cell and heterophil counts. 3. Decreased serum albumin caused by AF was significantly ameliorated by PVPP plus BNT. A similar increase was obtained in serum total cholesterol by adding BNT to the AF-containing diet. 4. The serum uric acid, white blood cell counts and percentage of lymphocyte and monocyte counts were numerically intermediate between control and AF values in all of the adsorbent treatments containing AF. The change in thrombocyte counts was alleviated by all of the adsorbent treatments containing AF, except AF plus SZ. The addition of the adsorbents in the AF-free diets did not significantly alter the serum biochemical and haematological parameters compared to controls.

Keenan, M. J., M. Hegsted, et al. (1992). "Interactions of vitamin D with sodium zeolite A in rats from low and adequate vitamin D colonies." *Int J Vitam Nutr Res* **62**(3): 228-32.

Weanling rats (21 days old) from either a low vitamin D colony or an adequate vitamin D colony fed either a vitamin D adequate or a vitamin D deprived AIN-76A purified diet were used as a model to investigate interactions of vitamin D status with dietary sodium zeolite A (100 mg/kg body wt/day). Rats with adequate or replete vitamin D status had greater overall body weight gain, dry tibia weights and femur densities and ash weights than rats fed a vitamin D deprived diet. Addition of sodium zeolite A to the diets did not have an effect on plasma calcium, body weight gain or on femur density, ash and percent ash. Dietary sodium zeolite A increased total tibia fat in rats fed the vitamin D adequate diet and decreased total tibia fat in rats fed the vitamin D deprived diet. This effect of sodium zeolite A appeared to be beneficial to bone status in the groups fed adequate vitamin D, since these treatment groups had higher, although not significant, dry tibia weights with and without fat.

Keshavarz, K. and C. C. McCormick (1991). "Effect of sodium aluminosilicate, oyster shell, and their combinations on acid-base balance and eggshell quality." *Poult Sci* **70**(2): 313-25.

Three experiments were conducted to determine the effect of sodium aluminosilicate (SAS), oyster shell (OS), and their combinations on production performance, eggshell quality, and acid-base balance. Experiments 1 and 2 were conducted during summer and Experiment 3 in winter. In Experiment 1, the effect of two levels of SAS (0 and .75%) and two levels of OS (0 and 50% substitution for pulverized limestone) was studied. In Experiment 2, the effect of SAS (.75%) with or without Na adjustment was investigated. When Na was adjusted, various sources of chloride were used to maintain an adequate level of this mineral. Calcium and available P were maintained at a constant 3.5 and .4%, respectively in Experiments 1 and 2. In Experiment 3, the levels of SAS and OS were similar to those of Experiment 1, but dietary Ca was either 2.8 or 3.5%. Egg production performance was not influenced by dietary treatments in Experiments 1 and 2 (P greater than .05). Egg production, but not egg mass, was reduced due to SAS in Experiment 3 (P less than .05). Dropping moisture increased when SAS was used in the diets with or without Na correction. Shell quality increased (P less than .05) due to SAS in the summer (Experiments 1 and 2) but not in the winter (Experiment 3). The shell quality response due to SAS was independent of Na correction or the source of dietary chloride. The OS increased shell quality in both summer and winter (P less than .05). Combinations of SAS and OS did not have an additive effect on shell quality (P greater than .05). Blood acid-base balance, plasma Ca and P, bone ash, bone Ca, and Ca retention were not influenced by dietary treatments. The results suggest that elevated environmental temperatures may be required in order for SAS to show its optimum effect on shell quality.

Khambualai, O., J. Ruttanavut, et al. (2009). "Effects of dietary natural zeolite including plant extract on growth performance and intestinal histology in Aigamo ducks." Br Poult Sci 0(1): 123-30.

1. To investigate the growth performance and histological intestinal alterations of Aigamo ducks fed on dietary combinations of zeolite, plant extract and vermiculite (ZEM, 14-d-old Aigamo ducks were divided into 4 groups, with 3 replicates of 3 male and 3 female ducks. They were fed ad libitum on a basal commercial duck mash diet with 0, 0.1, 0.5 and 1.0 g/kg dietary ZEM for 63 d. 2. Body weight gain tended to be higher for the 0.1 and 0.5 g/kg ZEM groups than for the control group at 9 weeks. 3. In light microscopic observation, most values of the intestinal villus height, villus area, cell area and cell mitosis numbers were higher in the ZEM group than those of the control in all intestinal segments, and the duodenal villus height, cell area and cell mitosis of the 0.5 g/kg ZEM group, as well as jejunal cell mitosis in the 0.1 g/kg ZEM group, increased ($P < 0.05$). In the scanning electron microscope results, all ZEM groups showed protuberant epithelial cells and cell clusters on the villus apical surface of the duodenum and ileum. In the jejunum, villus gyri were frequently observed in the 0.1 g/kg ZEM group. These histological intestinal alterations suggest that intestinal villi and epithelial cellular functions might have been activated. 4. From the present results, dietary ZEM showed hypertrophied functions of intestinal villi and epithelial cells at the duodenum and ileum, and the 0.1 and 0.5 g/kg levels improved body weight gain. These suggest that the ZEM can be supplemented until a level of 1.0 g/kg.
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Krivova, N. A., T. A. Lapteva, et al. (2001). "[Effect of prolonged dietary zeolites on survival rate and intestinal reaction toward irradiation in mice of different age]." Radiats Biol Radioecol 41(2): 157-64.

In model experiments on mice the influence of prolonged dietary consumption of zeolites on a survival rate, an average lifetime and a status of adherent mucous layer of a digestive tube was investigated. It was found that zeolite increased a survival rate and average lifetime in 55- and 95-day old mice exposed to a dose of 4 Gy. Zeolite shivirtuin caused more expressed effect, than pegasin. Apparently, shivirtuin causes the more expressed radioprotective effect, because it does not hinder in the development of compensatory responses in a structurally functional status of adherent mucous layer of an intestine after the exposure.

Kubena, L. F., R. B. Harvey, et al. (1993). "Efficacy of a hydrated sodium calcium aluminosilicate to reduce the toxicity of aflatoxin and diacetoxyscirpenol." Poult Sci 72(1): 51-9.

A hydrated sodium calcium aluminosilicate (HSCAS) was incorporated into diets (.5%) containing 3.5 mg/kg aflatoxin (AF) and 5.0 mg/kg diacetoxyscirpenol (DAS) singly and in combination. Male broiler chicks received ad libitum access to their respective diets and water from 1 to 21 days of age. Body weight gains were significantly ($P < .05$) depressed by AF and DAS singly and a synergistic interaction occurred between AF and DAS for a further depression of body weight gains. Alterations in hematological and serum biochemical values, as well as serum enzyme activities, were observed for the AF and the AF and DAS combination. Additionally, a significant interaction occurred between AF and DAS for some biochemical values and enzyme activities. Adding HSCAS resulted in almost total protection against the effects caused by AF alone, limited protection against the combination, but no protection against the DAS alone. These findings indicate that HSCAS can diminish the adverse effects of AF but not of DAS.

Kubena, L. F., R. B. Harvey, et al. (1993). "Effect of hydrated sodium calcium aluminosilicates on aflatoxicosis in broiler chicks." Poult Sci 72(4): 651-7.

In three experiments, three different hydrated sodium calcium aluminosilicates (HSCAS) were incorporated into chick diets (.5%) containing either 0 or 5.0 (Experiments 1 and 2) or 0 or 2.5 (Experiment 3) mg/kg aflatoxin (AF). Male broiler chicks consumed their respective diets and water ad libitum from 1 to 21 days of age. When compared with controls, body weights in chicks receiving 5.0 mg AF/kg were reduced by 214 g in Experiment 1 and 220 g in Experiment 2. The addition of .5% of the HSCAS compounds significantly diminished the growth inhibitory effects caused by AF by 39 to 68% in Experiment 1, by 46 to 88% in Experiment 2, and by 38 to 90% in Experiment 3. The increases in relative organ weights and the decreases in serum biochemical values caused by AF were significantly diminished to differing degrees by all three of the HSCAS compounds. These data demonstrate that these specific HSCAS compounds can be protective against the effects of AF in young growing broilers and further emphasizes the fact that all silicate-type sorbents are not equal in their ability to protect against aflatoxicosis. It also seems possible

to specially process compounds to increase their efficacy for protection against the toxicity of AF.

Kubena, L. F., R. B. Harvey, et al. (1990). "Diminution of aflatoxicosis in growing chickens by the dietary addition of a hydrated, sodium calcium aluminosilicate." *Poult Sci* **69**(5): 727-35.

The amelioration of aflatoxicosis in broiler and Leghorn chickens was examined by feeding a hydrated, sodium calcium aluminosilicate (HSCAS) or activated charcoal. In three experiments, HSCAS or activated charcoal at a concentration of .5% of the total diet were incorporated into diets for broiler and Leghorn chicks containing either no added, purified aflatoxin B1 (AFB1), 7.5 mg of AFB1 per kg, or 5 mg of aflatoxin (AF) per kg (produced by *Aspergillus parasiticus* on rice). Compared to the controls, the AFB1 reduced BW gains at 0 to 3 wk by 21 to 38% in broilers; and the AF reduced BW gains at 0 to 4 wk in Leghorns by 20 percent. The HSCAS significantly diminished the growth-inhibitory effects of AFB1 or of AF on growing chicks by 50 to 67 percent. Feeding 5 mg of AF per kg of diet with or without charcoal to Leghorn chicks caused a significant increase in the relative weights of the liver, kidney, proventriculus, and gizzard as well as significant increases in activity of serum gamma glutamyltransferase; also, significant decreases in the relative bursa weights as well as the concentrations of serum total protein and albumin. With the exception of the relative bursa weights, the toxic effects caused by aflatoxin were prevented or were reduced by adding hydrated, sodium calcium aluminosilicate. These data suggest that HSCAS can modulate the toxicity of AFB1 and AF in the chicken; however, adding activated charcoal to the diet did not appear to have protective properties against the effects of aflatoxin B1 or of aflatoxin.

Kubena, L. F., W. E. Huff, et al. (1991). "Effects of a hydrated sodium calcium aluminosilicate on growing turkey pouls during aflatoxicosis." *Poult Sci* **70**(8): 1823-30.

Effects of adding .5% of a hydrated sodium calcium aluminosilicate (HSCAS) to diets containing 1 or .5 mg aflatoxin (AF)/kg were determined in male turkey pouls from 1 day to 3 wk of age. Body weight gains were significantly reduced by 51 and 19% in turkey pouls fed 1 and .5 mg AF/kg, respectively; efficiency of feed utilization was not affected. There were no deaths in pouls fed .5 mg AF/kg; however, the mortality rate was 88% in pouls fed 1 mg AF/kg. The addition of .5% dietary HSCAS resulted in a 68% decrease in mortality to 28% for the 3-wk experimental period. Treatment-related changes in relative organ weights, hematological values, serum biochemical values, and enzyme activities were observed. The HSCAS in the absence of AF did not alter any of the parameters measured. The HSCAS diminished the adverse effects of AF on body weight gains, most relative organ weights, hematological values, serum biochemical values, and enzyme activities associated with .5 mg AF/kg, but not 1 mg AF/kg. These findings indicate that HSCAS may diminish many of the adverse effects of AF in an AF-sensitive species, the turkey.

Leach, R. M., Jr., B. S. Heinrichs, et al. (1990). "Broiler chicks fed low calcium diets. 1. Influence of zeolite on growth rate

and parameters of bone metabolism." *Poult Sci* 69(9): 1539-43.

An experiment with a factorial arrangement of treatments was conducted using five levels of dietary calcium and two levels of zeolite A. When dietary calcium was deficient or marginal, zeolite A improved calcium utilization, as evidenced by improved growth rate and a reduction in rachitic lesions. There was little benefit from adding zeolite A to diets adequate in calcium. The effect of zeolite A on the incidence of tibial dyschondroplasia was inconsistent.

Leung, S., S. Barrington, et al. (2006). "Zeolite (clinoptilolite) as feed additive to reduce manure mineral content." *Bioresour Technol*.

Clinoptilolite (a species of zeolite) as grower hog feed additive can potentially improve nutrient ingestion and lower manure nutrient levels. A first objective was to establish the optimal particle size of the zeolite powder, as a fine size increases the adsorption surface while a coarse size can facilitate handling. The second objective tested the effect of feeding zeolite on manure nutrient levels. For the first objective, three zeolite powders (250-500μm; 50-250μm, and 50-500μm) were exposed to an NH₄(+) solution under a pH of either 7.0 or 2.0. The resulting solutions were tested for cation exchange. A commercial zeolite was also tested for the pH of 2.0 to evaluate zeolite stability. At 0%, 5% and 10% humidity, the same three particle size powders were subjected to shear tests to determine the zeolite's angle of friction. For the second objective using metabolic cages, female hogs were subjected to one of four rations (a control and three with zeolite) while collecting and analyzing their manures. For the first objective, the coarse particle zeolite performed best, adsorbing 158 and 123Cmol(+)/kg of NH₄(+) under neutral and acid pH, respectively, and releasing an equivalent amount of minerals only under neutral pH. The commercial zeolite with less clinoptilolite released more Al, Fe, Cu and Pb, showing less stability. The high internal angle of friction of zeolite did not vary with particle size and moisture, indicating funnel flow under gravity. For the second objective, hogs fed a zeolite diet produced manure with 15% and 22% less N and P, respectively, and demonstrated a better feed conversion, although not statistically significant ($P>0.05$). These results show that there is some potential in using high quality clinoptilolite in the ration of grower hogs.

