The Joy of Individual Free-Choice Minerals

Everything you always wanted to know about self-regulated mineral feeding in domestic animals - but were afraid to ask.

A compendium of information compiled by:

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and

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Then

Now

Preface

Wild animals were balancing their own nutrient and mineral needs long before man came on the scene. In the wild, grazing animals had a large variety of plants to choose from and had little need for mineral supplements that could not be satisfied by the salt licks and mineral licks commonly found as they migrated or roamed from one region to another.

With domestication came confinement and soil depletion both of which limited the animal's nutritional choices. The nutritional wisdom of animals was subjugated to the so-called nutritional knowledge of Man.

A reasoned assessment of the current state of animal nutrition and health will judge the wisdom and effectiveness of this change.

The purpose of this book is to show how we can improve animal health and productivity by allowing them to, once again, exercise their nutitional wisdom by providing the opportunity for them to self select from a wide variety of minerals.

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TABLE OF CONTENTS

A Brief History of the Industry

As agriculture progressed and animals became domesticated, there are reports of cattle gnawing on bones (probably for phosphorus), chewing on wood, and eating dirt became common. We were not taught much about animal nutrition in Veterinary school in the late 1950's. We were told that if we could recognize the brand name of the feed or mineral being fed, it was probably adequate. Perhaps at that time over 60 years ago, that was more applicable than it is today. A common mineral mix recommended for livestock use at that time was 1/3 salt, 1/3 finely ground limestone, and 1/3 steamed bone meal. This was to be provided free choice. The use of salt blocks was common and there was always some discussion as to the merits of the colored trace mineral blocks over the plain white blocks.

Dr. Wm. Albrecht has been widely acclaimed as the Father of Modern Soil Science. In the 1940's, his research at the University of Missouri investigated the relationship between soil minerals and animal health. He established the concept that it takes healthy soil to have healthy plants, and healthy plants to have healthy animals.

One of Dr. Albrecht's favorite bits of advice was:

"Observe nature and study books, if they do not agree, throw away the books." Good advice … even today!

"You can trace every disease and every infection to a mineral deficiency from unequally yoked energy fields."

- Linus Pauling

(the only person to ever win two unshared Nobel prizes)

Talbot-Carlson, Inc.: A Pioneer in the Industry

It is thought that the work of Dr. William Albrecht at the University of Missouri inspired Tully Talbot. In 1957, using Dr. Albrecht's findings, Tully Talbot started TCI and developed a free choice mineral feeding system for livestock.

His first application was for Horses. One instance that illustrates the advantage is an Appaloosa gelding that participated in a two thousand mile endurance race. The horse covered fifty miles per day and never missed a day. He was the only one that achieved this accomplishment in that particular race.

This horse was on the free-choice minerals the entire trip, allowing him to adjust his Cation/Anion balance, and balance his nutritional needs to maintain his workload with different grasses and water every day.

This technology was then successfully adapted to beef, dairy, horse, sheep and goats. After Tully Talbot passed away, the company was dissolved.

A few years later, Bill Johnson, the General Manager of the old TCI company, resurrected the concept of individual free choice minerals and continued to develop and refine the technology under the logo of IDM.

IDM was very successful in introducing this concept to mega-dairies in California. These dairies were fed truck-farm processing waste; for instance, tomato rinds would be fed in the morning and carrot tops in the afternoon.

With the free choice system, he was able to maintain a rolling herd average of 70 to 100 lbs. of milk.

In 1988, Helfter Enterprises, Inc., dba Advanced Biological Concepts®, started manufacturing the product line for IDM. Eventually, Bill Johnson retired and Advanced Biological Concepts® purchased IDM. Advanced Biological Concepts® continues to be the premier supplier of individual free-choice minerals and the supporting technology.

An Interesting Historical Note from Bill Johnson

June 8, 2000
To: Advanced Biological Concepts
From: Bill Johnson
Subject: Free Choice

During this time of changes in feeding (grazing) and the introduction of new feeds and feeding programs, I would like to remind producers of a tried and proven program that has been used for 40 years or more. The idea of Free Choice is not new; Free choice has always been the program of choice by cattle if given the opportunity. Only with fences and confinement were the animals forced to eat what man thought was best for them.

The introduction of Free Choice (drug free) products started in the 1950's by a company in Southwest Iowa. Starting with Salt, Sodium Bicarbonate, Phosphorus and Calcium it has grown to 14 or 15 items available today. Magnesium, Trace Minerals and Iodine were added in the next couple of years. When I entered the industry in the early 70's, the program had grown to 10 products, adding Potassium, Sulfur, and Clay with a Vitamin A-D-E mix being used mainly in dairy.

The more confined the animal became, the harder it was to make this program work. Now people are waking up to the fact that Dairy and Beef animals do the best in the grazing environment and know that grasses change with the seasons and different pastures vary in mineral and energy content.

With Free Choice individual minerals (drug free), the animal can take care of its individual needs (they are all a little different) on a day-to-day basis. This is more economical because you don't force a mix of several minerals to the animal that may only need 1 or 2 at the time.

Bill Johnson

Jim Helfter

The IDM Mineral Program

The IDM Mineral program is designed to allow the animal to use its natural instinctive selective ability to satisfy nutrient requirements with specific references to minerals and vitamins. Contrary to the thoughts of some individuals, selective breeding has not reduced the ability of the animals to select those nutrients necessary to its well being, anymore than selective breeding has reduced the sex drive, or reduced the need of the animal to consume nutrients such as energy, or protein. Animals do select needed minerals and vitamins from the IDM Mineral program in proportion to palatability (solubility) of the individual compounds used in the formulation of the various IDM mineral products.

IDM therefore must use quality products that will be soluble in the mouth of the animal so that the taste bud system, which is triggered by deficiencies of nutrients in the tissue of the animal and more specifically the blood, will recognize the nutrients by its own merits rather than by some flavoring agent which may have been added to the compound. **IDM does not use any flavoring agent to entice the animal to consume the IDM minerals other than the taste of the mineral itself in soluble form, and has no flavoring or enticement additives.**

The major benefit of the IDM Mineral Program is that it not only allows the animal to satisfy mineral deficiencies of the present ration, **but also allows the animal to consume additional minerals, as necessary, to satisfy tissue deficiencies caused by previously unbalanced rations.** This results in the consumption of some of the IDM minerals at times in amount that are considered by some people to be more than the needs of a given ration.

When offering nutrients on a separate and free choice basis, such as the IDM Mineral Program, it must be clearly understood that animals will satisfy total nutrient needs. Consequently, the animal may need to consume additional amounts of the particular mineral in question until its tissue deficiencies are adequately satisfied. At that time the animal will then continue to consume only the amounts of the individual minerals that are necessary to satisfy deficiencies of the present ration, changing its consumption from the IDM Mineral Program in proportion to rations with little or no consideration to the previous history of the animal. Scientific research has proven time and again that various mineral deficiencies within the physiological system of the animal are the ones that in reality prevent the animal from producing and/or reproducing at optimum. The IDM Mineral Program both allows the animal to satisfy these physiological needs and satisfy deficiencies of the present ration.

IDM is very aware of the interrelationship of the tremendous number of mineral elements. Many feedstuffs contain excesses of some mineral elements that seem to be considered by some to be of no consequence. Nothing could be further from the truth. If we consider simply the Ca:P ratio, then a ration that contains 1% calcium will cause the animal to consume quantities of phos-

phorus from the IDM Mineral Program in amounts that would by some seem to be excessive, but if we consider that the animal's physiological system functions best with a proper ratio, then it becomes logical that the animal will consume amounts of phosphorus necessary to attempt to provide its system with that proper ratio. Genetic selection has created animals with different mineral needs than those currently published in nutrition requirement charts. IDM is confident that the IDM Mineral Program provides a more accurate mineral balance to range animals in the multitude of various soil types, climatic condition, and animal genetics.

Healthy animals are animals that are more productive. Even in the present economic circumstances, the IDM Mineral Program pays:

1. By supplying the necessary mineral elements to better balance the ration so that it can be digested more efficiently.
2. By allowing the animal to be in better physiological conditions so that it will be more productive and/or reproductive.
3. By not forcing unnecessary and unneeded minerals into any animal.
4. As ration quality changes, due to either changing feedstuffs or changing climatic conditions, the animal can adjust its mineral intake to maintain a balanced diet.
5. By allowing individual animals to selectively satisfy individual needs which is not possible with a mixed or force-fed mineral program.

The end result is improved health, which allows the animal to better produce to its genetic potential. **The IDM Mineral Program promotes improved health.**

Trouble-Shooting the Advanced Biological Concepts® Mineral Program

The Advanced Biological Concepts (formerly Helfter Feeds) Mineral Program will work, as designed, to provide profits to the customer. The 5 point feeding program is a vital part of the program. Violation of this 5 point program, to any degree, may be expected to cause a decrease in efficiency of production, reproduction and health. Animals not being allowed full access to the 5 point program may elect to consume available feedstuffs in uneconomical amounts in their attempt to compensate.

The following will serve as a guide when trouble-shooting problems associated with the feeding of Advanced Biological Concepts Free Choice Minerals.

APPARENT EXCESS CONSUMPTION OF FREE CHOICE MINERALS

If animals seem to be consuming excess minerals, it may seem to be uneconomical, but in reality it is a symptom of something causing a

mineral imbalance. Always check your water, as faulty water is often a major cause of excess mineral comsumption.

Beef Cattle on Lush Spring Pastures

- Lack of available low protein dry roughage preventing adequate dry matter intake.
- High protein and/or nitrate causing stress.
- Energy deficiency causing inadequate availability of minerals in grass.
- Beef cattle on dry summer grass or winter feed.
- Low digestibility of feedstuffs due to lack of soluble energy.
- Inadequate intake of feedstuffs due to poor digestibility.
- Actual mineral deficiencies.

Feedlot Cattle

- Wet ration causing decreased feed intake.
- Excessive amounts of grain with limited roughage causing low ash ration.
- Previous mineral deficiencies.

Dairy Cattle in Confinement Facilities

- Excessive amounts of grain with limited amounts of roughage resulting in low ash ration.
- Wet ration without availability of dry roughage. Can't consume enough feedstuffs, and consequently not enough mineral.
- Excessive amounts of protein and/or nitrates.
- High production of dairy cows requires more mineral intake than does that of beef cows.

Any situation that tends to limit availability of feed supply may result in uneconomical consumption of Free Choice Minerals. Uneconomical consumption of Free Choice Minerals indicates that one or more of the 5 points of feeding are being violated, causing the animal to attempt to compensate.

B. UNECONOMICAL CONSUMPTION OF A-MIX

1. Actual Vitamin A deficiency

- Low carotene content of feedstuffs.
- Actual Vitamin A deficiency of the animal.
- Limited availability of feedstuffs.

2. Stress conditions

- Disease.
- Calving.
- Weaning.
- Excess feeding of grain causing low ash ration.
- Excess protein of the ration without availability of low protein roughage for dilution.
- Nitrates in the feed and/or water.
- Weather stresses, either hot or cold.

- Internal and/or external parasites.
- High production stress.
- Shipping stress.
- Lack of available feedstuffs.

3. Energy deficiency

- Vitamin A is chemically an alcohol, therefore a contributor of hydrogen energy.
- Low digestibility of feedstuffs.
- High protein and/or nitrate ration.
- High nitrate content of water.
- Lack of available feedstuffs.