Lindemann, M. D., D. J. Blodgett, et al. (1993). "Potential ameliorators of aflatoxicosis in weanling/growing swine." *J Anim Sci* 71(1): 171-8.

Three trials using 207 crossbred pigs were conducted to evaluate the effects of aflatoxin-contaminated corn on young pigs and to determine whether several nutritional and nonnutritional dietary amendments would benefit performance or health in situations of aflatoxin B1 contamination. In Trial 1 using 90 pigs in a 49-d trial, linear ($P < .01$) and quadratic ($P < .05$) decreases in ADG were observed with increasing (0, 420, 840 ppb) dietary aflatoxin level. This growth decrease was associated with linear reductions ($P < .01$) in ADFI and decreases in gain/feed. Serum indicators of protein synthetic capabilities and of liver damage were also adversely affected. Improvements in growth rate for the total trial period in the presence of 840 ppb of aflatoxin were

obtained with the addition of the 2 ppm of folic acid ($P < .05$) or .5% hydrated sodium calcium aluminosilicate (HSCA) ($P < .01$); the magnitude of improvement was greater for the HSCA. The addition of HSCA to the contaminated diet also restored the serum clinical chemistry profile to that exhibited by pigs fed the diet without contaminated corn. The addition of .6 ppm of Se to a basal diet containing .3 ppm of Se was generally without effect. In Trial 2, 63 pigs were used in a 42-d trial to further assess the effectiveness of both folic acid and HSCA, as well as of two sodium bentonites, in reducing the effects of aflatoxin from naturally contaminated diets (800 ppb of aflatoxin). Folic acid had no positive effect in this trial, but HSCA improved ADG ($P < .01$) and all clinical chemistry indicators that had been negatively affected by the contaminated diet ($P < .05$). (ABSTRACT TRUNCATED AT 250 WORDS)

Martin-Kleiner, I., Z. Flegar-Mestric, et al. (2001). "The effect of the zeolite clinoptilolite on serum chemistry and hematopoiesis in mice." *Food Chem Toxicol* 9(7): 717-27.

Zeolites are natural or synthetic crystalline aluminosilicates with ion exchanging properties. Supplied in fodder, they promote biomass production and animal health. Our aim was to assess the effects of the natural zeolite, clinoptilolite, on hematopoiesis, serum electrolytes and essential biochemical indicators of kidney and liver function in mice. Two preparations differing in particle size were tested: a powdered form obtained by countercurrent mechanical treatment of the clinoptilolite (MTCp) and normally ground clinoptilolite (NGCp). Young adult mice were supplied with food containing 12.5, 25 or 50% clinoptilolite powder. Control animals received the same food ration without the clinoptilolite. After 10, 20, 30 and 40 days, six animals from each group were exsanguinated to obtain blood for hematological and serum for biochemical measurements as well as to collect femoral bone marrow for determination of hematopoietic activity. Clinoptilolite ingestion was well tolerated, as judged by comparable body masses of treated and control animals. A 20% increase of the potassium level was detected in mice receiving the zeolite-rich diet, without other changes in serum chemistry. Erythrocyte, hemoglobin and platelet levels in peripheral blood were not materially affected. NGCp caused leukocytosis, with concomitant decline of the GM-CFU content in the bone marrow, which was attributed to intestinal irritation by rough zeolite particles. The mechanically treated clinoptilolite preparation caused similar, albeit less pronounced, changes. In a limited experiment, mice having transplanted mammary carcinoma in the terminal stage showed increased potassium and decreased sodium and chloride levels, severe anemia and leukocytosis, decreased bone marrow cellularity and diminished content of hematopoietic progenitor cells in the marrow. The clinoptilolite preparations ameliorated the sodium and chloride decline, whereas the effects on hematopoiesis were erratic.

Mayura, K., M. A. Abdel-Wahhab, et al. (1998). "Prevention of maternal and developmental toxicity in rats via dietary inclusion of common aflatoxin sorbents: potential for hidden risks." *Toxicol Sci* 41(2): 175-82.

In earlier work, we have reported that a phyllosilicate clay (HSCAS or NovaSil) can tightly and selectively bind the

aflatoxins in vitro and in vivo. Since then, a variety of untested clay and zeolitic minerals have been added to poultry and livestock feeds as potential "aflatoxin binders." However, the efficacy and safety of these products have not been determined. A common zeolite that has been frequently added to animal feed is clinoptilolite. Our objectives in this study were twofold: (1) to utilize the pregnant rat as an in vivo model to compare the potential of HSCAS and clinoptilolite to prevent the developmental toxicity of aflatoxin B1 (AfB1), and (2) to determine the effect of these two sorbents on the metabolism and bioavailability of AfB1. Clay and zeolitic minerals (HSCAS or clinoptilolite) were added to the diet at a level of 0.5% (w/w) and fed to pregnant Sprague-Dawley rats throughout pregnancy (i.e., day 0 to 20). Treatment groups (HSCAS or clinoptilolite) alone and in combination with AfB1 were exposed to sorbents in the feed as well as by gavage. Untreated and AfB1 control animals were fed the basal diet without added sorbent. Between gestation days 6 and 13, animals maintained on diets containing sorbent were gavaged with corn oil in combination with an amount of the respective sorbent equivalent to 0.5% of the estimated maximum daily intake of feed. Animals receiving AfB1 were dosed orally (between days 6 and 13) with AfB1 (2 mg/kg body wt) either alone or concomitantly with a similar quantity of the respective sorbent. Evaluations of toxicity were performed on day 20. These included: maternal (mortality, body weights, feed intake, and litter weights), developmental (embryonic resorptions and fetal body weights), and histological (maternal livers and kidneys). Sorbents alone were not toxic; AfB1 alone and with clinoptilolite resulted in significant maternal and developmental toxicity. Animals treated with HSCAS (plus AfB1) were comparable to controls. Importantly, clinoptilolite (plus AfB1) resulted in severe maternal liver lesions (more severe than AfB1 alone), suggesting that this zeolite may interact with dietary components that modulate aflatoxicosis. In metabolism studies, adult male Sprague-Dawley rats, maintained on diets containing 0.5% (w/w) HSCAS or clinoptilolite, were dosed orally with 2.0 mg AfB1/kg body wt. The concentration of the major urinary metabolite (AfM1) was considerably decreased in the presence of HSCAS. These results suggest that the mechanism of protection of AfB1-induced maternal and developmental toxicities in the rat may involve adsorption and reduction of AfB1 bioavailability in vivo. Importantly, this study demonstrates the potential for significant hidden risks associated with the inclusion of nonselective aflatoxin binders in feeds. Aflatoxin sorbents should be rigorously tested individually and thoroughly characterized in vivo, paying particular attention to their effectiveness and safety in sensitive animal models and their potential for deleterious interactions.

Miazzo, R., C. A. Rosa, et al. (2000). "Efficacy of synthetic zeolite to reduce the toxicity of aflatoxin in broiler chicks." Poul Sci 79(1): 1-6.

Synthetic zeolites (NaX, NaY, NaA, and CaA) were evaluated in vitro for their ability to sorb aflatoxin (AF) B1 from an aqueous solution. Zeolite NaA (ZN) was selected to be tested in vivo because of its high affinity and its stable association with AFB1. This sorbent was incorporated into diets (1%) containing 2.5 mg/kg AFB1. Male broiler chicks from 21 to 42 d of age received ad libitum access to their respective diets and water. When compared with controls, BW gains were lower ($P < 0.05$) for broilers that were fed AF in their diets.

No differences were found between the BW gains of chicks fed diets without AF and those of chicks fed AF + ZN, indicating almost total protection against the effects caused by AF. Liver weights were considerably higher in chicks fed a diet containing AF, compared with those of controls, nevertheless, no significant differences were found in feed:gain ratio among the groups. The findings of this research suggest that ZN can counteract some of the toxic effects of AF in growing broiler chicks.

Mitrovic, B., G. Vitorovic, et al. (2007). "AFCF and clinoptilolite use in reduction of (137)Cs deposition in several days' contaminated broiler chicks." *J Environ Radioact* **9** (2-3): 171-7.

The objective of this study was to investigate the binding efficiency of AFCF and clinoptilolite, mixed to the feed and administered orally using gastric tube to chronically (137)Cs alimentary contaminated broiler chicks. Seventy-five male Hybro broiler chicks, between 35 and 47 days of age were divided into five groups (15 birds per group) reared in cages (five birds in a cage) and fed a standard diet. Every day during 13 days of the experimental period all chicks received orally 1 ml CsCl water solution with activity of 1310 Bq ml(-1)(137)Cs (gastric tube). Group 1 was the control group and received no binders. The experimental groups received the binders. Group 2 received 0.2 g of AFCF in the form of water solution (gastric tube); group 3 received 0.2% AFCF in the feed; group 4 received 2g clinoptilolite in the form of water suspension (gastric tube) and group 5 received 2% clinoptilolite in the feed. Five chicks from each group were sacrificed on days 4, 10 and 13 of the experimental period. Using gamma spectrometric methods specific activity of (137)Cs was determined in the samples of breast meat, liver and gizzard. The results obtained showed that administering binders to the chronically contaminated broiler chicks significantly ($p<0.01$) reduced (137)Cs transfer and deposition in breast meat, liver and gizzard. Decreasing deposition of (137)Cs in breast meat and internal organs increased with time of contamination and binders' administration. With AFCF as a cesium binder, on day 13 of measuring the (137)Cs activity in breast meat was 80-83% lower than that in the control group, 89% in liver and 83-84% in gizzard. Natural clinoptilolite demonstrated lower binding efficiency. On day 13 of measuring the (137)Cs activity in breast meat was 53-69% lower than that in the control group, 67-60% in liver and 59-71% in gizzard.

Mizik, P., J. Hrusovsky, et al. (1989). "[The effect of natural zeolite on the excretion and distribution of radiocesium in rats]." *Vet Med (Praha)* **4**(8): 467-74.

Observation was made of the influence of natural zeolite (clinoptilolite) supplement in food on 134Cs excretion and distribution after oral internal contamination of laboratory brown rats. After diet administration with 2.5, 5, and 10% zeolite supplement the 134Cs elimination in droppings increased and the radionuclide deposition in liver, kidneys and femoral musculature decreased. The zeolite decontamination effects were observed with preventive administration, as well as with sorbent administration from the 24th hour after a single internal contamination.

Mohri, M., H. A. Seifi, et al. (2008). "Effects of short-term supplementation of clinoptilolite in colostrum and milk on the concentration of some serum minerals in neonatal dairy calves." *Biol Trace Elem Res* 12 (1-3): 116-23.

In recent years, the use of both natural and synthetic zeolites in animal nutrition has increased mainly to improve their performance, health, and to protect against mycotoxin intoxication. Thirty calves were used in the present study for the determination of some physiologic effects of clinoptilolite supplementation. The animals were divided equally into three groups (control, test 1, and test 2). The three groups of calves were homogeneous for parity of dams, sex, and month of birth. For group test 1, clinoptilolite in the concentration of 2% of each colostrum meal was added for 48 h, and for group test 2, clinoptilolite in the concentration of 2% was added to each colostrum and milk meal for 14 days. Blood samples were taken from all calves 12 h after birth and at the end of the first, second, third, forth, fifth, and sixth weeks of life. Calcium (Ca), phosphorus (P), magnesium (Mg), iron (Fe), sodium (Na), and potassium (K) were determined in the serum. For statistical analysis of data, a repeated measures approach using analysis of variance (ANOVA) with mixed linear models was used. Clinoptilolite supplementation had significant effect on the concentrations of calcium, phosphorus, sodium, and iron. The concentrations of Fe significantly higher in test group 2 than other trial groups ($p < 0.05$). Calcium concentrations were significantly higher in serum of clinoptilolite-treated than control calves ($p < 0.05$). The concentrations of phosphorus were significantly lower in test groups than control group ($p < 0.05$). Sodium concentrations were significantly higher in clinoptilolite-supplemented groups than control calves ($p < 0.05$). Potassium and magnesium concentrations were not affected by clinoptilolite supplementation. Clinoptilolite supplementation could promote iron levels in serum and better hemopoiesis and prevent pathologic or physiologic drop of red blood cell (RBC) parameters in supplemented calves during a first few weeks of life. According to higher need and utilization of Ca in growing animals, clinoptilolite supplementation could increase available Ca. Based on the results of the present study and the importance of dietary phosphorus in many physiologic processes, the level of phosphorus in diet of neonatal dairy calves must be considered and adapted when clinoptilolite was supplemented. With an adequate supply of good quality drinking water, cattle can tolerate large quantities of dietary sodium chloride. Thus, it seems that significant increase in serum Na concentration during short-term supplementation of clinoptilolite in neonatal calves could be well tolerated without any adverse effects.

Moshtaghian, J., C. M. Parsons, et al. (1991). "Effect of sodium aluminosilicate on phosphorus utilization by chicks and laying hens." *Poult Sci* 70(4): 955-62.