C. LIMITED CONSUMPTION OF TCI FREE CHOICE MINERALS

- Excess ash in the ration.
- Ration is adequately balanced.
- Mineral Feeder is located in an area not frequented by the animals.
- Weather doors are closed with new cattle unaccustomed to the feeder.
- Minerals in the feeder caked or contaminated.
- Aged TCl A that has oxidized.
- Diseased cattle.
- High mineral content of water.
- Minerals force-fed in the ration.
- Deep mud hole in front of feeder.
- High carotene content of grass - only half converts to Vitamin A, but other half causes animal to feel that it has adequate Vitamin A when it is actually deficient.

D. CATTLE CONSUMING DIRT OR OTHER FOREIGN MATERIAL

- Lack of adequate ash with high grain ration (limited roughage).
- Rumen acidosis caused by excessive amounts of protein and/or nitrates in feedstuffs or water.
- Lack of adequate availability of feedstuffs.
- Mineral deficiency of ration, that is satisfied by consumption of foreign material.
- Diarrhea caused by any of the factors listed under the causes of diarrhea.

Mineral Interactions

Lack of dietary Boron also triggers poor copper metabolism in cattle. Check soil test levels. Try to maintain test levels above 1.0 ppm.

Do you have iron in your water or in the soil? High iron ties up copper. I see this in my Holsteins some summers when the black coat turns brown and gets really rough behind the shoulder blades. During winter when they eat kelp it clears up, but as the grass comes in they stop eating kelp and by mid summer we see the brown hair. We pretty much have only fed kelp as a mineral source for the last 10 years. They won't eat regular minerals free choice. We have high iron soils and lots of iron in the water. This could be because of the excessive iron in the mineral they are feeding.

SOME EFFECTS OF EXCESSES AND DEFICIENCIES

It has been known for quite a few years that certain minerals play an important role in animal nutrition. During recent years the list of minerals deemed "necessary to life" has grown steadily. Minerals not only furnish structural material for the growth of bones, teeth, blood and tissue, but also are necessary components of many of the enzymes which regulate vital life processes. Not having enough of any one of the "essential" minerals may cause a lack of thrift, poor gains, poor feed conversion, low production of meat or milk, or poor reproduction. Having too much of many of these minerals may result in toxic poisoning which can impair the health of an animal or even kill it. Not having a balanced ration of many of the minerals may cause symptoms of either excesses or deficiencies or both. Usually these symptoms are noticed only when they are serious enough to cause death or an excessive veterinary bill, even though they result in the loss of millions of dollars of profit to farmers, feeders and ranchers in the livestock industry.

This list is by no means meant to be a diagnostic guide but is rather a broad outline of some conditions which may be encountered during excesses of deficiencies.

DRY MATTER – This being, everything that is not water. Less then 20% dry matter is too wet for proper nutrition. When a feedstuff is too wet, the ruminant usually does not obtain adequate nutrition because it is forced to decide between having excess water in the rumen for a time and obtaining sufficient dry matter.

ASH – The ash content of the ration should be in a range of 4.85 – 5.5% of dry matter. The ash content of the ration is a measurement of the oxides of the minerals in the ration – however, if minerals have not been added to the ration, the ash content of the ration is a very good measurement of the fiber content of the ration. A ration should contain some natural roughage such as hay or dehydrated alfalfa, which is high in ash and not dependent entirely on inorganic minerals.

A. EFFECT OF AN EXCESS OF ASH OR FIBER - Excess ash or fiber usually means that a ration is low in energy and should be corrected by increasing feedstuffs low in ash.

1. Ration may be unpalatable.
2. Digestibility of the ration is low.
3. Butterfat test usually remains high but milk production drops.
4. Rate of gain decreases.
5. Dropping may be stiff and stack up – constipation.
6. Animal cannot eat enough to gain or produce at a maximum rate.

B. EFFECT OF A DEFICIENCY OF ASH OR FIBER – Solubility value of the rations in excess – ration should be rebalanced to increase feedstuffs high in ash. Feed moves through the digestive tract too fast for best absorption. Feed moves out of the rumen too fast for maximum digestion by bacteria. Inadequate scouring action of the rumen (for oxygen, carbon dioxide transfer) and intestinal wall (for food absorption into bloodstream). Additional minerals needed.

1. Poor fill.
2. Hard to keep on feed.

3. Feed intake varies.
4. Butterfat test drops.
5. Too much feed going through undigested.
6. Rate of gain drops.
7. Bloat.
8. Loose, watery manure.

CARBON – Carbon content of the ration should be in a range of 46.09 – 51,0% of total dry matter. When a ration contains an excess of protein, there has to be a deficiency of carbohydrates. The total amount of protein nitrogen plus primary elements should be 15%.

Therefore, 85% of an optimum ration must be carbon, hydrogen and oxygen, which is usually found in the form of carbohydrates, fats and sugars.

A. EFFECT OF AN EXCESS OF CARBON

1. Increases need for hydrogen, oxygen and nitrogen.

B. EFFECT OF A DEFICIENCY OF CARBON

1. Decreases need for hydrogen, oxygen and nitrogen.

HYDROGEN – Hydrogen content of the ration should be in a range of 7.83 – 8.61% of total dry matter.

A. EFFECT OF AN EXCESS OF HYDROGEN

1. Increased need for nitrogen and oxygen.
2. Energy value of the ration is in excess.
3. Conditions in rumen too far reduced and bloat is likely.
4. Burned rumen - founder.

B. EFFECT OF A DEFICIENCY OF HYDROGEN

1. Carbon and oxygen are wasted because of fermentation.
2. Feed intake is reduced.
3. Rate of gain decreases.
4. Milk and test drops.
5 Amount of undigested feed in droppings increases.
6. Starvation.
7. Nasal discharge (from clear to colored).
8. Watering eyes.
9. Incidence of mucosal disease complex is more prominent.
10. Increases need for Vitamin A.

OXYGEN – Oxygen content of the ratio should be in a range of 41 – 45% of total dry matter.

A. EFFECT OF AN EXCESS OF OXYGEN

1. Increased need for hydrogen.
2. Easily foundered.
3. Droppings Loose.
4. Poor fill.
5. Stiffness of gait.
6. Depth of body becomes shallow – “tucked up or snaky” appearance.
7. Amount of undigested grain and roughage in droppings increases.
8. Ration is too soluble.
9. Milk and butterfat drops.

10. Rate of gain decreases or completely stops in severe cases.
11. Osmotic pressure in rumen becomes excessive and slows down digestion.

B. EFFECT OF A DEFICIENCY OF OXYGEN

1. Ration is not soluble.
2. Milk production drops but butterfat test usually stays up.
3. Rate of gain decreases.
4. Digestibility of the ration is low.
5. Droppings may be stiff and stack up too high.

NITROGEN – Nitrogen content of the ration should be in a range of 2.0 – 2.3% total dry matter.

A. EFFECT OF AN EXCESS OF NITROGEN

1. Increases need for hydrogen.
2. Ketosis.
3. Scouring.
4. Incidence of mastitis increases.
5. Milk and test drops.
6. Rate of gain decreases.
7. More vulnerable to nitrate poisoning.

B. EFFECT OF A DEFICIENCY OF NITROGEN

1. Retarded growth.
2. Inefficient use of nutrients.
3. Reduced appetite.
4. Milk production drops.
5. Rate of gain decreases.
6. Irregular heat periods.
7. Reproductive failure.

PROTEIN EQUIVALENT (NITROGEN) – 6.25 x total nitrogen = protein equivalent. Nitrogen is probably the most important element in ruminant nutrition, because it is the major component of protein. Proteins are a major component of every living cell. A range of 12.5 – 13.75% of dry matter is optimum for all ruminants. This was proven at Panhandle A & M and the University of Nebraska.

A. EFFECT OF AN EXCESS OF PROTEIN

1. Ketosis.
2. Scouring.
3. Decreases feed efficiency.
4. Requires increase in feedstuff low in protein (corncobs, straw, ear corn, milo).

B. EFFECT OF A DEFICIENCY OF PROTEIN

1. Retarded growth.
2. Inefficient use of nutrient (undigested feed in manure).
3. Reduced appetite, wool production, milk productionand poor hair coat.
4. Irregular heat periods.
5. Requires increase in feedstuff high in protein (legume hay, protein supplement).

SULFUR – The optimum amount is in a range of .20 - .22% of the total dry matter. Sulfur is acidic in nature. Sulfur–nitrogen ration should be 1–10. Sulfur is

necessary for the synthesis of sulfur bearing amino acids.

A. EFFECT OF AN EXCESS OF SULFUR

1. Creates acid rumen.
2. Increases the need for copper.
3. Black scours.

B. EFFECT OF A DEFICIENCY OF SULFUR – Deficiency of sulfur limits NPN (non protein nitrogen) utilization.

1. Shedding wool in sheep.
2. Poor hair coat.
3. Poor hoof, hair and horn development.
4. Excess saliva.
5. Watery eyes.

POTASSIUM - The optimum amount is in a range of 0.93 – 1.02% of total dry matter. Potassium is a strong base. If excessive, the rumen requires more chlorine to excrete the excess as potassium chloride.

A. EFFECT OF AN EXCESS OF POTASSIUM – Excess potassium is excreted quickly in the urine but this may cause a wash out situation which can disturb the calcium-phosphorus balance and result in secondary effects concerning those elements.

1. Alkaline rumen, unless excess chlorine is also present.
2. Slows down bacterial growth and multiplication.
3. Poor feed efficiency.
4. Pressure inside the cell is too great for movement of food into the cell.

B. EFFECT OF A DEFICIENCY OF POTASSIUM

1. Decreases carbohydrate utilization.
2. Slow growth.
3. Reduced appetite.
4. Muscular weakness.
5. Nervous disorders.
6. Potassium needs to be supplied daily, because there is no appreciable reserve.

SODIUM – The optimum amount is in a range of 0.27 – 0.3% of the total dry matter. 90% of all rations are usually short of this element. Sodium is strongly alkaline.

A. EFFECT OF AN EXCESS OF SODIUM

1. Swelling due to excess water retention.
2. Creates alkaline rumen – may be excessive.
3. Slows down bacterial growth.
4. Poor utilization of non-protein nitrogen.

B. EFFECT OF A DEFICIENCY OF SODIUM

1. Decreases utilization of protein and energy.
2. Rough hair coat.
3. Retarded growth.
4. Loss of appetite.
5. Poor reproduction.
6. Depraved appetite.
7. Acidosis.

CALCIUM – The optimum amount is in a range of 0.45 – 0.53% of the total dry matter. Calcium is alkaline.

A. EFFECT OF AN EXCESS OF CALCIUM

1. Decreases availability of protein, phosphorus, iodine, iron, manganese, zinc and magnesium.
2. Birth paralysis.
3. Depresses rate and economy of gain.
4. Increased incidence of milk fever.
5. Ties up fatty acids in a form which is not usable.

B. EFFECT OF A DEFICIENCY OF CALCIUM

1. Bone growth severely impaired, resulting in lameness.
2. Increases need for Vitamin D2.
3. Depraved appetite.
4. Arched back.
5. No vigor.
6. Reduced milk production.
7. Increased milk fever.

MAGNESIUM – The optimum amount is in a range of 0.29 – 0.3% of the total dry matter. Magnesium is alkaline.

A. EFFECT OF AN EXCESS OF MAGNESIUM

Increases need for phosphorus and other elements.

B. EFFECT OF A DEFICIENCY OF MAGNESIUM

1. Irritability.
2. Irregular gait or shifting lameness.
3. Weak pastern.
4. Muscle tremors.
5. Grass tetany (animals temporarily blinded; may turn in circles until balance is completely lost; frothing at the mouth).

SILICON – The optimum amount is in a range of 0.33 – 0.36% of total dry matter. Excess amounts will slow down passage of food through the rumen. Silicon is acidic in nature.

A. EFFECT OF AN EXCESS OF SILICON

Decreases digestibility and palatability.

B. EFFECT OF A DEFICIENCY OF SILICON

1. Slows down growth and multiplication of rumen bacteria.
2. Poor fill.
3. Depraved appetite.
4. Rumenitis.

PHOSPHORUS – The optimum amount is in a range of 0.37 – 0.41% of the total dry matter. An excess amount of calcium will increase the need for phosphorus. These elements go hand in hand. There is a definite ration between calcium and phosphorus. When calcium is excessive, cattle will eat phosphorus to an excess and then excrete both calcium and phosphorus down to optimum. Phosphorus is acidic in nature.

A. EFFECT OF AN EXCESS OF PHOSPHORUS – Excess phosphorus causes an imbalance of zinc, manganese, magnesium, calcium, iron and other elements and symptoms of excess phosphorus are the same as deficiencies of the other elements, because it ties them up as insoluble phosphate salts, which are not usable by an animal.

1. Increases the need for iron, aluminum, calcium, magnesium, zinc and manganese.
2. Poor skeletal growth.

B. EFFECT OF A DEFICIENCY OF PHOSPHORUS – Increases the need for Vitamin D. Deficiency can be created by excess iron, aluminum, calcium and magnesium.

1. Depraved appetite – chewing wood, bones, dirt, etc.
2. No heat period, delayed heat period, silent heat period and prolonged interval between calving and first heat period.
3. Depresses the appetite, reduced rate of gain, milk production falls off.
4. Higher incidence of bloat.
5. Milk fever in dairy herds.

CHLORINE – The optimum amount is in a range of 0.42 – 0.46% of the total dry matter. Chlorine is a strong acid.

A. EFFECT OF AN EXCESS OF CHLORINE

1. Swelling due to excess water retention in the tissue.
2. Creates acid rumen.
3. Increases need for iodine.
4. Increased incidence of downer cows and grass tetany.

B. EFFECT OF A DEFICIENCY OF CHLORINE

1. Loss of appetite and weight.
2. Poor hair coat.
3. Hyper-alkalinity – tetany – death.

TRACE MINERALS – Trace minerals are reported as parts per million (PPM) on a dry matter basis (1% equals 10,000 ppm).

The range of optimum amounts of trace elements measured as parts per million of total dry matter are as follows:

Iron	100-200 ppm	Nickel	0.5-1.0 ppm
Aluminum	60-120 ppm	Selenium	0.1- 0.5 ppm
Manganese	60-120 ppm	Chromium	0.5-1.0 ppm
Zinc	60-120 ppm	Fluorine	30-50 ppm
Copper	10-20 ppm	Boron	10-20 ppm
Molybdenum	1-2 ppm	Iodine	0.5-1 ppm
Cobalt	0.5-1 ppm		

A. EFFECT OF AN EXCESS OF IRON

1. Interferes with phosphorus adsorption.
2. Requires use of sodium or potassium bicarbonate to precipitate iron excess.
3. Dark, almost black manure.

B. EFFECT OF A DEFICIENCY OF IRON

1. Anemia – most likely to occur in calves because milk is low and little iron passes across fetal membranes.
2. Cow and calf operation can show anemia and be more susceptible to diseases.
3. Calves born weak or dead.

A. EFFECT OF AN EXCESS OF ALUMINUM

Increases need for phosphorus.

B. EFFECT OF A DEFICIENCY OF ALUMINUM – Because of its prevalence, a deficiency of aluminum in not usually a practical problem. Under controlled clinical conditions it has been tied in with conversion of energy.

1. Leg deformities with over-knuckling in calves.
2. Egg not formed correctly.
3. Degeneration of testicles.
4. Offspring born dead.
5. Delayed heat periods.
6. Shortage created by excess of calcium and phosphorus.
7. Sterility.

A. EFFECT OF AN EXCESS OF MANGANESE

1. Interferes with calcium and phosphorus adsorption.
2. Interferes with utilization causing iron-deficiency anemia.

B. EFFECT OF A DEFICIENCY OF MANGANESE

1. Leg deformities with over-knuckling, lameness, enlarged joints.
2. Deformed young at birth.
3. Abortion.
4. Delayed estrus.
5. Egg not formed correctly.
6. Decreased sex drive and sperm formation.
7. Decreased carbohydrate utilization.

A. EFFECT OF AN EXCESS OF ZINC

Interferes with utilization of copper and iron, bringing about anemia.

B. EFFECT OF A DEFICIENCY OF ZINC

1. Growth failure.
2. Lesions of the skin.
3. Legs tender, easily injured, raw, bleeding and weak.
4. Poor hair coat, bald spots.
5. Poor feed efficiency.
6. Poor reproduction.

A. EFFECT OF AN EXCESS OF BORON

1. Diarrhea.
2. Increased flow of urine.
3. Visual disturbances.

B. EFFECT OF A DEFICIENCY OF BORON

Reduces rate of growth and rumen bacteria.

A. EFFECT OF AN EXCESS OF COPPER

1. Degeneration of liver, distended gall bladder and swollen, black kidneys.
2. Blood in urine.
3. Poor utilization of nitrogen.
4. Yellowish brown mucous membranes about the eye and mouth.

B. EFFECT OF A DEFICIENCY OF COPPER

1. Created by excess of molybdenum and cobalt.
2. Anemia due to poor iron utilization.
3. Depressed growth.
4. Depigmentation of hair and abnormal hair growth.
5. Impaired reproductive performance, heat failure, abortion.
6. Scouring.
7. Bones become fragile.
8. Retained placenta and difficulty in calving.
9. Muscular incoordination in young lambs and stringy wool.

A. EFFECT OF AN EXCESS OF MOLYBDENUM

1. Makes copper unavailable.
2. Depigmentation of hair.
3. Severe scouring.
4. Dehydration.
5. Arching of back.
6. Weakness.
7. Brittle bones.

B. EFFECT OF A DEFICIENCY OF MOLYBDNUM

1. Created by excess of sulfur.
2. Slows down cellulose digestion.
3. Calcium deposits in kidneys.
4. Chronic copper poisoning – depending on level of copper.
5. Slows down the conversion of nitrogen to protein.

Some Observations on Mineral Consumption From a Conversation with Jeff Chrisler

- A, D, and E consumption goes up if there are basic deficiencies in the feeds or the ration.
- BVC + Vitamin C intake increases with stress. Goats will eat A first, then BVC.
- P/Ca Ratio: In the 1980's, the Ca/P ratio was 1/3. In the 90's, there was higher Ca. In last 3 or 4 years, it is back to 1/3 again. Ca consumption may go down in the summer and up in the winter.
- Iodine consumption increases if nitrates are high or if there is stray voltage or a geo-magnetic field.
- Magnesium consumption increases when on spring grass. As Ca goes up, some may take more Mg.
- Potassium consumption usually stays level. If it goes up, may want to change rations.
- Sulfur is involved in Hair and Hoof growth.
- TS-K (with Kelp) goes up or down with feed content.
- Copper consumption goes up in young stock or with moldy feed. Goats may eat continuously. Associated with pigmentation of hair.
- Zinc is associated with feet/hoof health. Sometimes goes up in the fall.
- Selenium (Antioxidant optional, Top dress only!) Intake goes up in stress. Research done in horses.
- Bentonite, Volclay - Can attach to positive or negative ions as an aid to the excretion of toxins. Also silica - Goats eat like candy. At the start of feeding minerals, may want to take bentonite out and replace with 2-1.
- KLNZ, DUA; D.E.; B-2000 Enzymes (Forage Mate); Calf Bac.; TM; Propel; DUA; Bentonite (Volclay, not Redmond). Designed for Bison because they don't get grain. Also goats. Can negate the effects of conventional wormers. Can drench with 2 to 4 ounces in cattle or steers (stress) in dead or winter.
- IPR Wormer, DE and herbal extracts – Antagonistic to worms – not a killer.
- Red Clay (Montmorilamite clay) is not always palatable best in blend with Volclay and DUA.

Research

Unfortunately, there is a paucity of meaningful university research on either side of this issue and much of it is outdated because of the many changes in livestock management that have taken place over the years. Then too, most of the early research fell into the trap of trying to reduce a highly complex biological phenomenon to a single-factor analysis of the consumption patterns of just a few minerals over a short time period. Also, unfortunately, much of our research is designed to prove a theory or provide the basis for a sales pitch and not to investigate to see what is really happening.

I have been involved with the concept of self feeding individual minerals for over 50 years, as a veterinarian, as a livestock owner and as an industry consultant. In my experience it works most of the time - but not always. When it does not seem to work it is common to find water problems or gross nutritional imbalances of protein, carbohydrate and fiber.

University Research - Readin' between the lines.

By R. J. Holliday, DVM

We rely a lot on university research in many of our management decisions. Oftentimes this is useful, and sometimes not. To critically evaluate research there are several things to take into account.

- Who paid for the research?
- Who did the research?
- Where did the researcher work before?
- Where does the researcher anticipate working in the future?
- Has the researcher ever served on boards of commercial companies in related industries or worked for government agencies that regulate any aspect of the agricultural industry?
- Have you examined the whole content of the research in the light of common sense?

Many times the conclusion or summary statement does not match the actual data or results. Here is an example of an erroneous conclusion drawn by some researchers.

In 1977, a study was done at South Dakota State University entitled, "Cafeteria Style Free-Choice Mineral Feeder for Lactating Dairy Cows" by L. D. Miller, L. V. Schaffer, L. C. Ham, and M. J. Owens.
1977 J DairySci 60:1574-1582

The authors stated: "Little evidence was found that dairy cows offered minerals and vitamins free choice consumed to a specific appetite or need under the two nutritional regimes."

Let's take a closer look of some of the excerpts from that study along with some comments (comments in red):

"Trial 1 was 16 weeks in which two groups of cows in mid-lactation (10 cows / group) were group-fed rations with either corn silage or alfalfa hay as the sole

forage, and all supplemental minerals and vitamins were provided free choice." This is too small a group and too short a time to really evaluate the nutritional wisdom of animals.

"Minerals and vitamins were provided in a "cafeteria style" mineral feeder, one feeder per group. The feeder was sheltered and afforded protection from wind and rain. Mineral and vitamin mixes were: calcium (28 to 30% Ca from calcium carbonate), phosphorus (>20% P from monosodium phosphate), potassium (>31% K from potassium chloride), magnesium (21.5% Mg from magnesium oxide and sulfate), sulfur (47.5% S from flours of sulfur), trace mineral, bicarbonate of soda, sodium bentonite, sodium chloride, iodine mix (>.88%I), and vitamins A, D, and E (Vitamin A, 4,400,000 U.S.P. units/kg; Vitamin D, 2,200,000 U.S.P. units/kg; and Vitamin E, 1,100 IU/kg). The remaining portions of the mineral mixes were composed of products such as rice mill by-products, rice hulls, and dehydrated alfalfa. Intake of each individual mineral was determined weekly for each group."