Three experiments were conducted to evaluate the effects of sodium aluminosilicate (SAS) on performance of chicks and laying hens fed diets varying in nonphytate P (NPP), phytate, and fiber content. In two chick growth experiments a corn and soybean meal diet and a phytate and fiber-free casein-dextrose diet were used. These diets contained .1% NPP and 1.1% Ca and were fortified with 0, .05, or .10% P from KH₂PO₄ and 0 or .5% SAS. A 3 x 2 factorial arrangement of treatments was used. Sodium aluminosilicate supplementation significantly (P less than .05) depressed growth of chicks fed

the corn and soybean meal diets containing 0 or .05% supplemental AP. Sodium aluminosilicate addition decreased (P less than .05) tibia ash and total tibia P (tibia weight x P concentration) in both chick experiments, with the effect being greater for chicks fed the corn and soybean meal diet. In the laying hen experiment, birds were fed corn and soybean meal diets containing NPP levels of .1, .45, or 1.8% and SAS levels of 0 or 1.0%. Egg production and egg yield were depressed (P less than .05) by feeding diets containing .1 or 1.8% NPP, and egg specific gravity was decreased (P less than .05) by feeding 1.8% NPP. Addition of SAS to the .1% NPP diet caused a large reduction (P less than .05) in egg production, egg weight, and feed efficiency, whereas SAS supplementation of the 1.8% NPP diet had no significant effect. Sodium aluminosilicate supplementation increased (P less than .05) egg specific gravity for hens fed the .1 and 1.8% NPP diets.(ABSTRACT TRUNCATED AT 250 WORDS)

MS, K. J. L., B. D. N. PhD, et al. (2001). "Increased plasma silicon concentrations and altered bone resorption in response to sodium zeolite a supplementation in yearling horses." Journal of Equine Veterinary Science 21(11): 550-555.

This study examined the effect of supplementation of a bioavailable source of silicon (sodium zeolite A) on altering systemic markers of bone metabolism in horses. Twenty yearlings (ten Quarter Horses and ten Arabians) were randomly grouped as silicon (Si) supplemented (S; n=10), in which yearlings consumed 2% of the total diet as a Si-containing supplement, and a second non-supplemented control group (C; n=10). Blood samples were taken on days 0, 15, 30 and 45. Both plasma and serum were collected; the plasma was analyzed for Si concentrations and serum was analyzed for osteocalcin (OC), carboxy-terminal pyridinoline cross-linked telopeptide region of type I collagen (ICTP), and pyridinoline and deoxypyridinoline crosslinks (PYD). Supplemented yearlings had higher plasma Si concentrations than C yearlings by day 15, and remained higher than C yearlings on days 30 and 45 ($P < 0.0001$ for all days). There were no differences between treatment groups for OC or PYD concentrations ($P > .05$); however, ICTP concentrations were lower in S yearlings on day 45 when compared to C yearlings ($P = .04$). Results indicate that sodium zeolite A supplementation (consumed at 2% of the total diet) increases plasma Si concentrations. Furthermore, results indicate that Si-supplemented yearlings may have decreased bone resorption, which may provide for greater net bone formations, as OC concentrations were not different between groups. Unfortunately, systemic markers give no indication as to the quality of the bone that may be formed, and further research in the area of Si supplementation, bone metabolism and bone strength is required to establish conclusive evidence as to the benefits of supplemental Si to the skeletal system.

Oguz, H., T. Kececi, et al. (2000). "Effect of clinoptilolite on serum biochemical and haematological characters of broiler chickens during aflatoxicosis." Res Vet Sci 69(1): 89-93.

Clinoptilolite (CLI, a natural zeolite) incorporated into the diet at 1.5 and 2.5 per cent were evaluated for their ability to reduce the deleterious effects of 2.5 mg total aflatoxin (AF) kg(-1)diet on broiler chickens from 1 to 21 days of age. In total 360 broiler chicks were divided into six equal treatment groups (control, AF, CLI (1.5 per cent), AF plus CLI (1.5 per

cent), CLI (2.5 per cent) and AF plus CLI (2.5 per cent)). When compared with the controls, AF treatment significantly decreased serum total protein, albumin, inorganic phosphorus, uric acid, total cholesterol and the values of haematocrit, red blood cell counts, mean corpuscular volume, haemoglobin, thrombocyte counts, percentage of monocyte counts; increased values of white blood cell and heterophil counts. The addition of CLI (1.5 per cent) and CLI (2.5 per cent) to the AF-containing diet reduced the adverse effects of AF and should be helpful in a solution to the aflatoxicosis problem in poultry.

Oguz, H., F. Kurtoglu, et al. (2002). "Evaluation of biochemical characters of broiler chickens during dietary aflatoxin (50 and 100 ppb) and clinoptilolite exposure." Res Vet Sci 7 (1): 101-3.

Aflatoxin (AF) and clinoptilolite (CLI, a natural zeolite) were added to broiler food and some biochemical values and enzyme activities were evaluated. The experimental design consisted of six dietary treatments. (1) CONTROL: basal diet; (2) CLI: basal diet plus 15 g clinoptilolite kg(-1) diet; (3) 50 ppb AF: basal diet plus 50 microg total aflatoxin (AF; the composition given below) kg(-1) diet; (4) 50 ppb AF+CLI: basal diet plus 50 microg AF plus 15 g CLI kg(-1) diet; (5) 100 ppb AF: basal diet plus 100 microg AF kg(-1) diet; (6) 100 ppb AF+CLI: basal diet plus 100 microg AF plus 15 g CLI kg(-1) diet. A commercially available CLI was provided from the west region of Turkey and its chemical formula is "KNa(2)Ca(2)(Si(29)Al(7))O.7(2).32H₂O". For this a total of 576 1-day-old Ross broiler chicks were housed in six treatment groups from days 1 to 42. AF treatment significantly increased the serum Na levels and the aspartate-amino-transferase (ASAT) and alanine-amino-transferase (ALAT) enzyme activities, while total protein, albumin, total cholesterol uric acid, and K levels were not significantly different between groups. These results suggest that these low AF levels in food did not change the serum biochemistry but significantly affected the enzyme activities in broilers.

Oguz, H. and V. Kurtoglu (2000). "Effect of clinoptilolite on performance of broiler chickens during experimental aflatoxicosis." Br Poult Sci 41(4): 512-7.

1. The amelioration of aflatoxicosis in broiler chickens was examined by feeding 2 concentrations of natural zeolite (clinoptilolite). Clinoptilolite (CLI), incorporated into the diet at 15 and 25 g/kg, was evaluated for its ability to reduce the deleterious effects of 2.5 mg total aflatoxin (AF; 76.40% AFB1, 16.12% AFB2, 6.01% AFG1 and 1.47% AFG in diet on growing broiler chicks from 1 to 21 d of age. A total of 360 broiler chicks were divided into 6 treatment groups (6 replicates of 10 broilers each): control, AF, CLI (15 g/kg), AF plus CLI (15 g/kg), CLI (25 g/kg), and AF plus CLI (25 g/kg). 2. Compared to controls, the treatment had significantly decreased body weight gain from week 1 onwards. The adverse effect of AF on food consumption (8.0%) and food conversion ratio (8.3%) was also shown over the entire 21-d feeding period. 3. The addition of CLI (15 g/kg) to an AF-containing diet significantly reduced the deleterious effects of AF on food consumption and body weight gain. Food conversion ratio was also slightly improved by adding CLI (15 g/kg) to AF-containing diets. Food consumption, body weight gain and food conversion ratio values were rendered numerically intermediate between AF

and control groups by the addition of CLI (25 g/kg) to the AF-containing diet. 4. The addition of CLI (both 15 and 25 g/kg) to the AF-free diet did not produce any significant changes compared with the controls, except for decreased total food consumption in the CLI (25 g/kg)-alone group. 5. These results suggest that CLI (15 g/kg) addition effectively diminished the detrimental effects of AF on the values investigated. Also, the lower dietary concentration of CLI (15 g/kg) was more effective than the greater concentration against the adverse effects of AF on the variables investigated in this study.

Oguz, H., V. Kurtoglu, et al. (2000). "Preventive efficacy of clinoptilolite in broilers during chronic aflatoxin (50 and 100 ppb) exposure." *Res Vet Sci* **69**(2): 197-201.

This study was conducted to evaluate the protective efficacy of clinoptilolite (CLI, a natural zeolite) in the prevention of toxic effects of aflatoxin (AF). A total of 576 1-day-old Ross broiler chicks were housed in six treatment groups [six replicates of 16 each; control, CLI (15 g kg⁻¹)diet), 50 parts per billion (ppb) AF, 50 ppb AF plus CLI, 100 ppb AF, 100 ppb AF plus CLI] for 42 days. Compared to controls, 100 ppb AF treatment significantly decreased body weight gains of chicks. The addition of CLI to the 100 ppb AF - containing diet moderately reduced the adverse effects of AF on performances of chicks. The chicks consuming 50 ppb AF -containing diet showed no significant differences on investigated parameters compared to controls. Also, the single addition of CLI to the AF -free diet had no adverse effects in birds. These results suggest that CLI can be beneficial in broilers for protection of AF toxicity at the level above.

Olver, M. D. (1989). "Effect of feeding clinoptilolite (zeolite) to three strains of laying hens." *Br Poult Sci* **0**(1): 115-21.

1. One hundred and twenty 16-week-old, single combed pullets of three strains were fed on a diet containing 160 g protein/kg with or without 50 g clinoptilolite/kg in a trial with 20 hens per treatment. Sterile river sand replaced clinoptilolite in the control diet in order to keep the diets isoneric. 2. The hens were individually caged in a naturally-ventilated laying house and fed on one of the two diets for ten 28-d periods. 3. No significant dietary effects between treatments were observed with respect to body weight, age at first egg, egg weight, Haugh scores or food intake/hen. 4. Significant dietary effects in favour of clinoptilolite feeding were noticed with the number of eggs laid per hen, shell thickness, efficiency of food utilisation, droppings moisture content and mortality. 5. Significant differences between strains were observed with respect to all measurements taken except food intake/hen d.

Olver, M. D. (1997). "Effect of feeding clinoptilolite (zeolite) on the performance of three strains of laying hens." *Br Poult Sci* **8**(2): 220-2.

1. One hundred and twenty 16-week-old single combed pullets of three strains were fed on a diet containing 135 g protein/kg with or without 50 g clinoptilolite/kg in a trial with 20 hens per treatment. Sterile river sand replaced clinoptilite in the control diet in order to keep the diets isoenergetic. The hens were individually caged in a naturally ventilated laying house

and fed one of the two diets for ten 28-d periods. 2. Significant dietary effects of feeding clinoptilolite were observed with number of eggs laid per hen, shell thickness, efficiency of food utilisation and droppings moisture content. No significant dietary effects between treatments were observed with body weight, age at first egg, egg weight. Haugh units, food intake/hen and rate of amino acid absorption of radioactive lysine and methionine into the bloodstream. Significant differences between strains were observed with regard to all parameters except food intake/hen. There were no significant strain X clinoptilolite interactions.

Ortatanli, M. and H. Oguz (2001). "Ameliorative effects of dietary clinoptilolite on pathological changes in broiler chickens during aflatoxicosis." *Res Vet Sci* 71(1): 59-66.

The amelioration of aflatoxicosis in broiler chickens was examined by feeding two concentrations of natural zeolite (clinoptilolite). Clinoptilolite (CLI), incorporated into the diet at 1.5 and 2.5 per cent, was evaluated for the ability to reduce the deleterious effects of 2.5 mg total aflatoxin (AF) kg(-1) diet on growing broiler chicks from 1 to 21 days of age. A total of 360 broiler chicks were divided into six treatment groups [Control, AF, CLI (1.5 per cent), AF plus CLI (1.5 per cent), CLI (2.5 per cent), and AF plus CLI (2.5 per cent)] each consisting of 60 chicks. Compared to controls, the AF consuming chicks showed increases in the relative weights of liver and kidney; and gross-histopathologic hepatic lesions such as paleness, friability, diffuse hydropic degeneration and/or fatty change, bile-duct hyperplasia and periportal fibrosis. Glomerular hypertrophy, increases in the number of mesengial cells and hydropic degeneration of tubular epithelium in kidneys of chicks fed diet AF alone were also observed. Atrophy and lymphoid depletion were seen in the thymuses and bursa of Fabricius from the chicks fed AF alone. The additions of CLI (1.5 and 2.5 per cent) to the AF-containing diet moderately (significantly in some cases) decreased the number of affected broilers and/or the severity of lesions. The addition of CLI to the AF-free diet did not produce any significant changes compared with the controls. These results suggest that CLI was effective for the protection of AF-toxicity in broilers and it could contribute to a solution of the AF problem in poultry production.

Ortatanli, M., H. Oguz, et al. (2005). "Evaluation of pathological changes in broilers during chronic aflatoxin (50 and 100 ppb) and clinoptilolite exposure." *Res Vet Sci* 78(1): 61-8.