"Intake of phosphorus, potassium, and vitamins differed between rations. A higher free choice intake of phosphorus by cows fed alfalfa was not expected." It should have been expected, as it is well known that cattle need to balance their Ca/P ratio. "Cows could possibly have been consuming more P to narrow the wide Ca:P ratio due to high Ca intake from alfalfa." Of course they ate more P to balance the high Ca in alfalfa. That's what free choice is all about – giving them the opportunity to self regulate their needs.

"Cows fed corn silage consumed more potassium free-choice, but additional intake still was needed to meet requirements." Whose requirement are they trying to meet - NRC standards, or what the cow actually needs? The authors could not explain why this group's milk production exceeded the alfalfa group even with their assumed K deficiency.

"Little evidence was found in these two short trials that lactating dairy cows have a specific appetite for individual minerals. Where corn, silage, and alfalfa forages that differ in mineral content were fed as the sole forages to two groups of cows, only in the cases of potassium and vitamins did cows fed corn silage consume large amounts free-choice, possibly to compensate for a dietary deficiency." Actually, the main mineral ratios were balanced by the cow's mineral preferences. They balanced the critical Ca/P ration by eating more P to compensate for the high Ca in alfalfa. The cows in the alfalfa group took almost no K while the corn silage group consumed 36 times more K than the alfalfa group.

Given the above perspective, it's difficult to understand how the authors concluded that – "Little evidence was found that dairy cows offered minerals and vitamins free choice consumed to a specific appetite or need under the two nutritional regimes."

The first article reprinted below by Dr. Barrows gives an excellent view of self fed minerals from several decades ago. After that is the contact information and refferences to the current research by Dr. Fred Provenza.

Research Efforts Have Lagged in FREE-CHOICE FEEDING

By George T Barrows, DVM

Reprinted from ANIMAL NUTRITION & HEALTH, May 1977

It appears that many knowledgeable scientists and researchers in a number of fields agree that animals have an amazing ability to self-select ration

components. Logically, the question arises in every paper, whether it is possible to supply these ration components separately in a manner that the animal can recognize and consume.

In order to survive, animals not only have to find a sufficient quantity of food, but they must also obtain nutritionally adequate substances. Animals must, therefore, exhibit some degree of selection in their ingestion of feedstuffs.

To survive and therefore reproduce, animals historically have been required to associate foods with the consequences of their ingestion. To ignore this fact leaves us with the unfeasible alternative that all food getting is entirely haphazard or entirely determined by genetics.

A great number of experiments and field trials have documented the ability of animals to select and qualitatively monitor their intake of nutrients. These studies are from a number of fields including nutrition, physiology, genetics, agriculture, psychology, medicine and veterinary medicine.

The research in this area has at times been both confusing and contradictory. In most cases, animals have either been placed on a total self-selection regimen or have been allowed a limited choice of a small number of mixed diets or nutrient solutions. Under total self-selection, the animal is offered an array of either purified or natural feedstuffs and allowed to choose its diet completely. The alternative methods usually involve a two-choice situation between more or less nutritionally adequate diets or the provision on one diet and the choice of several solutions. Often, the total self-selection method has been used in the absence of any manipulation simply to test the selection ability and nutrient requirements of normal animals. The two most common methods of inducing a need have been through the feeding of a deficient diet and through physiological intervention by surgical procedures or drug injections.

Animal Studies

Work done with rats indicates a positive ability of the animal to self-select its own diet. Curt Richter has done extensive investigation in the self-regulatory behavior of animals. In one case, he offered female rats casein, sucrose, yeast, olive oil and six vitamins and mineral solutions. All animals survived and despite a 20% lower caloric intake, showed weight gains equivalent to a control group placed on stock laboratory diet (1). Griffith, Rufus and Harmon report satisfactory selection and normal fat intake among with Norway rats (2). In another of the few experimental selection studies that have used a non-domesticated species, Harriman found that seven Plains Wood rates successfully selected a balanced diet from a choice of casein, sucrose, vegetable oil and a mineral mix (3).

In other studies, Davis maintained children up to 4¼ years on a self-selected regimen. At no time during this period was any effort made to control the children's intake of the 30 unseasoned and unmixed foods that were used. All children were judged to be exceptionally healthy and were largely or entirely free from digestive upsets such as diarrhea, constipation or stomach upset. In addition, one child admitted to the program with an advanced stage of rickets showed a marked appetite for cod liver oil. This appetite disappeared when the ricketic symptoms were no longer demonstrable on X-rays (4).

Albrecht noted that cows allowed to graze from four haystacks ate exclusively from the single stack made of hay grown on fertilized soil. A chemical analysis revealed that the hay chosen was slightly, though consistently, of better nutritive quality (5).

Green found that in the phosphorus-poor grazing land of South Africa, cattle frequently became osteophagic or bone eaters presumably to satisfy their phosphorus requirements. The addition of phosphorus to the ration caused a cessation of the bone-eating pica (6). Gordon, Tribe and Graham pastured a sheep on a phosphorus-poor grazing area, but found neither pica nor an appetite for phosphorus salts despite decreased levels of blood phosphorus (7). McCandish, Nevens and Evvard demonstrated that cows, on total self selection maintenance with a number of feeds such as grain, oatmeal and roughages have shown selection abilities that allow normal to above normal growth and production.

The same authors conducted a similar study with swine and observe a favorable growth rate. One sow grew to be the largest pig producer at the Iowa Agricultural Station up to that time (8,9,10). Glimp noted that as sheep mature they select a diet of increasing protein and energy content (11). A number of self-selection studies with chickens have been conducted which have been successful, relative to control (12).

Vitamin Selection

Richter was the first to show animals' apparent recognition of dietary vitamins. He and his co-workers implicated a role of the B vitamin in protein and carbohydrate metabolism and also a possible B vitamin sparing action fat. They found when rats were made nitrogen deficient, their protein and carbohydrate intakes decreased while their fat intakes showed a marked increase. Richter also demonstrated the ability of animals to select not only the B-complex vitamins but also A, D and E (13,14,15).

Many authors have studied the effects of physiological manipulation on dietary free choicing. For example, following the removal of the parathyroids which results in excess calcium excretion and phosphorus rejection, Richter and Echert found in rats a decreased phosphorus intake and an increased ingestion of calcium, strontium and magnesium solutions. These self selecting animals were able to keep themselves free of tetany, a diagnostic symptom of calcium deficiency (16).

An interesting study on the role of self-selection is by Emmers and Nocenti. Parathyroidectomized rats were placed on a total self-selection and the characteristic increase in calcium intake was observed. Half the animals then underwent an ablation of the thalamic gustatory nucleus. The ablation of the nucleus was complete, and there was a failure of calcium selection resulting in tetany and death (17).

Overmann describes an experimental method of total self-selection of nutrients by animals allowed to regulate their ingestion of a wide variety of feedstuffs which are either isolated nutrients of naturally occurring but incomplete feeds. With limited choice of selection, however, the animals were given two or more essentially nutritionally complete diets for a single diet and a choice of solutions.

A common practice in these studies is to induce a dietary need through the feeding of a deficient diet or one enriched in the needed nutrient. A specific hunger or satisfactory selection is demonstrated if the deficient animals show a preference for the enriched feed or if enough of the enriched diet is ingested to alleviate deficiency symptoms.

The nutrients which have received the largest amount of experimental attention with this method are the B vitamins, especially thiamine (18). Harris, Clay, Hargreaves and Ward demonstrated that vitamin B deficient rats were

shown to prefer a diet enriched with a natural, distinctively flavored vitamin D supplement, over a deficient diet lacking the supplement. The rats were also able to discriminate between diets containing different percentages of the natural supplements (19).

Chesyers and Quarterman, 1970, and Christensen, Caldwell and Oberlas, 1974, demonstrated that zinc deficient rats have shown an increased intake of zinc containing solutions or diets (20, 21). In 1914, Evvard tried a free-choice system of feeding pigs and concluded that the appetite of the pig appears to be a very good guide as to its body needs (10).

F. R. Bell demonstrated a precise taste threshold for ruminants associated with sodium depletion. He concluded his paper by saying, "It becomes apparent, therefore, that in ruminants there is a close inter-relationship between taste, metabolism and nutrition." At present, the experimental data is sparse, but the availability of a good experiment preparation augurs well for future investigation (22).

Mineral Preference

The Kerr Foundation, in its 1969 Nine Year Research report, discusses a three-year experiment evaluating the ability of cattle to select major and trace minerals free choice. The minerals offered were potassium, phosphorus, sodium, sulfur, magnesium, calcium and sodium chloride. The minor minerals offered were iron, manganese, zinc, boron, copper, cobalt, iodine and a control. Their conclusions were: "To determine the results of this experiment, it appears to be necessary to break the minerals into major and minor elements. This appears to be especially important in trying to determine if cattle can select these elements. Salt consumption appears to be consumed in relation to the sodium and chloride content of the grass."

"Calcium is another element where it appears that consumption is related to the content of the grass. Phosphorus and magnesium were also consumed in amounts that closely followed the grass analysis. The trace minerals appeared to have delayed reaction to the element in the grass. Consumption of all the elements tended to decline as the cows increased in age. Primary consumption of the minor minerals including salt occurred in October, November, December, January, February and March; primary consumption of the minor minerals occurred during March, April, May, and June" (23).

Richter concluded, "Proof of the existence of behavior regulators was taken from experiments in the field of endocrinology and nutrition. It was shown that disturbances created in the internal environment by removal of one of the other of the endocrine glands were corrected by the animals themselves. It was demonstrated that the ability to select diets with relation to internal needs seems to depend more on taste sensations than on experience, and it was pointed out that this knowledge of the ability of animals to make beneficial selections can be used to study a variety of the problems in the field of endocrinology and nutrition.

"Evidence was further presented for the existence and successful operation of similar behavior regulators in human beings. Thus, we believe that the results of our experiments indicate that in human beings and animalsl the effort to maintain a constant internal environment or homeostasis constitutes one of the most universal and purposeful of all behavior urges or drives (24).

Study Comparison Difficult

Other scientists have completed work which agrees with Richter. For example, Overmann concludes, "Animals do exhibit the ability to select and regulate their

ingestion of nutrients. This ability has been demonstrated in a number of species under a variety of conditions and with a host of different nutrient sources. Although the diversity of methods, animals and feedstuffs adds substantial evidence to the validity of dietary self–selection abilities, it has also contributed to an apparent lack of reliability. Comparisons between studies are difficult, and contradictory findings are common" (18).

Rosin has pointed out, however, that positive demonstrations of selection or regulation must be considered more convincing than negative findings, lack of selection or regulation (25).

One primary factor contributing to these contradictions between studies is the nutrients offered to animals. Various feedstuffs differ widely in palatabillity and nutritional value. For example, various protein sources differ both in palatability...

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PROVENZA RESEARCH

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www.behave.net contains a wealth of information including newsletters, fact sheets and an online version of:

"Foraging Behavior: Managing to Survive in a World of Change" - a 63 page booklet and its companion DVD can be ordered from:

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Especially see:

Provenza, F.D. and J.J. Villalba. 2006. Foraging in Domestic Vertebrates: Linking the Internal and External Milieu. Pages 210-240 in V.L. Bels (ed.) Feeding in Domestic Vertebrates: From Structure to Function. CABI Publ., Oxfordshire, UK.

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Learned appetites for calcium, phosphorus, and sodium in sheep1,2
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Mineral Nutrition: Are Animals Nutritionally Wise?

Provenza, F.R. and J.J. Villalba 2006

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Early studies on nutritional wisdom focused on the innate ability of livestock to balance minerals in their diet. From these studies, nutritionists concluded that livestock are unable to consume minerals in correct quantities to prevent or correct mineral deficiencies, and they are not nutritionally wise. However, many of the assumptions nutritionists held about diet selection are questionable if one considers animals must learn about foods and the consequences of eating those foods before they can make correct choices.

Listed below are assumptions implied by nutritional wisdom studies and alternative explanations about how animals learn about foods and nutrients, including minerals.

1. Animals are "genetically programmed" to instinctively recognize needed nutrients similar to the way animals regulate intake of sodium. Animals don't instinctively recognize nutrients. When an animal eats a food that contains needed nutrients, once digested the effects of those nutrients on cells and organs in the body feed back to the brain and the animal comes to prefer the food. Thus, experiences with foods shape food preferences.

2. Animals ingest nutrients in exact amounts needed to meet their daily requirements - no under or over consumption. There is no scientific evidence that animals eat to prevent nutritional deficiencies. Instead, they respond to excesses, deficits, and imbalances in their diet. While they may under- or over-consume needed nutrients within a meal, they generally do a good job of meeting daily nutritional needs. When animals suffer from deficits or imbalances, they seek out different and sometimes unusual foods. If eating a food rectifies the deficiency or imbalance they form a preference for that food.

3. All individuals select nutrients in amounts that match NRC requirements. Many researchers have little appreciation for individual variation. Variation is often viewed as the enemy of statistics. In reality, individuals within a species vary in their need for nutrients. Every animal has its own unique morphology and physiology causing animals to need different amounts of nutrients, including minerals. An animal's experience with foods also shapes food preferences and influences diet selection.

4. Social learning and culture are not considered in nutritional wisdom. Social learning and culture are critical for animals to acquire nutritional wisdom. Animals that learn about foods from mom or herd mates are more productive than animals that learn about foods by trial and error. Wild animals are often considered better than livestock at balancing their diet. However, wildlife have an advantage over livestock because they tend to stay with their mothers until they are much older, facilitating the transfer of information about their environment and foods over a longer period of time. In addition, wildlife tend to live in the same place for generations enabling one generation to pass on information about surviving in their environment to the next.

If animals can learn to prefer foods that contain needed nutrients, then why didn't they learn to consume minerals in the correct amounts when fed in cafeteria trials? Given the design of most mineral cafeteria trials, animals may have been more confused than educated about the value of minerals. Listed below are some possible problems with past studies that may have made it difficult for animals to consume minerals in expected amounts.

1. Sodium was often mixed with every mineral. Many minerals are required in minute amounts, so researchers mixed minerals with salt to limit intake. Unfortunately, animals only required a limited amount of sodium each day and it may have either encouraged or limited the intake of other minerals. Also, given the flavor of sodium, the minerals probably tasted similar. Animals discriminate among foods by flavor. If the minerals tasted similar, animals couldn't associate feedback from the mineral with its flavor.

2. Flavor, not color. Researchers colored the minerals so livestock could discriminate among them. As stated above, animals discriminate among foods by flavor, not color. If foods taste the same, they are the same to the animal regardless of how they look. We select foods the same way. If a bowl of jelly-beans are all lime-flavored and you don't like lime jelly beans, then you won't eat them even if they are in different colors. It's flavor that matters.

3. Prevent vs. rectify. Researchers expected animals to eat minerals to prevent deficiencies, but animals eat to correct, not prevent, deficiencies. When animal diets are adequate in nutrients, animals usually continue to eat the same foods. If animals are deficient in nutrients, they seek new foods. Animals develop preference for foods that correct deficiencies.

4. NRC recommendations. Researchers thought animals would eat

minerals in the amounts recommended by NRC. However, NRC recommendations are often higher than an animal's needs. Some minerals can be stored in the body and don't need to be consumed each day. In addition, many minerals are only needed in small amounts, a few grams or milligrams per day. A single bite may be more than an animal needs for the day. Finally, whether or not an animal consumes a mineral depends on the mineral status of the animal and the mineral compound offered. For example, cows deficient in calcium tend to avoid phosphorus, thus salts of calcium and phosphorus are poor minerals to use when studying calcium-deficient animals.

Looking to the Future

Considering the complexities of plants and landscapes, most researchers never imagined that animals were learning about the foods they eat. A better understanding of diet selection is leading to better experiments to determine if animals can learn to rectify mineral deficiencies. One important change in these studies is allowing animals the opportunity to pair the flavor of a mineral with recovery from a deficit of that mineral.

In a recent study, sheep on a phosphorus (P)-deficient diet increased intake of a P supplement when given a choice between a P, calcium (Ca) or sodium supplement. Conversely, sheep eating a Ca-deficient diet ate more of a Ca supplement than sheep eating a Ca-adequate diet. Calcium-deficient sheep also reduced intake of a P supplement typical of animals on low Ca diets. In another study, lambs avoided P during periods of P abundance, and increased their preference for P during periods of P need.

Mineral nutrition is extremely complex. The amount of a particular mineral an animal will ingest depends not only on the level of that mineral in the body but also on its interactions with other minerals in the diet and the body. The body's feedback mechanisms likely enable animals to make correct choices and maintain their mineral status. Recent studies indicate that animals can likely learn to balance minerals in their diets provided they are allowed to pair flavor with recovery from a mineral deficiency.

Ohio Study on Mineral Consumption in Horses

Calcium-Phosphorus Balance

According to an article in Horse Care Review, W. J. Tyznik, a nutritionist on the staff at Ohio State University, reported on experiments regarding the calcium-phosphorus regulating ability of horses. In his experiments, four boxes containing plain salt, trace mineral salt, pulverized limestone and a phosphorus supplement were placed in widely separated locations in test horses' stalls. To prove the horses' regulating ability with these minerals, Tyznik had the location of each box changed and the amount of each supplement weighed weekly. The weights noted each week were compared with those of the previous week to determine the amount of each supplement consumed that week.

Tyznik discovered that by changing from high calcium to low calcium natural feeds, the horses would seek out the correct boxes and adjust their calcium and phosphorus consumption according to the ration, and at all times maintained the proper amounts of calcium and phosphorus in the body tissues and circulating blood.

The above was taken from the article, "Research Efforts Have Lagged in FREE-CHOICE FEEDING" by George T. Barrows, DVM and published in the May, 1977 issue of *Animal Nutrition and Health.* The reference quoted: Anonymous. In search of Horse Nutrition, Horse Care Review, Fall, 1976 Vol. 1, No. 2.

A Vet Looks at Free-Choice Minerals
by Richard J Holliday, DVM

In my pre-vet studies at the University of Missouri I had the good fortune to study soils under the late Dr. William A. Albrecht. I don't remember many details from that course nor did I really understand the real importance of his work while I was taking the class. But I shall never forget the sage advice he gave when he said, "Observe nature and study books, if they do not agree, throw away the books." Over the years I have tried to follow this advice, and it has paid huge dividends in insights and knowledge gained.

With that as a starting point, my goal has always been to share the idea that anyone can prove the fundamental concepts of animal health by watching and learning from animals, who will share their secrets with us if we are attentive.

Early on in my veterinary practice in Missouri, my office was next to a feed store that carried a line of free-choice minerals and trace minerals. I didn't pay much attention to that concept until one day the salesman for the company invited himself out to my small farm to educate me on the benefits of his mineral program for my small group of horses and beef cattle. He suggested putting out a dozen or more separate minerals. That seemed like over-kill to me, especially since I already put out some mixed mineral once in awhile and the livestock usually had a trace-mineral salt block available. Being persistent, this fellow even rigged up several small separate compartments in the ends of a couple of my existing feed bunks. He filled each one with a different mineral. He asked me to watch and see what happened. I was amazed. After only one day, it was apparent that the stock had sampled everything, the phosphorus source was licked clean and a lot of calcium was gone. I kept the boxes full. Though erratic at first, consumption gradually tapered off but never ceased entirely. Any new animals added to the group would spend the first few days at the mineral box. Some would gorge on calcium and some on phosphorus. Most would sample all the minerals to one extent or another. Once they reached satiety, the total consumption was negligible unless pasture or weather conditions changed or when feeding hay or grain from a new or different source.

Anyone who doubts that cattle can make valid nutritional choices only needs to watch a cow graze in a mixed pasture. They do not just mow grass like a lawn mower, but pick and choose each mouthful and if given the opportunity will balance their nutritional needs during each feeding period. They judiciously avoid eating the bright green grass surrounding 'cow pies' in the pasture but will search the fence-rows for weeds because many of them concentrate various essential trace minerals.

Let me relate a few other examples of how animals self regulate their diets to help you discover similar occurrences in your own animals.

When I first became interested in holistic animal care, I had a client that planted a large acreage of corn (maize) in a fertile river bottom area. Everyone that farmed around him used chemical fertilizer, herbicides and pesticides. He used only natural soil amendments. He experienced little damage from insects or weeds but the native deer would come from miles around to eat his organic corn, leaving his neighbor's crops untouched.

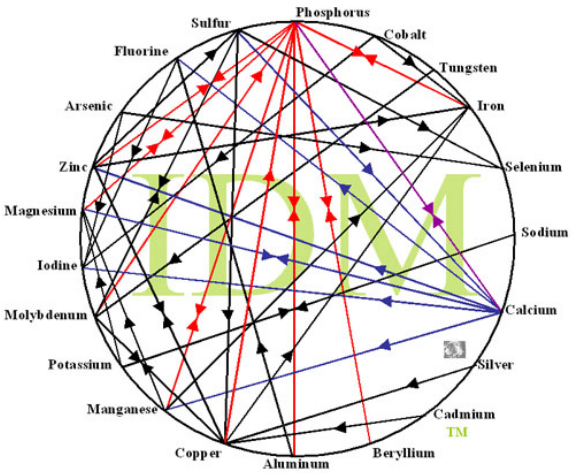
Ruminants can instantaneously detect minute changes in forage quality. Research from England indicates that grazing cows prefer clover during the day and grasses during the evening, because sugar levels are highest in grass late in the day.

In their natural state American bison roamed over thousands of miles of range and thus had access to naturally occurring minerals from a variety of soil types. A "buffalo" rancher in the upper Midwest must confine his herd to a few hundred acres. To duplicate as near as possible their former range of mineral choices, he provides continuous year-around access to 12 different free choice minerals. Their consumption varies greatly, sometimes on a day-to-day basis, depending on the season, the weather and the quality of the other feeds available. His animals are extremely healthy and productive.

I realize that most mainstream nutritionists tend to downplay or totally reject the idea that animals can self-regulate their nutritional needs. I admit that this ability may not apply to all situations and to every type of feed. Some feed items (grain and concentrates) may be so tasty that most animals would overeat if fed free choice. Nevertheless, this natural trait can be correctly channeled to improve animal health and nutrition.

No computer generated ration can match the exact needs of every animal or group of animals. In any given group being fed a total mixed ration (TMR), a few may get about what they need and the others will either get too much or too little. This is especially true of mineral components. For example, to provide trace minerals, many nutritionists add a trace mineral package that provides the suggested total trace mineral requirements disregarding those already present in the feed. In theory, this assures that adequate amounts will be present. However, it does not address the possibility of interference caused by any excess thus created. (See Mineral Wheel below)

I think we should build a ration just as good as we are able and also provide an opportunity for the animal to fine-tune its needs by giving them access to a professionally compounded free choice mineral package. It does not hurt to have two opinions: One from your nutritionist, and one from the consumers, your animals. I will leave it to you to decide which one is the most reliable.