This study was conducted to evaluate the pathological changes in broilers fed a diet containing low-levels of aflatoxin (AF) and clinoptilolite (CLI) until 42 days of age. A total of 576 one-day-old Ross-308 type broiler chicks were treated with varying levels of AF and CLI (15 g kg(-1)). The gross and histopathological changes in the liver, kidneys, spleen, thymus and bursa of Fabricius were investigated and relative organ weights were calculated. Compared to controls, significant changes ($P<0.05$), such as slight to moderate hydropic degeneration and/or fatty change (8 cases of 10), bile-duct hyperplasia (7 of 10) and periportal fibrosis (5 of 10), were found in chicks fed 100 ppb AF-containing diet. No gross-pathological changes were observed in any treatments. The addition of CLI to the 100 ppb AF-containing diet

significantly decreased the number of affected broilers and/or the severity of lesions (hydropic degeneration and bile-duct hyperplasia) in the livers ($P<0.05$). The addition of CLI to the AF-free diet did not produce any significant lesions compared with the controls.

Papaioannou, D. S., C. S. Kyriakis, et al. (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." *Res Vet Sci* 76(1): 19-29.

This study was conducted to assess the effect of dietary use of a clinoptilolite-rich tuff (Cp) on health status and performance of weaned, growing and finishing pigs and its compatibility during simultaneous oral administration of antimicrobials (AM) such as enrofloxacin (E) or salinomycin (S). Weaners (720) were assigned in 2 experimental groups and 4 subgroups based on the inclusion or not of Cp and AM in their feed (subgroups: NC, ES, Cp, Cp+ES) in order to evaluate their health status, under PWDS prevailing herd conditions. A second part of the trial aimed to the evaluation of piglet performance under conditions with minimized PWDS herd risks. For this purpose, a second set of 264 weaners were assigned in 2 groups and 4 subgroups, in a respective manner. All piglets remained on-trial until slaughter age; Cp was incorporated in their feed at a rate of 2% from the day of weaning until slaughtering. The health status evaluation consisted in monitoring piglets for adverse effects related to Cp consumption, average daily diarrhoea scoring during weaning and mortality rate calculations throughout. Performance evaluation included individual weighing at the end of weaning, growing and fattening periods and feed consumption assessments. Average daily gain (ADG), average daily feed intake (ADFI) and feed conversion ration (FCR) on a pen basis were further calculated. Cp ingestion was well tolerated by the piglets. Simultaneous administration of Cp and AM in feed, resulted in less severe forms of PWDS, which had a shorter clinical course ($P<0.05$). Mortality decreased ($P<0.05$) during the weaning period due to AM administration. Concerning mean pig body weight at the end of each production phase, both Cp and AM had favorable effects ($P<0.05$). ADG estimated for the whole observation period was improved ($P<0.05$) by Cp-use along with AM. FCR improvements ($P<0.05$) were noticed during the different stages of growth due to AM or Cp administration, while Cp/AM interaction was noticed only at weaning ($P<0.05$).

Papaioannou, D. S., S. C. Kyriakis, et al. (2002). "Effect of in-feed inclusion of a natural zeolite (clinoptilolite) on certain vitamin, macro and trace element concentrations in the blood, liver and kidney tissues of sows." *Res Vet Sci* 72(1): 61-8.

The study was conducted to evaluate, under field conditions, the effect of the long-term dietary use of a natural zeolite (clinoptilolite, CLI) and antibacterials (chlortetracycline, CTC) on the concentrations of certain vitamins (vitamin A and vitamin E) and minerals (K, Na, P, Ca, Mg, Cu and Zn) in blood and body tissues of the sow. Twenty-four sows were assigned to two main experimental groups and four subgroups, depending on the presence or absence of CLI and CTC in their feed, respectively. CLI was provided to the sows from weaning, during the service, gestation and lactation periods

and up to the date of the next service, while CTC was administered for a 2-week period post-service, as well as for a 2-week period following the allocation of the sows in the farrowing house, around 5 days prior to the expected parturition. Blood samples were collected on the starting day of the trial, on the 30th and the 90th day of each pregnancy, on the day of each parturition and on the day of each weaning. Furthermore, 20 sows were similarly distributed in the same experimental groups and subgroups and at the end of the trial they were slaughtered and liver and kidney samples were collected for biochemical analysis. Neither CLI nor CTC supplementation of the diets had any significant effect on vitamins' and minerals' uptake and their distribution in the body, since there was no alteration in their blood serum and liver/kidney concentrations. Furthermore, no CLI x CTC interaction was noticed.

Papaioannou, D. S., S. C. Kyriakis, et al. (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." *Res Vet Sci* 72(1): 51-9.

The study was conducted to evaluate the effect of the long-term dietary use of a natural zeolite (clinoptilolite, NZ) on health status and reproductive performance of sows/gilts and performance of their litters, along with its compatibility with antibacterials (chlortetracycline, CTC) periodically used in medication programmes. Two hundred and forty sows/gilts and their litters were assigned to two main experimental groups and four subgroups, depending on the inclusion of NZ and CTC in their feed. During the trial, frequent sampling of pregnancy feed for mycotoxicological analysis revealed a high contamination level with zearalenone. No adverse or side effects attributed to NZ were noticed. Furthermore, the combined use of NZ and CTC revealed no clinically apparent interactive effect on the availability of the latter. Reproductive performance was significantly improved by the dietary inclusion of both NZ and CTC. The results also suggested that the beneficial effect of NZ could be additionally considered as an indicator of the amelioration of zearalenone exposure consequences.

Parlat, S. S., A. O. Yildiz, et al. (1999). "Effect of clinoptilolite on performance of Japanese quail (*Coturnix coturnix japonica*) during experimental aflatoxicosis." *Br Poult Sci* 40(4): 495-500.

Clinoptilolite (CLI, a natural zeolite), incorporated into the diet at 50 g/kg, was evaluated for its ability to reduce the deleterious effects of 2.0 mg total aflatoxin (AF; 83.06% AFB1, 12.98% AFB2, 2.84% AFG1 and 1.12% AFG2)/kg diet on growing Japanese quail chicks from 10 to 45 d of age. A total of 40 Japanese quail chicks were divided into 4 treatment groups (control, AF, CLI, AF plus CLI) each consisting of 10 chicks. The performance of the birds was evaluated. The AF treatment significantly decreased food consumption and body weight gain from the 3rd week onwards. The adverse effect of AF on food conversion ratio was also significant from week 4 of the experiment. The addition of CLI to an AF-containing diet significantly reduced the deleterious effects of AF on food consumption, body weight gain and food conversion ratio. Food consumption was reduced by 14% in quail chicks consuming the AF diet without CLI, but by only 6% for quail chicks consuming the AF plus CLI diet. Similarly, overall body

weight gain was reduced by 27% in birds consuming the AF diet without CLI, but by only 8% for birds consuming the AF plus CLI diet. The addition of CLI to the AF-free diet significantly decreased food consumption and body weight gain during week 4, but these parameters were similar to the controls in week 5. No mortality was observed in any of the groups. These results suggest that CLI effectively diminished the detrimental effects of AF on the variables investigated in this study.

Petkova, E., T. Venkov, et al. (1982). "[Prophylactic efficacy of Bulgarian potassium-calcium zeolite in digestion disorders in pigs]." *Vet Med Nauki* 19(10): 45-51.

Laboratory and economic experiments were carried out with the Bulgarian potassium-and-calcium zeolite. It was found to produce a good prophylactic effect with regard to disturbances in the digestive tract in amounts of up to 4 per cent of the concentrated feed. Pigs that were given zeolites showed higher general resistance. This was demonstrated by the increase in Ca, P, total protein, alfa 2, gamma 1, and gamma 2-globulins in the serum parallel to the rise of the leukocyte and lymphocyte count and the hemoglobin level in the blood. It was also established that the zeolite contributed to lower morbidity and mortality rates. Certain age-associated differences were observed with regard to the growth rate-- those of the pigs that obtained the zeolite showed higher weight gain in the interval between the 30th and 60th day from birth.

Phillips, T. D. (1999). "Dietary clay in the chemoprevention of aflatoxin-induced disease." *Toxicol Sci* 2(2 Suppl): 118-26.

Aflatoxins are harmful by-products of mold growth and, though invisible to the naked eye, are potentially fatal. The aflatoxin problem is long-standing and inextricable. Concerns about the aflatoxins originate from the strong implications of their involvement in disease and death in humans and animals, yet scientists and clinicians are still seeking ways to effectively deal with these dangerous and elusive chemicals. Safe, practical, and effective strategies for the detoxification of aflatoxin-contaminated food and feed are highly desirable. A simple and effective approach to the chemoprevention of aflatoxicosis has been to diminish or block exposure to aflatoxins via the inclusion of HSCAS clay in the diet. HSCAS clay acts as an aflatoxin enterosorbent that tightly and selectively binds these poisons in the gastrointestinal tract of animals, decreasing their bioavailability and associated toxicities. Further studies to delineate the molecular mechanisms of action have shown that the dicarbonyl system of aflatoxin is essential for tight binding by HSCAS. In these studies, adsorption data was fitted to multiple isotherm equations including the Langmuir, multi-Langmuir, general Freundlich, Langmuir-Freundlich, Toth and various transforms. Information derived included: the Gibbs standard free energy change of adsorption, enthalpy of adsorption, capacity, affinity, and heterogeneity coefficient. Computer modeling was also utilized to provide additional structural information and insight into the mechanism. Evidence suggests that aflatoxins may react at multiple sites on HSCAS particles, especially the interlayer region, but also at edges and basal surfaces. Since clay and zeolitic minerals comprise a broad family of functionally diverse chemicals, there may be significant hidden risks associated with their indiscriminate

inclusion in the diet. All aflatoxin binding agents should be rigorously tested, paying particular attention to their effectiveness and safety in aflatoxin-sensitive animals and their potential for interactions with critical nutrients.

Phillips, T. D., L. F. Kubena, et al. (1988). "Hydrated sodium calcium aluminosilicate: a high affinity sorbent for aflatoxin." Poult Sci **67**(2): 243-7.

Aluminas, silicas and aluminosilicates were evaluated for their ability to sorb radiolabeled aflatoxin B1 (AFB1) from aqueous solution (in vitro). Hydrated sodium calcium aluminosilicate (HSCAS) was selected for testing in vivo due to its high affinity for AFB1, because of its stable association with AFB1, and its GRAS (generally recognized as safe) status as an anticaking agent. The HSCAS, when added to the diet of Leghorn and broiler chicks at a level of .5%, significantly diminished the adverse effects of feeding 7.5 mg AFB1/kg of feed. Thus, this agent (and other aluminosilicate congeners) may prove effective in the preventive management of aflatoxicosis.

Phillips, T. D., S. L. Lemke, et al. (2002). "Characterization of clay-based enterosorbents for the prevention of aflatoxicosis." Adv Exp Med Biol **404**: 157-71.

Appropriate chemical interventions that can block, retard, or significantly diminish foodborne exposure to aflatoxins are high priorities. A practical and effective approach to the aflatoxin problem has been the dietary inclusion of a processed calcium montmorillonite clay (HSCAS). HSCAS acts as an enterosorbent that rapidly and preferentially binds aflatoxins in the gastrointestinal tract resulting in decreased aflatoxin uptake and bioavailability. In mechanistic studies, we have shown that the intact dicarbonyl system in aflatoxin is essential for optimal sorption by HSCAS. Evidence also suggests that aflatoxins react at multiple sites on HSCAS clay surfaces (especially those within the interlayer region). Due to conceivable risks associated with the dietary inclusion of nonspecific binding agents, all aflatoxin enterosorbents should be tested in sensitive animal models for efficacy, safety, and the potential for nutrient interactions.

Plank, G., J. Bauer, et al. (1990). "[The protective effect of adsorbents against ochratoxin A in swine]." Tierarztl Prax **18** (5): 483-9.

Adsorption of the mycotoxin ochratoxin A by activated charcoal, various bentonites (acid, alkaline, neutral), and hydrated sodium calcium aluminosilicate was tested in vitro as well as in feeding experiments with pigs. In vitro tests showed that the 1% addition of activated charcoal leads to complete adsorption of ochratoxin A from aqueous solutions. This effect was not influenced by pH-values ranging from 3-8. In contrast, adsorption by bentonite and hydrated sodium calcium aluminosilicate occurred primarily in the acid range (pH 3-4). Dietary addition of hydrated sodium calcium aluminosilicate (1%) and acid bentonite (1%, 10%) to ochratoxin A-contaminated feed (1.0 mg/kg) had no effect on the blood or tissue levels of the toxin in pigs. The addition of 1% activated charcoal caused a slight decrease of ochratoxin A in the blood, whereas a tenfold dosage resulted in a 50% to 80% reduction of ochratoxin A levels in both blood and tissue. Reduction of ochratoxin A absorption via the dietary

administration of activated charcoal (5%) was confirmed in a 16 week feeding experiment. However, this experiment also showed the serum level of vitamin E to be lower than in the controls receiving adsorbent-free feed.

Pond, W. G. (1989). "Effects of dietary protein level and clinoptilolite on the weight gain and liver mineral response of growing lambs to copper supplementation." *J Anim Sci* 67(10): 2772-81.