MILK FEVER
"It's all about internal mineral balance!"

One of your best cows calved a couple of days ago and now she's down, laying on her sternum, head laying along her side with a kink in her neck. Her eyes are glazed over, pupils dilated and she can't get up. If observed earlier she may have been off feed and exhibiting muscle tremors and unsteady gait. This is an easy diagnosis for most dairymen to make: Milk fever, Parturient paresis (calving paralysis) or Hypocalcemia (hypo (low) calcemia (calcium). Whatever term you use, if untreated, this condition can result in death in a few hours.

I believe that almost all dairy cows suffer from some degree of low blood calcium at calving time. Most are subclinical in nature and do not show the classical signs described above. Calcium is necessary for all muscle function. Even moderately low blood calcium can predispose to calving problems, retained placentas, uterine prolapse and reduced reproductive performance as well as digestive and metabolic disorders such as displaced abomasums and ketosis. Low blood calcium affects the immune response and may be a factor in mastitis, metritis and other infections.

Incidence of this condition may vary from 3% to as high as 30% in some herds. Estimated profit loss from lost production, death loss, and veterinary costs associated with clinical cases of milk fever range as high as $225.00 for each episode, and the losses from subclinical milk fever may be even higher but more difficult to measure. Some old-timers say that if a cow "yawns" when you pinch her withers, it indicates low blood calcium. Hmmm?

The standard treatment for this emergency is calcium borogluconate. It may be administered intravenously, subcutaneously or intraperitonealy. If the animal does not respond, a solution containing magnesium and phosphorus along with calcium may be indicated. In early cases or as a preventative in high risk cows, liquid calcium or calcium chloride jels given orally may be beneficial. (Always check with your certifier.)

Different authorities cite different causes for milk fever. In the past, excess calcium was considered the culprit and limiting calcium levels in the dry cow ration was the standard recommendation. Some blame the high potassium in legumes and some grasses caused by inappropriate fertilizer practices. Low calcium, high calcium, high potassium, low phohorus, low or high Vitamin D, low magnesium, reduced mineral adsorption if rumen pH

is over 6.8 to 7.2 , water pH over 8.5 have all been implicated at one time or another. I guess you can just take your pick. In truth, all these factors play a part and the common denominator is a "mineral imbalance." While mineral balance is important to animal health at any time it is especially critical for the dairy cow at calving time.

During the dry cow period and especially in the last 3 weeks before calving, if the Ca/P ration is 1:1 or even higher in Ca there is a relative deficiency of phosphorus. To compensate for this the body sets-up to reject calcium and to absorb phosphorus. After calving, it takes 72 hours for the metabolism to readjust to absorb adequate amounts of Calcium.

As the cow approaches calving large amounts of calcium are drained from the blood reserve to form colostrum (high in calcium) and to begin milk production. At calving, the sudden increased demand for calcium by the mammary gland depletes blood calcium faster than it can be replenished from other body reserves and thus sets the stage for hypocalcemia.

The key to prevention of milk fever is management of the close-up dry cow.

1. All health begins in the soil. Strive for crops grown on highly mineralized, high organic matter soils that are free from residues of insecticides, herbicides and GMO sources.
2. Feed a high forage-low grain ration. A cow is a ruminant, don't feed her like a hog. Avoid alfalfa and other feeds or forages that are high in calcium and potassium.
3. Feed an enzyme product with good levels of phytase to release the naturally chelated minerals already present in your feeds. Minerals from this source are much more available than minerals from ground up rocks added to the ration. This not only benefits the health of your animals but also saves money by the more efficient utilization of home grown feedstuffs.
4. Allow your animals to adjust their own mineral needs by providing individually and free choice a highly available source of phosphorus (monosodium phosphate) along with sources of calcium, magnesium, potassium and trace minerals. Dicalcalcium phosphate is not suitable for this purpose because of its high ratio of calcium to phosphorus. Monosodium phosphate is the most expensive source and not generally used in the feed industry. The quality of ingredients used can vary greatly. Check labels; all minerals are not the same. Organically certified commercial products that meet these criteria are available from Advanced Biological Concepts.

Milk fever is not a disease but only the clinical expression of a mineral imbalance at a period of physiological stress. While the final expression of milk fever is caused by low blood calcium the predisposing cause is either low phosphorus in the ration or sources of phosphorus that are relatively unavailable. What an animal actually absorbs into its system is the only thing that counts.

It's all about internal mineral balance!

What Really Causes Grass Tetany?

Historically, grass tetany has been attributed to a magnesium deficiency brought about by cattle grazing spring pastures when there is a superabundance of young, rank, quick-growing grasses rich in proteins. Environmental stresses such as frost or freezing increases the risk.

This is a simplistic view of the problem.

Early researchers noted several other clues that have been largely ignored until recently.

A grass tetany syndrome can occur during the winter when feed is excessive in protein.

In some herds, cattle manifest pica suggesting that some necessary ingredient is lacking in the ration, likely a lack of sodium.

Animals grazing in strongly manured pastures stripped all trees within their reach of herbage until they were barren.

The sodium-content in the blood was subject to fluctuations, probably greater than in normal animals.

NITRATE TOXICITY

It is apparent that nitrate toxicity in herbivores is much more prevalent than previously reported. A well documented form of nitrate toxicity occurs in ruminants when nitrate is converted to nitrite by the microflora of the gastrointestinal tract and then the nitrite induces a methemoglobinemia and anoxia. Common factors are excessive nitrogen fertilization of pastures and feeding rations excessive in protein and non-protein nitrogenous compounds.

However, another form of nitrate toxicity that is likely more common and more detrimental, and previously overlooked may occur when the nitrate depletes essential cations in an attempt to maintain critical ionic balances, thus causing a severe electrolyte and mineral imbalance in ruminant and non-ruminant herbivores.

The excessive nitrate anions are excreted along with cations to maintain a critical ionic balance. This may result in mineral and electrolyte imbalances that may initiate a host of metabolic diseases in ruminants, as well as monogastric animals, including horses. This explains why cattle, other ruminants, and horses appear to be suffering from a host of metabolic disorders when exposed to forages and diets high in protein, non-protein nitrogenous compounds and nitrate. The nitrate anion per se may not be that toxic in cattle and horses, but indirectly it appears to be inducing mineral, electrolyte and ionic imbalances, and secondary immune suppression associated with these disorders. Sodium chloride, sodium bicarbonate, and high sodium zeolite compounds appear to neutralize the toxic effects of excessive nitrogenous diets, including nitrate toxicity.

Nitrogen is probably the primary initiating factor for inducing hypomagnesemia and hypocalcemia. Excessive NH+ may also interfere with the absorption of magnesium from the gut.

This form of nitrate toxicity is an important factor in the development of the grass tetany syndrome and likely other syndromes in herbivores, including reproductive disorders.

When this occurs, the excessive anionic ions need to be neutralized by cations and this causes a "washing out" effect of essential cations including calcium, magnesium and sodium in the urine, feces and milk, and then hypocalcemia, hypomagnesemia and hyponatremia occur.

Nitrate in the diet is utilized in protein metabolism. However, if the nitrate is excessive in ruminants, in some cases, nitrate is converted to nitrite by the gut bacteria and methemoglobinemia may occur. The majority of excessive nitrate is eliminated in the urine, feces or milk by bonding with the cations magnesium, calcium and sodium, but usually not with potassium. If there is a deficiency of sodium, and most forages and rations are deficient in sodium and excessive in potassium, and when there is a spike in nitrate, or excessive nitrate in the body, anionic nitrate is eliminated from the body as an ionic complex associated with magnesium and calcium.

EFFECT ON CALF HEALTH

The high nitrate in the milk, associated with the feeding of high protein diets in herbivores, may also affect suckling neonates with the same detrimental effects as in adults. This explains why neonates on dams that are fed excessive proteins seemingly are affected with a multitude of opportunistic gastrointestinal diseases, including gastric ulcers and other intestinal disorders. Conversely, for dams fed a low protein diet and adequate sodium, their neonates rarely suffer from these gastrointestinal disorders.

SODIUM DEFICIENCY

A dietary sodium deficiency causes an electrolyte and mineral imbalance. Seemingly, adequate dietary sodium not only protects against nitrate toxicity, but also aids in the prevention of grass tetany syndrome in herbivores, and other metabolic and reproductive disorders induced by nitrate in herbivores.

Low Blood Sodium (Hyponatremia)

Low concentrations of sodium were found in tetany-prone grass, and grass tetany was prevented by supplementing cows with sodium chloride. The incidence of grass tetany disappeared at sodium concentrations above 0.2% in the grass.

However, if there is adequate sodium in the diet and organs and tissues, the excessive anionic nitrate is removed by the gut, kidneys, and mammary glands in lactating animals, as a ionic complex associated with sodium, and magnesium and calcium are maintained at physiologic levels and hypomagnesia and/ or hypocalcaemia will not occur.

For this reason adequate levels of sodium in the body and ration will lessen or prevent the drastic effects of nitrate toxicity. Also, it explains why adequate sodium in the diet will aid in the prevention of grass tetany, which is associated with high potassium and low magnesium levels.

The livestock industry has limited sodium chloride in mineral supplements to encourage livestock to consume more minerals, and this has led to the over consumption of essential minerals that are normally not toxic if fed at correct levels, but can be if fed in excessive amounts.

The restriction of sodium is seemingly contributing to a multitude of syndromes, including hypomagnesemia, hypocalcemia, grass tetany, downer cow syndrome, acute bloat, vaginal and rectal prolapses as well as a host of opportunistic diseases and immune suppression.

Also, the restriction of sodium and the prolonged over feeding of magnesium may result in decreased performance, especially milk production in dairy cows and severe reduction of calf weights in calves of beef cows.

Furthermore, the forced feeding and overfeeding minerals that are contaminated with heavy metals have drastic effects on performance due to toxicities, mineral imbalances, immune suppression, and the induction of a host of opportunistic diseases. It is important to have adequate, pure forms of calcium and magnesium of high quality in the diet for high producing animals. Most diets have adequate calcium and magnesium, but when there are acute spikes in anionic ions, the calcium and magnesium may be acutely depleted, resulting in hypocalcemia, hypomagnesemia and a hyponatremia. But, adequate access to sodium appears to help alleviate these acute deficiencies during spikes in nitrate.

SALT BLOCKS

Most cattlemen assume they have adequate sodium if cattle are exposed to salt blocks. Cattle and other herbivores cannot obtain enough salt or sodium from hard salt blocks during periods of acute needs. The most dominate animals in a herd will hoard a salt block and the remainder will leave without any salt. Even the animals that hoard the block cannot consume enough salt to neutralize the acute excessive dietary nitrate during periods of acute stress to forages, like frosts and freezes to high nitrogenous forages. Therefore, it is imperative to either have adequate sodium in the complete rations, which is preferable, and/ or to have readily available sodium in the form of sodium chloride, and/or sodium bicarbonate in the loose form always available, especially in times when environmental conditions are conducive for nitrate spikes in forages.

Seemingly, the excessive potassium in forages, which occurs along with the excessive nitrate after a frost and freeze, discourages animals to consume salt, or sodium compounds free choice as potassium substitutes for sodium in plants as well as in animals. This further increases the ratio of K/Ca+Mg and for this reason, sodium needs to be force fed in complete rations for optimum results. It is important to have fresh water available and place salt mixtures near water sources.

Along with the grass tetany syndrome that frequently affects cattle grazing lush grass and legume pastures, acute bloat is often seen in the same cattle herds. It has been observed that if cattle have access to adequate loose salt, they rarely die from grass tetany or acute bloat.

If there is a spike in potassium and nitrate due to adverse environmental conditions while cattle are deprived of salt, cattle are often found dead, or suffering from a host of metabolic and opportunistic diseases. Seemingly, cattlemen with the healthiest cattle are very aware of the need for cattle to have unlimited access to loose salt and/ or loose trace mineralized salt at all times. These same cattlemen have observed that if cattle are without salt, even for short periods of time, some may be found dead, or suffering from clinical signs of grass tetany or acute bloat, especially after periods of severe environmental stress, like frosts or freezes to lush pastures containing legumes.

LOW BLOOD MAGNESIUM

With low blood magnesium (hypomagnesemia), the majority of mineral supplements currently used in an attempt to prevent grass tetany are deficient in sodium and excessive in magnesium. Excessive magnesium can cause weight loss, wasting, severe diarrhea, and reduced milk production when fed with high protein rations. Lack of sodium and excessive potassium seemingly also interferes with the absorption of magnesium from the gut.

Hypomagnesemia may occur in animals foraging on diets low in magnesium, but it may also occur when diets have adequate magnesium in the forages or rations. This suggests that there are some factor(s) either tying up the magnesium and/or chelating the magnesium making it unavailable, or causing it to be removed from the body excessively through the kidneys, mammary glands and in the feces, thus causing an acute hypomagnesemia.

LOW BLOOD CALCIUM

The clinical signs of grass tetany or hypomagnesemia are unlikely to occur unless there is also a hypocalcemia.

HIGH BLOOD POTASSIUM

The same conditions that are involved in grass tetany - lush growth of pastures in early spring, along with cool, cloudy and wet weather and possible freezes or frosts, will cause acute spikes in potassium as well as nitrate in affected growing pastures. Analyses of these affected pastures during and after periods of frosts and freezes revealed elevated levels of potassium and nitrate.

The acute spike in potassium and nitrate is seemingly causing an electrolyte and mineral imbalance in affected herbivores. These imbalances, in pastures forages include an increase ratio of K/ Ca+Mg, and a deficiency in sodium. These imbalances may not be readily apparent, unless blood samples are obtained while animals are suffering from marked clinical signs, as the body can obtain cations from tissues until they are depleted, then severe acute clinical signs and death occur.

SOIL

When there is a deficiency of calcium and sodium and excessive potassium and

nitrogen in the soil, there is likely a more dramatic spike in potassium and nitrate in plants during and after stress, like frosts and freezes, to pasture forages. If the excessive potassium and nitrate in affected forages is consumed by herbivores, it may induce a toxicity and/or mineral and electrolyte imbalances.

When there is an acute deficiency of magnesium and/or calcium, not only are the skeletal muscles affected, but also the smooth muscles of the gut, including the rumen. When atony of the smooth muscles of the rumen occurs, cattle are more susceptible to acute bloat, especially animals grazing lush high legume pastures. In addition, cattle or sheep grazing similar pastures may be affected with vaginal or rectal prolapses. It is suspected that the mechanism of action is similar as the vaginal and rectal muscles relax and then may prolapse. Also, nitrate seemingly has an estrogenic-like effect in that it causes relaxation of smooth muscles which may also be playing a role in smooth muscle atony of the reproductive tract, rumen and intestinal tract. Adequate sodium in the diet seemingly prevents these syndromes that are believed to be associated with excessive potassium and nitrate in the diet.

Over-feeding of protein can be somewhat alleviated by feeding adequate calcium, magnesium and sodium preferably in complete rations, but also they should be available free choice if affected animals desire and need more to neutralize the anionic excesses. Calcium and sodium if fed at optimum concentrations are non toxic, but magnesium if fed at high levels for prolonged periods, may be toxic and may result in chronic wasting, reduced milk production and diarrhea. Seemingly, the feeding of adequate levels of magnesium and increased levels of calcium and sodium during period of environmental stress will aid in the prevention of grass tetany that is induced by acute anionic imbalances due to nitrate in high producing animals.

PREVENTION

- Build the soil and avoid over application of nitrogenous fertilizers including manure.
- Supply white salt free choice - no salt blocks.
- Provide a wide variety of free choice minerals.
- Do not feed excess protein or NPN substances.

A HUNDRED AND ONE NUTRITIONISTS?

by Richard J. Holliday, DVM

A TMR (Total Mixed Ration) is a standard feeding strategy for most large dairies and many small ones. A TMR purports to provide all of the nutritional requirements for each cow in the group.

A TMR has many advantages for dairymen. Grouping the cows according to common characteristics allows the dairyman or his nutritionist to formulate a daily diet for the average needs of each cow in the group. With a TMR you can quickly and easily reformulate the ration to use different commodities or ingredients as price and availability change. A TMR is easier to feed since everything is rolled up into one neat 'one bag fits all' package. Dairymen and nutritionists like the precision of a computer printout and the control it gives them over the animals' diet. All of the above advantages affect the convenience and control of the managers, but is it really the best way to feed dairy cows?

Remembering that you don't get something for nothing, what is the negative payback for the convenience of using a TMR? Unfortunately, a TMR is a good way to push way more protein than is healthy for ruminants, especially when they do not have the opportunity to adjust their need for fiber in the diet. Bad feet, reproductive problems and lowered longetivity seem to go hand-in-hand with the push for high production at any cost. Perhaps the most meaningful word in the above paragraph is AVERAGE. TMRs are designed to fit the average cow, which means that if a cow does not exactly match the average, she either has certain nutrient excesses or deficiencies to deal with. There is so much individual variation in nutritional needs that it is doubtful that we could adjust the TMR to accommodate most of the group. Although some variation is acceptable, in a large group it is theoretically possible that no animal receives its exact needs. Reducing the size of the group does help as it tightens up the spread of individual variation. If we carried the 'smaller group is better' idea to its extreme we would need a ration for each individual cow and to go even further over the edge we might need one nutritionist for each cow. How cool would that be? Obviously, that's impracticable if not impossible, but it does raise an interesting question. What if we could provide a basic feeding strategy that did address the needs of each individual cow for a balance of all nutrients, including carbohydrates, proteins, fats, vitamins, minerals and water? All animals have the intrinsic ability to balance their nutritional needs if appropriate choices are provided. Here are some steps to build on our nutritional knowledge by taking advantage of the animal's nutritional wisdom.

- Use a TMR or a modified TMR to provide basic nutrition. Remember that a cow is a ruminant, so keep the grain to roughage ratio as low as possible.
- Provide a separate free-choice source of fiber.
- Provide a free choice source of individual minerals.
- Feed a high quality prebotic/probiotic.

There are several advantages to all of this.

- The animals are healthier and stay in the herd longer.
- Providing a free-choice source of minerals insures that each animal has the chance to balance their mineral needs. Trace minerals are the basis for enzymes which are the spark-plugs that enable all metabolic processes. Balance is important – excess can be as damaging as deficiencies.
- Feeding probiotics increases the digestibility and utilization of all feedstuffs. You get more nutrition from your home-grown feeds and need to buy less off-the-farm commodities. This equals more profit.

The bottom line is: You don't need a hundred and one nutritionists if you allow your cows to be part of your nutritional management team.

"Hey, Doc, my cows are eating dirt. Waddya got for that?"

By Richard J. Holliday, DVM
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A few years ago, I posed this question at several dairy seminars in the Midwest: *"Do your animals chew on wood or eat dirt if they have the chance?"* A few said their cows would chew on wood. Almost all indicated their cows would eat dirt if available. One fellow said that he had to haul in dirt around the foundations of his buildings to replace the soil his cows had eaten over a period of years. Strangely enough, a few even told of their cows licking or drinking from urine puddles if they could get to them. As bad as that sounds, it is even more alarming when conventional opinion regards this eating behavior as being almost normal because it is so common. It's the "everybody's doing it, so it must be OK" syndrome. And it may be "normal" in the sense that it is appropriate, compensatory behavior for animals forced to subsist on a mineral deficient ration. Eating dirt and other abnormal appetites are attempts to secure some vital element or attain some nutritive balance that is not otherwise present in their diet. It should be considered a warning signal that something is amiss in the ration.

To examine the problem from a holistic viewpoint, let's go back in time and look at the effect of domestication on today's dairy cattle. Most authorities agree that primitive cattle or Aurochs (Bos taurus primigenius) were first domesticated about 8000 years ago. Before domestication, cattle lived a lifestyle similar to that of bison in the American west. They were free to roam over wide, naturally fertile areas. Specific imbalances of soil in one area would be offset by excesses or adequacy of the same element in other areas. A multitude of different plants were available. Many plants had the ability to absorb and concentrate different minerals and trace minerals, giving the grazers even greater nutrient options. Thus, over a period of time they could seek out and obtain balanced mineral and nutritional needs. Predators strengthened the genetic pool by culling the weak and unfit.

It's a lot different today. Dairy cattle have been genetically modified to produce at levels never intended by nature, increasing their need for minerals.

Ever more restrictive confinement limits their ability to seek out and consume adequate diets. In a natural grazing situation, herbivores probably had hundreds of different plants from which to choose. Today they are limited to 6 or less: grass, alfalfa, corn, soybeans, cottonseed and maybe some oats or barley. Seeds and grains in the amount currently fed are detrimental to dairy cow health. Cows are ruminants and need a high-forage diet!

Crop quality has declined. Every crop harvested or animal removed from a farm or ranch takes with it a finite amount of life supporting nutrients. Major elements can be replaced but it is difficult to restore a natural balance that includes high organic matter, adequate trace minerals, and vibrant biological life. Intensive NPK fertilization results in higher yields at the expense of nutritive values and mineral content in the crops.

"AVERAGE" IS A MYTH! A total mixed ration (TMR) is the industry standard feeding strategy that purports to provide, in one total mix, all the nutrition required by the 'average' cow in the group. This concept fails to consider the

individuality of each animal's nutrient requirements. **No two animals have the same needs.** Variables such as breed, age, pregnancy, stage of lactation, weather, season of the year and others have a marked influence on the need for mineral supplementation. With a TMR probably no one animal will get exactly what it needs. A few may get pretty close but many will be lacking in some nutrients while others will have excesses. This limits their production, eventually depresses their immune response and ultimately may result in various herd health problems. Eating dirt, if available, is their way of responding to these imbalances.

Unfortunately, mainstream nutritionists tend to downplay the ability of animals to balance their nutritional needs. Anyone who doubts that cattle can make valid nutritional choices needs to watch cows graze in a mixed pasture. They do not just mow grass like a lawn mower, but pick and choose each mouthful. They avoid eating the bright green grass surrounding 'cow pies' in the pasture but will search the fence-rows for weeds that concentrate various essential trace minerals. Given the chance, they will balance their nutritional needs during each feeding period.

The following incident illustrates another aspect of this ability. Weather had made it a bad year for crop quality. In late winter, a good client called me about two problems. His cattle were eating excessive amounts of mineral and his heifers would abort a live calf about 10 days before they were due to calve. The calf would live, but the heifer would usually die. Focusing first on his mineral problem, he decided to try a "cafeteria" mineral program in which each mineral was fed separately. He had to carry each bag of mineral through his cow lot to get to the mineral feeder. His first few trips were uneventful. Then suddenly several of the normally docile cows surrounded him, tore a bag of mineral from his arms, chewed open the bag and greedily consumed the contents…a zinc supplement.