Growing male Synthetic I (1/2 Finnish Landrace x 1/4 Dorset x 1/4 Rambouillet) lambs were used in two experiments (64 lambs in Exp. 1 and 63 in Exp. 2) to test the hypothesis that dietary CP level (9 or 14% of diet as fed) and(or) clinoptilolite (clino; 0 or 2% of diet) affects growth and tissue mineral concentrations of growing lambs fed supplemental Cu. Lambs were individually fed their respective diets ad libitum and killed after 12 wk (Exp. 1) or 16 wk (Exp. 2) to obtain carcass measurements, organ weights and liver mineral concentrations. In Exp. 1, 20 ppm added Cu (as CuSO₄.5H₂O) increased mortality and depressed BW gain (P less than .01) and daily feed intake (P less than .05) in the presence or absence of clino and at both levels of CP. Liver Cu concentration was greater (P less than .01) in lambs fed added Cu than in those not fed Cu (408 ppm vs 110 ppm, respectively). Neither CP nor clino affected liver Cu concentration. Clinoptilolite increased daily gain of lambs fed high CP but not low CP (P less than .01). In Exp. 2, clino in the diet had no effect on daily gain or daily feed, but 20 ppm Cu addition depressed daily gain (P less than .01) and gain/feed (P less than .07). Organ weights and levels of trace elements other than Cu in the liver generally were not affected by diet in either experiment. It is concluded that high dietary CP or 2% dietary clino did not protect against toxic signs of Cu when Cu was added to the basal diet (10 ppm Cu) at 10 or 20 ppm.

Pond, W. G. and J. T. Yen (1983). "Protection by clinoptilolite or zeolite NaA against cadmium-induced anemia in growing swine." *Proc Soc Exp Biol Med* 177 (3): 332-7.

Weanling Landrace X Yorkshire swine were fed a basal diet or a diet containing 3% clinoptilolite (a natural zeolite) with or without 150 ppm CdCl₂ or 3% zeolite NaA (a synthetic zeolite) with or without 150 ppm CdCl₂ for 31 days. Hematocrit and hemoglobin were depressed significantly in animals fed Cd in the absence of zeolites, but not in their presence. Liver Cd concentration was increased dramatically by added dietary Cd but was significantly lower in animals fed clinoptilolite with Cd than in those fed Cd alone (11.4 vs 16.5 ppm). Liver Fe and Zn were decreased by dietary Cd; liver Fe was not affected significantly by clinoptilolite or zeolite NaA, but liver Zn was increased by zeolite NaA. Kidney dry matter, Zn, and Cd concentrations were increased by dietary Cd; neither clinoptilolite nor zeolite NaA affected kidney Cd concentration. Zeolite NaA increased kidney dry matter both in the presence and in the absence of dietary Cd. Plasma urea-N, K, Na, and Mg were unaffected by Cd or by either zeolite. The data illustrate the different effects of dietary clinoptilolite compared with zeolite NaA on blood plasma, liver, and kidney concentrations of minerals and provide evidence that both zeolites offer some protection against Cd-induced Fe-deficiency anemia; the magnitude of this protection and the effects of each zeolite on tissue

concentrations of Cd and other materials need further quantification.

Poschl, M. and J. Balas (1999). "Reduction of radiocaesium transfer to broiler chicken meat by a clinoptilolite modified with hexacyanoferrate." *Radiat Environ Biophys* **8**(2): 117-24.

The effect of RADEKONT (a natural clinoptilolite modified by hexacyanoferrate) on ^{137}Cs uptake into meat was tested in experiments with broiler chickens. Three experiments determined the influence of RADEKONT on radiocaesium transfer after single or repeated applications of artificially contaminated feed mixture and one experiment investigated the effect of RADEKONT when feeding a mixture containing wheat contaminated by the Chernobyl fallout. Independent of the effect of RADEKONT, the uptake of radiocaesium was faster in leg meat than in breast meat. Reduction factors (^{137}Cs transfer without the RADEKONT additive compared with those observed after supplementation of the additive into the feed mixture) of 1.1-1.3 and 1.2-2.3, respectively, were achieved after single and repeated administrations of artificially contaminated feed. No significant differences in reduction between breast and leg meat were observed. RADEKONT was more effective when the chickens were fed with Chernobyl-contaminated wheat (reduction factors of up to 3.7) than an artificial ^{137}Cs source. RADEKONT as a supplement during the decontamination period decreased the biological half-life of ^{137}Cs to less than 1 day. The timing of the application of RADEKONT might be important in determining its effectiveness, especially in young, rapidly growing chickens.

Pristiazhniuk, I. E. and V. N. Gorchakov (1997). "[Changes in the lymph nodes of rats under the influence of natural sorbents in damaging exposure to carbophos]." *Morfologija* **112**(4): 54-6.

The experiment was performed in male Wistar rats to study the influence of natural sorbents (Tyumen diatomites and Novosibirsk kudurites) administered with food at dose 6% of its dry weight on lymph nodes. The data obtained demonstrated that addition of natural sorbents to food does not exert pathological influence on lymph nodes of experimental animals. Sorbent diet affects follicular and paracortical lymph node structures, changing their sizes and cytological composition; natural sorbents increase immune potential which is realized after the impairing action.

Pylev, L. N., L. A. Vasil'eva, et al. (2003). "[Carcinogenic danger of zeolite from Kholinsk]." *Gig Sanit*(2): 53-6.

The carcinogenic activity of the enterosorbent optisorb (pure zeolite) and the biologically active food additive litovite [zeolite and rye brans (1:1)] based on zeolite-clinoptololite from the Kholinsk deposit was studied. The intrapleural three-fold administration of optisorb (20 mg x 3) to rats and the inclusion of optisorb (5% of the feed) and litovite (5 and 0.06%) into the feed showed that these agents had no carcinogenic activity.

Rabon, H. W., Jr., D. A. Roland, Sr., et al. (1991). "Influence of sodium zeolite A with and without pullet-sized limestone or oyster shell on eggshell quality." *Poult Sci* **70**(9): 1943-7.

To determine whether particle size of CaCO₃ influences the hen's response to sodium zeolite A (ZA), two experiments were conducted. In Experiment 1, hens were fed 0, .75, and 1.50% ZA for 6 wk with and without a Na correction. At the end of the 4th wk, pullet-sized limestone was substituted for 50% of the added fine granular limestone in the diet containing no ZA. In Experiment 2, hens were fed diets containing 0, .68, and 1.36 ZA for 8 wk with and without one-half of the added fine granular limestone substituted for oyster shell. No correction for Na was made. A dietary calcium concentration of 2.75% was used in Experiment 1 and 3.5% in Experiment 2. Egg specific gravity, egg production, feed consumption, and egg weight were measured. Sodium zeolite A increased egg specific gravity, and the beneficial effects of ZA were maintained during Weeks 5 and 6 when pullet-sized limestone was added to the control diet containing no ZA (Experiment 1). Oyster shell and ZA improved egg specific gravity in Experiment 2 and the effect was additive. Dietary treatments had no effect on egg production or egg weight in Experiments 1 or 2 and there was no effect on feed consumption (Experiment 1). Feed consumption was reduced by ZA, when hens were fed oyster shell, but not when they were fed ZA with fine granular limestone (Experiment 2). It was concluded that the beneficial effect of ZA on egg specific gravity was independent of particle size of CaCO₃ in the diet.

Rabon, H. W., Jr., D. A. Roland, Sr., et al. (1995). "Absorption of silicon and aluminum by hens fed sodium zeolite A with various levels of dietary cholecalciferol." *Poult Sci* **74**(2): 352-9.

Two experiments were conducted to determine whether 1) serum Si and Al is increased in hens intubated with sodium zeolite A (SZA); and 2) dietary cholecalciferol (vitamin D3) influences the absorption of Si or Al by hens fed SZA. In Experiment 1, hens were intubated at oviposition with 0, 1, or 2 g of SZA. Blood samples were collected from the brachial vein at oviposition, and 4, 8, 12, 16, and 20 h postoviposition. Serum samples were analyzed for Si and Al. Peak serum Si and Al were observed at 4 and 8 h postoviposition, respectively. In Experiment 2, hens consumed commercial layer diets ad libitum containing five levels of dietary cholecalciferol (100 to 500 IU/kg) with or without .75% SZA for 6 wk. Blood samples were collected at the end of the 6-wk period by cardiac puncture at oviposition. When dietary cholecalciferol was increased from 100 to 200 IU/kg of diet there was an increase ($P < .05$) in serum Si but not Al. Levels of cholecalciferol above 200 IU/kg did not produce an additional increase in serum Si. The results showed increased ($P < .01$) serum concentrations of Si and Al for hens intubated with or fed SZA. It was concluded that Si and Al from SZA are absorbed by commercial Leghorn hens, and a possible involvement of Si or Al should be considered in the mechanism of action of SZA associated with improved eggshell quality and bone development.

Rizzi, L., M. Simioli, et al. (2003). "Aflatoxin B1 and clinoptilolite in feed for laying hens: effects on egg quality, mycotoxin residues in livers, and hepatic mixed-function oxygenase activities." *J Food Prot* **66**(5): 860-5.

Ninety-six laying hens were allocated to four groups administered different diets (group 0-0 received a complete diet, group 0-AF received a diet supplemented with 2.5 ppm

of aflatoxin B1 [AFB1], group 2-0 received a diet supplemented with 2% clinoptilolite [CPL], and group 2-AF received a diet supplemented with 2% CPL and 2.5 ppm of AFB1) for 4 weeks to evaluate the effect of AFB1 and/or CPL on egg quality and the ability of CPL to interact with the oral administration of AFB1. The possible effects of AFB1 on cytochrome P450-dependent hepatic mixed-function oxygenase (MFO) activities were also evaluated. Mycotoxin reduced yolk weight, while CPL influenced albumen percentage relative to that of eggs laid by chickens in group 0-AF. Eggs laid by chickens in groups 0-AF and 2-AF had stronger shells and weighed less than the eggs of other groups. The eggs of treated groups were lighter in color than those of the control group ($P < 0.01$), and the tendency to yellowness in eggs was increased by CPL, probably through the affinity of red pigments for adsorbents and a consequent prevalence of yellow tonality. Color parameters might be connected with AFB1's interference with lipid metabolism and pigment deposition. The livers of hens in groups 0-AF and 2-AF showed very low mycotoxin concentrations that were significantly different ($P < 0.01$). The highest levels observed were those in the livers of the hens receiving the diet supplemented with the mycotoxin alone. AFB1 did not exert any significant effects on the hepatic MFO activities examined.

Roland, D. A., Sr. (1988). "Further studies of effects of sodium aluminosilicate on egg shell quality." *Poult Sci* 67(4): 577-84.

Five experiments were conducted using 36 dietary treatments to compare chloride salts and HCl as chemical sources of Cl for the adjustment of dietary Cl when using sodium aluminosilicate (SAS), to compare SAS to natural zeolites (clinoptilolite and mordenite), and to determine the appropriate level of dietary SAS for optimum egg specific gravity. The methods of Na and Cl correction used in the various treatments included altering the levels of NaCl, calcium chloride (CaCl₂), potassium chloride (KCl), magnesium chloride (MgCl₂), iron chloride (FeCl₃), or hydrochloric acid (HCl). Experimental diets were fed for 6 to 8 wk. Results of all experiments (except Experiment 2) indicated that the addition of SAS to layer diets improved egg specific gravity and that correction for Na by removal of NaCl and the addition of HCl was not necessary for SAS to be effective. No beneficial effects of dietary SAS on egg specific gravity were observed when Na and Cl corrections were made using CaCl₂, KCl, MgCl₂, or FeCl₃. The feeding of SAS has no influence on egg production in Experiments 1 and 3 but significantly improved egg production in Experiment 4, when it was added to diets containing 2.75% Ca. An adverse effect on production of feeding SAS was observed, especially at the higher levels of SAS in Experiments 2 and 5. In general, SAS tended to reduce feed consumption, with no effect on egg weight. It was concluded that .75% SAS will improve egg specific gravity approximately 1 to 3 units and that correction for Na was not necessary for SAS to be effective.

Roland, D. A., Sr., D. G. Barnes, et al. (1991). "Influence of sodium aluminosilicate, hydroxy-sodalite, carnegieite, aluminum sulfate, and aluminum phosphate on performance of commercial Leghorns." *Poult Sci* 70(4): 805-11.

Experiments were conducted to determine if the high ion-exchange capacity of sodium aluminosilicate (ZA) marketed as

ETHACAL Feed Component or its aluminum content or both are related to the beneficial effect of ZA on egg specific gravity (ESG). In Experiments 1 and 2, ZA was compared with hydroxy-sodalite (HS) and carnegieite, which have the same chemical formula as ZA but little or no ion-exchange capacity. Two levels of ZA (0 and 1.5% of the diet) and three levels of HS (0, .75, and 1.5%) were fed in Experiment 1. In Experiment 2, 0, .75, and 1.5% of ZA and carnegieite were fed. In Experiment 3, ZA, carnegieite, aluminum sulfate, and aluminum phosphate were fed at levels calculated to contain .148 and .101% aluminum. Criteria evaluated were ESG, egg production, feed consumption, and egg weight. Egg specific gravity was significantly improved by ZA in all experiments and was not affected by HS, carnegieite (Experiments 1 and 2), aluminum sulfate (.148% Al), or aluminum phosphate (Experiment 3). Carnegieite and aluminum (.101%) from aluminum sulfate increased ESG in Experiment 3. In Experiments 1 and 3, egg production and feed consumption were not influenced by various treatments. Carnegieite and ZA reduced egg production and feed consumption in Experiment 2. It was concluded that the ion-exchange capacity and aluminum content of ZA may contribute to its beneficial effect on ESG.

Roland, D. A., Sr., S. M. Laurent, et al. (1985). "Shell quality as influenced by zeolite with high ion-exchange capability." Poult Sci 64(6): 1177-87.

Sixteen dietary treatments applied to a total of 960 hens were used to determine the influence of zeolite A on shell quality and egg size. In Experiment 1, sodium zeolite A (SZA) was fed at three levels (0, .75, and 1.50%) in diets containing 4.0 and 2.75% calcium (Ca) for 8 weeks to old hens. In Experiment 2, the same levels of SZA were fed in diets containing two total sulfur amino acid levels (TSAA, .61 and .51%) to young hens for 12 weeks. Calcium zeolite A (CZA) was also fed at .68% in Experiment 1 in the 4.0% Ca diets and in Experiment 2 in the .51 and .61% TSAA diets. These diets were adjusted for sodium (Na) and chloride (Cl). SZA (.75% unadjusted for Na and Cl) was fed to old hens receiving the 2.75% Ca diet in Experiment 1. All diets were isocaloric and isonitrogenous within diets having the same Ca or TSAA level within an experiment. Response criteria were egg production, feed consumption, egg specific gravity, serum Ca, and body weight. A significant linear response in egg specific gravity occurred within 2 or 3 weeks, when diets supplemented with SZA were fed to old (Experiment 1) and young (Experiment 2) hens. Average Ca intake for control hens (Experiment 1) fed the 2.75 and 4.0% Ca diets was 2.93 and 4.54 g, respectively. Average Ca intake for control hens (Experiment 2) fed the .51 and .61% TSAA diet was 4.38 and 4.00 g, respectively. The CAZ (Experiments 1 and 2) and SZA (unadjusted for Na and Cl, Experiment 1) also gave significant increases in egg specific gravity. Zeolite A had little or no influence on egg weight, feed consumption, or egg production in Experiments 1 or 2. When Na and Cl were not adjusted in the SZA treatments (Experiment 1) a significant reduction in production occurred. It was concluded that zeolite A will significantly increase egg specific gravity and we hypothesize that the mechanism responsible for the significant improvement is related to the high ion-exchange capability of zeolite A.

Roland, D. A., Sr., H. W. Rabon, et al. (1990). "Response of commercial Leghorns to sodium aluminosilicate when fed

different levels and sources of available phosphorus." Poult Sci **69**(12): 2157-64.

Two experiments were conducted to elucidate possible explanations for the adverse interaction of sodium aluminosilicate (ZA) and low phosphorus on egg production. In Experiment 1, hens were fed available phosphorus at two levels (.40 and .31%) and from three sources (dicalcium phosphate, defluorinated phosphate, and meat and bone meal). Two levels (0 and .75%) of ZA were concomitantly fed with these treatments. In Experiment 2, hens were fed two levels (.30 and .20%) and two sources (dicalcium phosphate and defluorinated phosphate) of phosphorus with and without ZA (0 and .75%). In both experiments, egg production, egg specific gravity, feed consumption, and egg weight were measured. In Experiment 2, plasma sodium, potassium, chloride, total and free calcium, and phosphorus were also monitored. Results of both Experiments indicated that ZA significantly increased egg specific gravity; whereas, phosphorus level and source had no effect on egg specific gravity. Egg production was influenced by ZA level, phosphorus source, and phosphorus level with significant phosphorus source by phosphorus level interactions. In Experiment 1, ZA reduced egg production at the higher phosphorus level when dicalcium phosphate or defluorinated phosphate was used but not at the lower phosphorus level. Egg production was not influenced by ZA when meat and bone meal was the source of phosphorus. In Experiment 2, ZA reduced egg production more at the lowest level of phosphorus and more when the phosphorus source was defluorinated phosphate than when it was dicalcium phosphate but the interaction was not significant. Sodium aluminosilicate had no influence on egg weight, but it did reduce feed consumption.(ABSTRACT TRUNCATED AT 250 WORDS)

Roussel, J. D., J. K. Thibodeaux, et al. (1992). "Effect of feeding various levels of sodium zeolite A on milk yield, milk composition and blood profiles in thermally stressed Holstein cows." Int J Vitam Nutr Res **62**(1): 91-8.

Mid-lactation Holstein cows ($n = 48$) were equally and randomly assigned to one of four feeding treatments of sodium zeolite-A (SZA). SZA was mixed in a grain mixture (50:50 grain to forage ratio) of 0% (control), 0.5%, 1.0% and 1.5% SZA on a dry matter intake basis. Cows were fed alfalfa hay in the first phase and corn silage in the second phase of the study as roughage sources. Milk samples were taken three times weekly (am and pm) and analyzed for milk fat, protein and lactose with blood profiles conducted from samples collected weekly. SZA significantly ($P < .05$) increased feed intake at all three levels for both diets. Milk yield was significantly ($P < .05$) greater in the alfalfa diet. However, milk fat percent and percent protein were greater ($P < .05$) in the corn silage diet. The addition of SZA to the corn silage diet increased ($P < .05$) milk fat percent at the 1.0% level and milk protein at the 1.5% level. Calcium in milk was significantly ($P < .05$) increased and respiration rates significantly lowered ($P < .05$) in both diets at the 1.0% level. Serum calcium was higher ($P < .05$) at the 1.0 and 1.5% level in the hay diet and the 1.5% level in the corn silage diet. Also, serum glucose and alkaline phosphate levels were significantly ($P < .05$) higher in the corn silage diet.

Schell, T. C., M. D. Lindemann, et al. (1993). "Effectiveness of different types of clay for reducing the detrimental effects of aflatoxin-contaminated diets on performance and serum profiles of weanling pigs." *J Anim Sci* 71(5): 1226-31.

Three trials were conducted with recently weaned pigs ($n = 198$) to determine the effects of feeding different types of clay in conjunction with aflatoxin-contaminated diets. In Trial 1, pigs ($n = 54$; trial length 4 wk) were assigned to either an uncontaminated treatment (NC), 800 ppb of aflatoxin from contaminated corn (AC), or AC with one of four clays. In Trial 2 ($n = 81$; trial length 5 wk), pigs were assigned to NC, AC (500 ppb of aflatoxin from rice starch), or AC with one of seven types of clay. In both trials, pigs fed AC had decreased ADG and gain:feed ratios ($P < .05$) compared with controls. The clays differed in their ability to produce gains similar to those of controls. The clays did reduce changes in the serum measurements normally affected by aflatoxin, including albumin, total protein, gamma glutamyltransferase (GGT), and alkaline phosphatase (ALP) levels, in a manner similar to their effect on ADG. In Trial 3, pigs ($n = 63$) were assigned to one of seven diets for 4 wk: NC, AC (800 ppb of aflatoxin) with no clay, AC with one of four levels of a treated Ca bentonite (.25, .5, 1, and 2%), or AC and .5% hydrated sodium calcium aluminosilicate. The addition of treated Ca bentonite to AC improved ADG ($P < .05$) and ADFI ($P < .01$) linearly. Gain:feed ratios were not affected by treatments. The inclusion of treated Ca bentonite to the AC diet linearly decreased aspartate aminotransferase (AST) levels and quadratically decreased ALP and GGT levels ($P < .05$). (ABSTRACT TRUNCATED AT 250 WORDS)

Shurson, G. C., P. K. Ku, et al. (1984). "Effects of zeolite A or clinoptilolite in diets of growing swine." *J Anim Sci* 9(6): 1536-45.

Growth, nutrient balance, plasma ammonia levels and urinary p-cresol excretion were evaluated in growing pigs fed diets containing various levels of zeolite A or clinoptilolite. In one growth trial, crossbred pigs averaging 25 kg initial body weight were assigned to diets containing no zeolite, .3% zeolite A or .5% clinoptilolite for a 6-wk growing phase trial. Average daily gain (ADG), average daily feed intake (ADF) and feed/gain (F/G) were unaffected by supplementation of either zeolite in the diet, but metabolizable energy (ME) utilization was improved by feeding diets containing either zeolite. A second growth trial utilized the same crossbred pigs, which averaged 65 kg initial body weight, and were assigned to diets containing no zeolite, 1% zeolite A or 5% clinoptilolite for an 8-wk finishing phase trial. Average daily gain, ADF, and ME utilization were unaffected by feeding either zeolite diet, while F/G was increased in pigs fed the diet containing 5% clinoptilolite. In two nutrient balance trials, 16 crossbred pigs averaging 7.5 kg in initial body weight were fed diets containing 0, 1, 2 or 3% zeolite A in one trial and 16 crossbred pigs averaging 7.0 kg initial body weight were fed diets containing 0, 2.5, 5.0 or 7.5% clinoptilolite in a second trial. In both trials, digestible energy, ME, N-corrected ME and ME corrected for N balance and zeolite levels were linearly reduced as increasing amounts of either zeolite were fed. Daily fecal N increased and apparent digestibility of N was linearly reduced by feeding increasing amounts of zeolite A or clinoptilolite. Biological value of protein was improved linearly as higher levels of zeolite A were fed, indicating that there may be some ammonia binding to zeolite A in the

gastrointestinal tract. Net protein utilization was reduced by feeding increasing levels of clinoptilolite in the diet. Calcium, P, Mg, Na, K and Fe retentions were linearly reduced by feeding increasing amounts of zeolite A in the diet, while increasing levels of clinoptilolite caused only P retention to be linearly reduced. Both free and conjugated forms of urinary p-cresol were linearly reduced by feeding increasing levels of clinoptilolite. Plasma ammonia levels were reduced at subsequent bleedings after a meal and by increasing levels of clinoptilolite.

Smith, T. K. (1980). "Effect of dietary protein, alfalfa, and zeolite on excretory patterns of 5',5',7',7'-[³H]zearalenone in rats." Can J Physiol Pharmacol 8(11): 1251-5.

A series of experiments was conducted to determine how dietary protein, alfalfa, or zeolite influence the excretory patterns of zearalenone (Z), a uterotrophic mycotoxin synthesized by Fusarium fungi. Rats were fed diets containing 16.3% casein, 40% casein, 11.2% casein + 25% alfalfa, or 25% casein + 25% alfalfa. Also fed were diets containing 0, 1, 2, or 5% anion exchange zeolite. Tracer doses of [³H]Z were administered either as a constituent of the diet or as a topical application on the skin at the base of the skull. When Z was administered orally, no differences were seen in the fraction of the dose excreted in urine or feces as a result of varying dietary levels of alfalfa and protein. Topical doses resulted in rats fed 25% casein + 25% alfalfa or 40% casein excreting more Z in urine than those fed 25% alfalfa or 16.3% casein. Fecal excretion of Z was greatest for rats fed 25% casein + 25% alfalfa whereas rats fed 40% casein excreted more fecal Z than those fed 16.3% casein. Feeding Z to rats receiving dietary zeolite resulted in a positive correlation between dietary zeolite and fecal excretion of Z but a negative correlation with urinary excretion of Z. Topical administration of Z produced a positive correlation between dietary zeolite and fecal Z excretion but no effect on urinary excretion. It may be concluded that protein and alfalfa treatments alleviate Z toxicosis through increased metabolism whereas zeolite binds Z in the digestive tract to prevent absorption.

Sorokina, E., I. N. Aksiuk, et al. (2001). "[Assessment of the effectiveness of biologically active food additives based on zeolites in experimental animals]." Vopr Pitan 70(4): 35-8.

The aim of present study was an investigation of effective of product from ceolites which is suggested as biologically active food additive. The high-calorie, high-fat, high-cholesterol diet was developed. The rats (female and male) were fed with the biologically active food additive during 1 month at dose 70 mg per kg of body weight. Their blood and liver were investigated to measure total lipids, total cholesterol, phospholipid, triglycerides. Morphologic parameters of liver was studied. Cholesterol lowering effect of biologically active food additive in rat (female) has been shown.

Sorokina, E., A. B. Levitskaia, et al. (1995). "[Study of long-term effects of zeolites on the body of laboratory animals]." Vopr Pitan(3): 16-8.

The aim of present study was an investigations of embryotoxic, teratogenic and gonadotoxic effects of zeolites of Pashensky and Chongurinsky (chongurin) deposits. Zeolites

are suggested as feed additives in stock-breeding animal and poultry-keeping. In long-term experiments it was shown that zeolites included in animal diet as much as 5% of diet mass had no unfavourable effect on animals. Negative effect on growth and development of generation, hematologic parameters of blood and activity of some enzymes were also not observed.

Spotti, M., M. L. Fracchiolla, et al. (2005). "Aflatoxin B1 binding to sorbents in bovine ruminal fluid." Vet Res Commun 29(6): 507-15.

A recent approach to the problem of contamination of agricultural products by aflatoxin B(1) (AFB(1)) is to add non-nutritional adsorbents to animal diets in order to sequester ingested aflatoxins. We conducted in vitro experiments to develop a rapid and cheap model using ruminal fluid to assess the ability of sorbent materials to bind AFB(1). Seven sorbents (hydrated sodium calcium aluminosilicate; clinoptilolite; zeolite; two types of bentonite; sepiolite; and PHIL 75), commonly added to bovine diets were incubated in water and ruminal fluid in the presence of AFB(1). Hydrated sodium calcium aluminosilicate, sepiolite and one of the bentonites bound 100% of the AFB(1) in the presence of both ruminal fluid and water; clinoptilolite bound about 80% of AFB(1) in both liquids; whereas the affinities for the mycotoxin of zeolite (50%) and the other sample of bentonite (60%) in water seem to be increased by about 40% in ruminal fluid incubations. PHIL 75 had the poorest binding ability: about 30% in water and 45% in ruminal fluid. In view of the differences in toxin binding in water and ruminal fluid, it is preferable to use the ruminal fluid model for the in vitro pre-screening of sorbent materials potentially useful as adjuvants to ruminant feeds.

Thilsing, T., T. Larsen, et al. (2007). "The effect of dietary calcium and phosphorus supplementation in zeolite treated dry cows on periparturient calcium and phosphorus homeostasis." J Vet Med A Physiol Pathol Clin Med 4(2): 82-91.

Previous studies have proved the possibility of preventing parturient hypocalcaemia by zeolite A supplementation during the dry period, and a recent in vitro study has indicated a marked calcium (Ca) as well as phosphorus (P) binding effect of zeolite A in rumen fluid solutions. Because of the connection between the Ca and P homeostatic systems, the preventive effect against parturient hypocalcaemia may arise from zeolite induced decreased availability of dietary Ca as well as P. In the present study, the expected Ca and P binding capacity was challenged by feeding high and low levels of dietary Ca and/or P to zeolite A treated dry cows. Twenty-one pregnant dry cows were assigned to four experimental groups receiving a dry cow ration unsupplemented or supplemented with extra Ca and/or P. During the last 2 weeks of the dry period all cows additionally received 600 g of zeolite A per day. A high level of dietary P prepartum significantly decreased the plasma Ca concentration before as well as immediately after calving (day 0-3). Conversely, the plasma inorganic phosphate concentration was higher among these cows than among cows receiving no supplemental P. The prepartum dietary Ca level significantly affected the serum 1,25-dihydroxyvitamin D concentration during zeolite supplementation, whereas the periparturient plasma Ca

concentration was apparently not affected by the dietary Ca level. During zeolite A supplementation plasma parathyroid hormone was significantly higher among cows receiving additional P. The urinary deoxypyridinoline/creatinine ratio was not affected by the prepartal dietary Ca or P level. Serum aluminium (Al) was significantly higher during zeolite A supplementation than during the preceding period, indicating partial destruction of the zeolite in the intestinal tract with subsequent release and absorption of Al. It is suggested that the effect of prepartum zeolite supplementation on the periparturient Ca homeostasis depends on the level of Ca as well as P in the dry cow ration.

Thilsing-Hansen, T. and R. J. Jorgensen (2001). "Hot topic: prevention of parturient paresis and subclinical hypocalcemia in dairy cows by zeolite A administration in the dry period." J Dairy Sci 84(3): 691-3.

To test the effects of a zeolite feed supplement on parturient calcium status and milk fever, two groups of dry cows were treated with either 1 kg of zeolite/d or none for 4 wk prepartum. At calving and d 1 and 2 after calving all cows were given 250 g of calcium carbonate as a drench, and a blood sample was taken. Serum calcium analysis revealed a greater calcium concentration in zeolite-treated cows. While three control cows contracted milk fever, necessitating intravenous calcium therapy, and six out of eight control cows experienced serum calcium levels below 2 mmol/L in one or more samples taken, none of the zeolite-treated cows contracted milk fever or experienced subclinical hypocalcemia.

Thilsing-Hansen, T., R. J. Jorgensen, et al. (2002). "The effect of zeolite A supplementation in the dry period on periparturient calcium, phosphorus, and magnesium homeostasis." J Dairy Sci 85 (7): 1855-62.

One potential way of preventing parturient hypocalcemia in the dairy cow is to feed dry cow rations very low in calcium (<20 g/d); but, because it is difficult to formulate rations sufficiently low in calcium, this principle has been almost abandoned. Recent studies have shown, however, that it is possible to prevent milk fever, as well as subclinical hypocalcemia, by supplementing the dry cow ration with sodium aluminium silicate (zeolite A), which has the capacity to bind calcium. The aim of this study was to further evaluate the effect, if any, of such supplementation on other blood constituents, feed intake, and milk production in the subsequent lactation. A total of 31 pregnant dry cows about to enter their third or later lactation were assigned as experimental or control cows according to parity and expected date of calving. The experimental cows received 1.4 kg of zeolite pellets per d (0.7 kg of pure zeolite A) for the last 2 wk of pregnancy. Blood samples were drawn from all cows 1 wk before the expected date of calving, at calving, at d 1 and 2 after calving, and 1 wk after calving. Additionally, a urine sample was drawn 1 wk before the expected date of calving. Zeolite supplementation significantly increased the plasma calcium level on the day of calving, whereas plasma magnesium as well as inorganic phosphate was suppressed. Serum 1,25(OH)2D was significantly increased 1 wk before the expected date of calving among the experimental cows, whereas there was no difference in the urinary excretion of the bone metabolite deoxypyridinoline between the two

groups. Feed intake was decreased among the zeolite-treated cows during the last 2 wk of pregnancy. No effect was observed on milk yield, milk fat, and milk protein in the subsequent lactation. The mechanisms and interactions involved in zeolite supplementation are discussed in relation to the observed improvement in parturient calcium homeostasis and to the observed depression in blood magnesium and inorganic phosphate.

Thilsing-Hansen, T., R. J. Jorgensen, et al. (2003). "The effect of zeolite A supplementation in the dry period on blood mineral status around calving." *Acta Vet Scand Suppl* **97**: 87-95.

This article summarizes the results obtained in 6 separate studies concerned with the effect of zeolite A supplementation in the dry period on blood calcium, magnesium and phosphorus status around calving. The experiments were conducted on 5 different farms, and comprised a total of 117 cows. Two of the experiments (exp. 5 and 6) were conducted under extensive farming conditions whereas the rest (exp. 1-4) were conducted on intensively driven farms. All cows included in the experiments had completed at least 2 lactations. The cows were allocated as either untreated control cows or zeolite treated experimental cows according to expected date of calving and parity. The experimental cows were fed between 0.5 and 1.0 kg of zeolite A per day during the last 2 to 4 weeks of the dry period. Blood samples were drawn on the day of calving and day one and two after calving (all experiments), three weeks before the expected date of calving (exp. 1 and 2) and one week after calving (exp. 3 and 4). The zeolite supplementation significantly increased the mean serum Ca level on the day of calving. The efficiency of the zeolite supplementation to prevent hypocalcaemia (serum Ca < 2.00 mmol/l) on the day of calving was calculated. Efficiencies varied ranging from 3 to 100%, with a mean efficiency of 58%. The zeolite-calcium ratio (g of zeolite per cow per day/g of dietary calcium per cow per day) was calculated in each experiment. From the results it seemed, that zeolite-calcium ratios below 5 did not effectively prevent parturient hypocalcaemia, whereas ratios of 10 to 20 proved very efficient in preventing hypocalcaemia. There was apparently no additional effect from feeding zeolite for 4 instead of 2 weeks prepartum. Feeding zeolite in the dry period significantly decreased plasma phosphate before as well as after calving. The phosphate level was normalized within one week after calving. Plasma magnesium was significantly lower among the experimental cows on the day of calving, but stayed within the normal range of plasma magnesium. The control cows on the other hand experienced hypermagnesemia after calving.

Turner, K. K., B. D. Nielsen, et al. (2007). "Tissue Response to a Supplement High in Aluminum and Silicon." *Biol Trace Elem Res.*

The objective was to determine the effects of sodium zeolite A (SZA) on mineral metabolism and tissue mineral composition in calves. Twenty calves were placed on study at 3 days of age and were placed into one of two groups: SS, which received 0.05% BW SZA added to their milk replacer, and CO, which received only milk replacer. Blood samples were taken on days 0, 30, and 60 for mineral analysis. Urine and feces were collected on day 30 for mineral metabolism, and on day 60,

the calves were euthanized, and samples were taken from numerous organs for mineral analyses. Aluminum retention was increased in the SS calves ($p = 0.001$). Silicon concentrations were increased in the aorta, spleen, lung, muscle, and kidney of the SS calves, and aluminum was increased in all SS tissues ($p < 0.05$). Calcium concentrations were increased in aorta, liver, muscle, and tendon; phosphorus concentrations were increased in aorta, but decreased in plasma; magnesium concentrations were increased in aorta, heart, kidney, liver, and pancreas, but decreased in plasma; and iron concentrations were decreased in kidney and liver ($p < 0.05$). The accumulation of tissue aluminum and therefore potential adverse consequences may preclude any benefits of using SZA as a dietary supplement.

Varel, V. H., I. M. Robinson, et al. (1987). "Effect of dietary copper sulfate, Aureo SP250, or clinoptilolite on ureolytic bacteria found in the pig large intestine." Appl Environ Microbiol (9): 2009-12.

The predominant ureolytic bacteria in the pig large intestine were determined while growing pigs were fed a basal diet or basal diet plus copper sulfate, Aureo SP250, or clinoptilolite. Fecal samples were collected from four pigs fed each diet at 3, 9, and 14 weeks and analyzed for total colony counts and percent ureolytic bacteria. Fecal urease activity, ammonia nitrogen, and identity of the ureolytic bacteria were determined at 14 weeks. Copper sulfate and Aureo SP250 reduced the number of ureolytic organisms, with a marked decrease occurring in the *Streptococcus* spp., which made up 74% of the ureolytic isolates from the pigs on the basal diet. Other ureolytic species detected at lower concentrations were *Staphylococcus* spp., *Selenomonas ruminantium*, *Bacteroides multiacidus*, and *Eubacterium limosum*. Copper sulfate also reduced fecal urease activity (P less than 0.10). Fecal ammonia concentrations were not different between pigs fed the various diets. These data suggest that the streptococci are the most numerous ureolytic species in the pig intestinal tract and are significantly reduced by copper sulfate and Aureo SP250; however, only copper sulfate reduced intestinal urease activity.

Ward, T. L., K. L. Watkins, et al. (1990). "Interactive effects of sodium zeolite A (Ethacal) and monensin in uninfected and *Eimeria acervulina*-infected chicks." Poult Sci 69(2): 276-80.

An experiment was conducted with 5- to 18-day-old Arbor Acres broiler chicks to evaluate the interaction of sodium zeolite A (NZA) and monensin in uninfected and in coccidiosis-infected chicks. Sodium zeolite A (0 and .75%) or monensin (0 and 121 ppm), or both, were fed to uninfected chicks or to chicks infected with 4×10^5 sporulated, *Eimeria acervulina* oocysts, resulting in a 2-by-2-by-2 factorial arrangement of treatments. Coccidial infection reduced (P less than .01) weight gain, feed intake, feed efficiency, percentage of bone ash and of bone calcium; but the infection increased (P less than .05) bone Zn percentage. Monensin alleviated (or at least partially so) the adverse effects of the coccidial infection on weight gain, feed intake, feed efficiency and percentage of bone ash (coccidiosis by monensin, P less than .01). In addition, monensin increased the bone-calcium (P less than .06) and zinc content (P less than .02) in uninfected chicks and in those infected with coccidiosis. Sodium zeolite A tended to reduce feed intake by coccidiosis-infected chicks

(coccidiosis by NZA, P less than .07), but increased (P less than .01) the bone zinc and decreased (P less than .01) serum inorganic phosphorus in uninfected chicks and in those infected with coccidiosis.

Ward, T. L., K. L. Watkins, et al. (1993). "Research note: interactive effects of sodium zeolite A and *Eimeria acervulina* infection on growth and tissue minerals in chicks." *Poult Sci* **72** (11): 2172-5.

Two experiments were conducted to assess the interactive effects of dietary sodium zeolite A (SZA) and experimental *Eimeria acervulina* infection on growth and tissue mineral concentrations in chicks. The average initial weight of the chicks was 71.8 g, and the experimental periods were from 5 to 15 days posthatching. In both experiments, the corn-soybean meal basal diet was supplemented with 0 or .75% SZA and fed to uninfected chicks or to chicks infected with 4 x 10 (5) sporulated *E. acervulina* oocysts on Days 0, 3, and 6 of the experiments. Both coccidial infection and SZA reduced (P < .05) gain and feed intake; however, feed efficiency was reduced (P < .01) only in the coccidiosis-infected chicks. Neither SZA nor the coccidial infection affected (P > .10) plasma Ca or P, tibia P, liver Ca, Zn, Fe, or Mn, or pancreas Cu. Sodium zeolite A increased (P < .05) plasma Zn but only in uninfected chicks (SZA by coccidiosis, P < .10). The coccidial infection decreased (P < .02) tibia ash percentage. Sodium zeolite A decreased tibia Ca in uninfected chicks but increased tibia Ca in coccidiosis-infected chicks (SZA by coccidiosis, P < .10). The coccidial infection increased (P < .05) tibia Mg, Cu, Fe, Pb, Mn, and Al concentrations. Dietary SZA also increased (P < .02) tibia Zn, Mn, and Al concentrations. The coccidial infection decreased (P < .02) tibia Zn concentration, and SZA decreased (P < .05) tibia Mg and Fe. Sodium zeolite A by coccidiosis interactions (P < .10) were evident in tibia Zn, Fe, Mn, and Al concentrations.
(ABSTRACT TRUNCATED AT 250 WORDS)

Ward, T. L., K. L. Watkins, et al. (1991). "Interactive effects of sodium zeolite-A and copper in growing swine: growth, and bone and tissue mineral concentrations." *J Anim Sci* **69**(2): 726-33.

An experiment was conducted with 64 crossbred pigs to determine the effect of 0 or .50% dietary sodium zeolite-A (NZA) in combination with 0 or 250 ppm supplemental Cu (as CuSO₄.5H₂O). Pigs were assigned randomly to one of the following four treatments: 1) corn-soybean meal basal (B), 2) B + .50% NZA, 3) B + 250 ppm Cu, or 4) B + .50% NZA + 250 ppm Cu. Each treatment was replicated four times with four pigs per replicate. Average initial weight was 7.5 kg and the experimental period lasted 144 d. Overall rate and efficiency of gain, incidence of gastric ulcers, dressing percentage, carcass weight, percentage of muscling, 10th rib fat, loin eye area, blood urea N, and bone Ca, P, Mn, Fe, Ni, Na, and Al concentrations were not affected by treatment. The addition of 250 ppm Cu increased liver (P less than .01), serum (P less than .06), and bone (P less than .07) Cu concentrations but decreased mean backfat thickness (P less than .09), bone ash percentage (P less than .03) and serum (P less than .09) and bone (P less than .01) Zn concentrations. Sodium zeolite-A increased serum alkaline phosphatase (P less than .04), carcass length (P less than .06), and liver (P less than .02) and bone (P less than .01) Zn content but decreased (P less

than .04) serum Ca and serum inorganic P concentrations. Sodium zeolite-A did not protect against liver Cu accumulation or gastric ulceration in growing swine fed 250 ppm supplemental Cu.

Watkins, K. L. and L. L. Southern (1991). "Effect of dietary sodium zeolite A and graded levels of calcium on growth, plasma, and tibia characteristics of chicks." *Poult Sci* 70(11): 2295-303.

Sodium zeolite A (SZA), a synthetic sodium aluminosilicate having high ion-exchange capacity, has been shown to increase eggshell specific gravity in laying hens and to improve Ca utilization in chickens. A 4 x 2 factorial arrangement of treatments was used to investigate the effect of dietary Ca (.6, .8, 1.0, and 1.2%) and SZA (0 and .75%) on growth, plasma, and tibia characteristics of chicks from 5 to 15 days of age. Increasing dietary Ca linearly increased (P less than .05) Ca and alkaline phosphatase (AP) in plasma and increased tibia shearing force and percentage ash, Ca, and P in tibiae. However, dietary Ca linearly decreased (P less than .05) inorganic P and Mg in plasma and Mg and Mn in tibiae. Sodium zeolite A decreased (P less than .05) plasma P and AP and tibia Mg but increased (P less than .05) tibia Ca, Zn, Al, and Mn concentrations. Tibia ash and shearing force were increased in chicks fed SZA receiving inadequate dietary Ca, but they were decreased in chicks fed SZA and excess Ca (Ca by SZA interaction, P less than .05). Tibia density showed a similar trend, but the effect was not significant (Ca by SZA interaction, P less than .12). The addition of SZA enhanced tibia ash, density, and shearing force when dietary Ca was low; however, when added to diets containing 1.2% Ca, SZA reduced many bone mineralization indices with the exception of tibia Ca.

Watkins, K. L. and L. L. Southern (1992). "Effect of dietary sodium zeolite A and graded levels of calcium and phosphorus on growth, plasma, and tibia characteristics of chicks." *Poult Sci* 71(6): 1048-58.

Sodium zeolite A (SZA), a synthetic sodium aluminosilicate having a high ion exchange capacity, has been shown to influence Ca and P utilization in chickens. A 3 x 2 x 2 factorial arrangement of treatments was used to investigate the effect of dietary P (.41, .55, and .69% total P), Ca (.6 and 1%), and SZA (0 and .75%) on growth, plasma, and tibia characteristics of chicks from 5 to 15 days of age. Growth, feed intake, gain:feed ratio, and tibia characteristics were influenced by dietary Ca and P in a manner consistent with dietary recommendations for these macro minerals. The addition of Ca, SZA, or both exacerbated the adverse effects of feeding low-P diets, yet alleviated the adverse effects of feeding a low-Ca, high-P diet. Dietary SZA had no effect (P greater than .5) on plasma Ca or alkaline phosphatase; however, SZA reduced (P less than .01) plasma P. Dietary SZA increased (P less than .02) tibia Mn, Zn, Cu, and Al. The SZA-induced increase in tibia Al was most evident in chicks fed low levels of P (SZA by P interaction, P less than .02). The overall response to dietary SZA addition paralleled the response observed from Ca supplementation, indicating that SZA increased Ca utilization, reduced P utilization, or contributed to both of these effects. These data demonstrate that the effects of SZA are influenced by the dietary concentration of

Ca and P and that the addition of SZA to diets low in P results in bone Al accumulation.

Watkins, K. L. and L. L. Southern (1993). "Effect of dietary sodium zeolite A on zinc utilization by chicks." *Poult Sci* 72(2): 296-305.

Two experiments were conducted with chicks from 5 to 15 days posthatching to study the effect of sodium zeolite A (SZA) on Zn utilization. The corn-soybean meal basal diet was supplemented with ZnCO₃ to provide three levels of dietary Zn (35, 40, and 85 ppm) in Experiment 1, and two levels of dietary Zn (85 and 4,000 ppm) in Experiment 2. Experimental diets also contained either 0 or .75% SZA, resulting in a 3 x 2 and a 2 x 2 factorial arrangement of treatments in Experiments 1 and 2, respectively. The tendency for increased growth, feed intake, and hematocrit in chicks fed Zn-supplemented diets in Experiment 1 suggests that the 35-ppm level of Zn in the basal diet was marginal for chicks. Both supplemental Zn and SZA increased ($P < .02$) hematocrit and plasma, pancreas, and tibia Zn and decreased ($P < .02$) tibia Cu. Sodium zeolite A increased (SZA by Zn, $P < .03$) tibia Al and tended to increase (SZA by Zn, $P < .09$) liver Fe in chicks fed either 35 or 85 ppm Zn, but SZA had no effect on tibia Al and liver Fe in chicks fed 40 ppm Zn. In Experiment 2, both SZA and excess dietary Zn decreased gain, feed intake, gain:feed, hematocrit, hemoglobin, and plasma alkaline phosphatase (AP) activity, and increased tibia, liver, and pancreas Zn, and tibia Al. In addition, excess Zn increased ($P < .05$) plasma Zn and liver Al but decreased ($P < .01$) plasma, liver, and pancreas Cu and percentage of tibia ash. The addition of SZA enhanced the adverse effects of excess Zn by further decreasing feed intake, hematocrit, hemoglobin, and plasma AP and Cu and by increasing tibia Al and liver Zn. Sodium zeolite A increased pancreas ($P < .09$) and tibia ($P < .03$) Zn regardless of dietary Zn concentration; however, SZA increased plasma Zn only in chicks fed 85 ppm Zn (SZA by Zn, $P < .03$). Sodium zeolite A tended to improve Zn utilization in chicks fed inadequate Zn but exacerbated the adverse effects of feeding excess Zn. The addition of SZA to the diet of chicks fed inadequate, adequate, or toxic levels of Zn resulted in increased tissue Zn concentration.

Watkins, K. L., D. B. Vagnoni, et al. (1989). "Effect of dietary sodium zeolite A and excess calcium on growth and tibia calcium and phosphorus concentration in uninfected and *Eimeria acervulina*-infected chicks." *Poult Sci* 68(9): 1236-40.

Two identical trials were conducted with 5 to 14-day-old broiler chicks. Sodium zeolite A (NZA, 0 and .75%) and Ca (1.0 and 1.5%) were fed to both uninfected and *Eimeria acervulina*-infected chicks resulting in a 2 x 2 x 2 factorial arrangement of treatments. Coccidial infection reduced weight gain and gain:feed (P less than .01), and tibia ash, Ca, and Ca:P ratio (P less than .05). Excess dietary Ca reduced (P less than .05) weight gain and tibia ash in uninfected chicks but had no effect (P greater than .10) in coccidiosis-infected chicks (Ca x coccidiosis interaction, P less than .05). Addition of NZA to diets with excess Ca further decreased (P less than .05) weight gain and tibia ash in both uninfected and E. acervulina-infected chicks. Tibia Ca, as a percentage of dry fat-free tibia, was reduced (P less than .05) by the addition of NZA. This effect was not observed when tibia Ca was

expressed as a percentage of ash. These results suggest that NZA may exacerbate the adverse effects of excess dietary Ca.

Wu-Haan, W., W. J. Powers, et al. (2007). "Effect of an acidifying diet combined with zeolite and slight protein reduction on air emissions from laying hens of different ages." *Poult Sci* **86**(1): 182-90.

The objectives of the study were to evaluate the effectiveness of a reduced-emission (RE) diet containing 6.9% of a CaSO₄-zeolite mixture and slightly reduced CP to 21-, 38-, and 59-wk-old Hy-Line W-36 hens (trials 1, 2, and 3, respectively) on egg production and emissions of NH₃, H₂S, NO, NO₂, CO₂, CH₄, and non-CH₄ total hydrocarbons as compared with feeding a commercial (CM) diet. At each age, 640 hens were allocated, randomly to 8 environmental chambers for a 3-wk period. On an analyzed basis, the CM diet contained 18.0, 17.0, and 16.2% CP and 0.25, 0.18, and 0.20% S in trials 1, 2, and 3, and the RE diet contained 17.0, 15.5, and 15.6% CP and 0.99, 1.20, and 1.10% S in trials 1, 2, and 3. Diets were formulated to contain similar Ca and P contents. Average daily egg weight (56.3 g), average daily egg production (81%), average daily feed intake (92.4 g), and BW change (23.5 g), across ages, were unaffected by diet ($P > 0.05$) over the study period. Age effects were observed for all performance variables and NH₃ emissions ($P < 0.05$). In trials 1, 2, and 3, daily NH₃ emissions from hens fed the RE diets (185.5, 312.2, and 333.5 mg/bird) were less than emissions from hens fed the CM diet (255.1, 560.6, and 616.3 mg/bird; $P < 0.01$). Daily emissions of H₂S across trials from hens fed the RE diet were 4.08 mg/bird compared with 1.32 mg/bird from hens fed the CM diet ($P < 0.01$). Diet ($P < 0.05$) and age ($P < 0.05$) affected emissions of CO₂ and CH₄. A diet effect ($P < 0.01$) on NO emissions was observed. No diet or age effects ($P > 0.05$) were observed for NO₂ or non-CH₄ total hydrocarbons. Results demonstrated that diet and layer age influence air emissions from poultry operations.

Wu-Haan, W., W. J. Powers, et al. (2007). "Nutrient digestibility and mass balance in laying hens fed a commercial or acidifying diet." *Poult Sci* **86**(4): 684-90.

The objectives of the current study were to evaluate the effect of an acidifying diet (gypsum) combined with zeolite and slightly reduced crude protein (R) vs. a control diet (C) on nutrient retention in laying hens and compare 3 approaches to estimating nutrient excretion from hens: 1) mass balance calculation (feed nutrients - egg nutrient), 2) use of an indigestible marker with analyzed feed and excreta nutrient content, and 3) an environmental chamber that allowed for capturing all excreted and volatilized nutrients. Hens ($n = 640$) were allocated randomly to 8 environmental chambers for 3-wk periods. Excreta samples were collected at the end of each trial to estimate apparent retention of N, S, P, and Ca. No diet effects on apparent retention of N were observed (53.44%, $P > 0.05$). Apparent retention of S, P, and Ca decreased in hens fed R diet (18.7, -11.4, and 22.6%, respectively) compared with hens fed the C diet (40.7, 0.3, and 28.6%, respectively; $P < 0.05$). Total N excretion from hens fed the C and R diet was not different (1.16 g/hen/d); however, mass of chamber N remaining in excreta following the 3-wk period was less from hens fed the C diet (1.27 kg) than from hens fed the R diet (1.43 kg). Gaseous emissions of NH₃ over the 3-wk period from hens fed the C diet (0.74 kg

per chamber) were greater than emissions from hens fed the R diet (0.45 kg). The 3-wk S excretion mass (estimated using the calculation, indigestible marker, and environmental chamber methods, respectively) was greater from hens fed the R diet (1.85, 1.54, and 1.27 kg, respectively) compared with hens fed the C diet (0.24, 0.20, and 0.14 kg, respectively). The 3-wk P excretion was similar between diets (0.68 kg). Results demonstrate that feeding the acidified diet resulted in decreased N emissions, but because of the acidulant fed, greatly increased S excretion and emissions.

Yannakopoulos, A. L., A. S. Tserveni-Gousi, et al. (1998). "Effect of natural zeolite on yolk:albumen ratio in hen eggs." *Br Poult Sci* 9(4): 506-10.

1. The egg yolk: albumen (Y:A) ratio during the laying year was investigated in a commercial strain (Hisex) when natural zeolite was added to a layer's diet. 2. Dietary natural zeolite (NZ) increased both egg weight and albumen weight, while yolk weight was not significantly affected. 3. The Y:A ratio was less (more albumen) in eggs laid by hens on zeolite treatments. It was concluded that by feeding NZ it is possible to alter the Y:A ratio.

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