Within a week after the mineral change, consumption returned to normal and his remaining heifers calved normally. Apparently, the previous year's stressful growing season had resulted in crops that were deficient in zinc or perhaps high in zinc antagonists. His mineral mix was high in Calcium with only small amounts of zinc. Their quest for zinc impelled them to over-eat the mixed mineral. Excess calcium interferes with zinc absorption. Every mouthful they took increased the imbalance and escalated their need for zinc. Inevitably, metabolic problems began in the most vulnerable group - young, growing heifers in the last stages of pregnancy. Finally they just gave up and checked out...all for want of a few grams of zinc.

If your cows are eating dirt or if you just want to experiment; give your cows a chance to participate in their own diet formulation. Provide separate free-choice sources of these 6 items: salt, bentonite, bicarb, a basic mixed mineral with a 2 to 1 Ca/P ratio, one with a 1 to 2 Ca/P ratio, and kelp. Cows with rumen acidosis will prefer bicarb or bentonite. The separate sources of Ca and P allow them to adjust that critical ratio. If they lack trace minerals they may also eat a lot of kelp. If kelp consumption remains high you may want to provide separate sources of some of the trace minerals. There are commercial companies that provide a broad range of separate free-choice minerals and trace minerals.

We should use our nutritional knowledge to formulate dairy rations, but also rely on the nutritional wisdom of animals to fine-tune their individual needs. It doesn't hurt to have two opinions ... one from your nutritionist's computer and one from the real experts, your cows. I will leave it to you to decide which one is the most reliable.

TOOLS OF THE TRADE

by Richard J. Holliday, DVM

The other day when I had my van in for service, I noticed the fine array of wrenches and other tools available for use by the mechanic. Since I am a guy who feels fully equipped if I have more than one adjustable crescent wrench, I was impressed not only by the sheer numbers of the different tools but also by the specific applications for some of them. Given the necessary skills, the mechanic had all the tools he needed to take apart and put back together the complex engines that power today's vehicles.

I remembered then some things I learned years ago from my good friend and veterinary colleague, Dr. Bob Scott. Bob had a unique way of looking at things and could translate complicated subjects into an easy to understand broad overview using simple analogies. Here is his view of the role of minerals in plants and animals.

Plants are basically made up of air and water. If you combine carbon, as from carbon dioxide with oxygen and hydrogen (also from air or water) you have the basic building block for starch, sugar or carbohydrates. Add nitrogen to this basic formula and you have an amino acid or a basic building block for protein. If you burn a plant, thus reducing it to ash, you are left with that part of the plant that came from the soil - usually around 5 %. Therefore, 95% of the makeup of plants comes from air and water, combined together by the sunshine generated miracle of photosynthesis.

Minerals are nature's "tools" that enable this process to proceed. They are basic to the enzyme systems that catalyze the storage of the sun's energy into the chemical bonds within the plant itself. The major elements are the big wrenches, and the smaller ones are the trace minerals. All are essential. Any deficiency or imbalance limits the production and the quality of the crops grown. If some elements are lacking in the soil they will be lacking in the crop. If they are lacking in the crop, they will be lacking in the animal that eats the crop.

When an animal consumes plants, the same tools used by the plant to combine the CHO & N to store energy are needed to break down chemical bonds and release energy to power the metabolic processes of life and production. If the plant doesn't have enough built-in tools (minerals), extra tools must be provided. Most of our soils are so depleted in minerals that it is almost a given that some sort of mineral supplementation is necessary, especially to arrive at the high levels of productivity that we strive for today. Without the mineral tools proper digestion and assimilation of the energy in the feeds simply does not take place.

Even without computers, animals are smarter than man when it comes to balancing their individual needs for the elements of nutrition, especially the major, minor and trace minerals. Providing a choice in mineral supplementation allows the animals to pick the tools they need without being totally locked in to only the tools recommended by the computer.

Most farmers probably wouldn't think much of a mechanic that tried to overhaul a tractor with a screwdriver, a pair of pliers and a couple of crescent wrenches. Unfortunately, in their role as animal caretakers, some livestock men seem to think that a cheap sack of high calcium minerals and a trace mineral salt block are all the tools needed by our livestock to fully utilize the energy stored in our feeds. They are wrong!

7-hole or 14-hole upright feeder

Precision Tools

"Low Boy" 12-Hole Wooden Feeder

Space for 12 different items

Plans for these feeders are available upon request.

NUTRITIONAL WISDOM FROM THE PAST

A REVIEW OF THE LITERATURE OF TCI MINERALS AND THE WRITINGS OF JOHN D. BUSER, DVM and OTHERS

BALANCING DAIRY RATIONS
By John D. Buser, DVM

Producing dairy cows are highly stressed animals and need a well balanced ration. This is best achieved by allowing the dairy cow free choice access to all parts of the TCI Five Point Feeding Program consisting of water, low protein dry roughage, TCI minerals fed separately and free choice, a source of available protein and grain.

Total free choice feeding is not always feasible as the result of modern confinement and management practices. Properly balanced rations may then be achieved by the use of laboratory analysis of all involved feedstuffs and the combining of these feedstuffs in a manner similar to the way the animal would have consumed them had it been given the free choice opportunity.

Most dairy rations will balance quite well for energy, ash and protein if good quality grain makes up 50% pf the total dry matter requirement of the dairy cow. This generally amounts to feeding 20 – 30# of grain daily depending on the percent dry matter. More or less grain may then be fed individually dependent on the stage of lactation.

The remaining, 50% of the dry matter requirement can be generally satisfied by providing 25% alfalfa hay or haylage and 25% corn or sorghum silage or grass hay on the dry matter basis. All roughages should be kept available 24 hours a day to allow all animals the opportunity to satisfy their total dry matter intake requirements. If only one roughage source such as alfalfa hay is provided free choice, dairy cows are often forced to consume excessive amounts of protein and/or mineral ash simply because they are hungry! This will result in an unbalanced ration that will cause production and reproduction problems. Providing grass hay or straw will allow the animal to satisfy this hunger without a protein excess.

Once the ration has been balanced for energy, protein and ash, the minerals that make up the ash may still be unbalanced. By using the laboratory analysis of the feeds and water, a custom mixed mineral can be designed by TCI to better balance the minerals for the average cow in the herd. TCI minerals fed separately and free choice should always be provided, even when custom mixed minerals are used, to allow each individual animal to balance its individual needs dependent on genetics and stage of production and reproduction.

When the above recommendations are followed, good production and reproduction can be expected. If individual cows become too fat and don't produce as well as their herd mates, they're simply indicating that they genetically are not capable of good production so are in good condition to market immediately.

The dairy cow is one of nature’s very delicately designed creatures with the specific purpose of providing a very nutritious source of food for mankind, namely milk. She has the genetic ability to produce large quantities of this food when she is fed properly. When not fed properly, she must struggle for her own survival and can be very costly to her owner.

The dairy cow can derive considerable amounts of energy, protein, vitamins, and minerals from forage type feeds. She is capable of this because she is a ruminant animal with literally "billions of helpers," the microscopic microbial crop in her "fermentation vat," the rumen. This microbial crop can digest the cellulose contained in roughage type feeds rather efficiently in comparison to

single stomached animals. This cellulose is a good form of energy to the cow, but does not provide nearly adequate energy to meet the demands of today's high producing dairy cow.

Grain is a good source of soluble energy to the dairy cow. When added to rations in moderate amounts, grain can greatly increase the amount of energy needed for high milk production. The problem of digestive upsets and other mineral deficiency problems often occur though, when excessively large amounts of grain are used in an attempt to satisfy the energy requirements of today's dairy cow.

The addition of ethyl alcohol contained in TCI Liquid Supplements, when added to dairy rations stimulates better digestion of the roughage consumed by the cow. This results in more energy being made available to the cow for the increased production of milk. The use of TCI TALIX PLUS will then allow dairy cows to be fed a well-balanced ration that will result in less stress on the cow, and at the same time will result in improved production simply because of improved digestion of the ration.

HIGH MILK PRODUCTION, EARLY BREEDING CHALLENGE NUTRITIONISTS
NOTES FROM JOHN D BUSER, D.V.M.

In our estimation, most progressive dairymen feed their prized super-cows quite liberally in terms of the major nutrients. With regard to vitamins, trace minerals, special additives, etc., sometimes they go overboard. In many instances, however, we have not observed any visible detrimental symptoms caused by this extra fortification, which we feel is an unnecessary luxury. Many authorities warn of vitamin deficiencies (A, D and E), phosphorus deficiencies and trace mineral deficiencies (including selenium). In many cases, we have been more concerned about "excessive nutrition", which is really another form of malnutrition.

Dairymen readily recognize the problems associated with "over conditioned fat cows." With higher capacity for milk production, the modern super-cow must freshen in "good flesh" if she is to peak high and perform well in the subsequent lactation. There is undoubtedly a fine line between a "fat cow" and a "well conditioned cow," which only keen observers can differentiate.

Short changing dairy cows on protein reduces milk production and solids non-fat production. Feeding increasing levels of protein with certain limitations has dramatically increased milk production not only under strict experimental conditions but under commercial operations as well. This has led many dairymen to overfeed protein beyond a reasonable level.

Recent data accumulated in this country, in Israel, and in Europe have shown that overfeeding protein in early lactation is not only costly but may even be detrimental to fertility. Kaufman (1984) cited some data in which the level of protein in the ration was related to the level of urea in the milk and fertility. This is shown in Table 1.

TABLE 1. Relationship between protein content of ration, urea in the milk, and fertility.

	Protein Content of Ration		
	13.0%	**14.5%**	**17.5%**
Milk, urea - mg/100 ml	26.0	31.0	33.0
Services / conception	1.64	1.72	1.93
Days open	88.0	88.0	97.0

Therefore, in our opinion, excessive intakes of protein may be a more serious problem affecting breeding efficiency in high performance herds than protein deficiency per se, since these highly motivated dairymen prefer to err toward the high side in favor of their cows.

Reprinted from FEEDSTUFFS magazine, Feb. 25, 1985

DISEASE AND NUTRITION, NOT UNCOMMONLY LINKED

Notes from John. D. Buser, DVM

Imbalances in vital nutrients can wreak havoc on even the best swine herd health problems.

Disease and nutrition interactions are not uncommon. In fact, there are about four areas where deficiencies, imbalances and excesses in feed can affect the health status of the animals on your farm.

According to Fhilip Wagenknecht, former technical services manager for Wayne Feeds, the first problem begins with the person who did not make a good formulation with a proper balance.

The second area is ingredients quality. The formulator must assume a certain level of potency and availability of ingredients. “If you use vitamins that have lost potency or need amino acids that are not available, you may have a problem,” says Wagenknecht.

Mixing is the third problem area. The formulator must be careful to thoroughly arid uniformly mix the correct balance of ingredients.

“The fourth area is that often producers do not get into the pig what we ‘think’ we get into the pig. In other words, feeding equipment and systems make a lot of difference in the amount of waste or what the animal actually consumes. We say we feed a sow 4 lbs. of feed in gestation, but how much does she really consume,” questions Wagenknecht?

Over the past ten years, Wagenknecht has observed how nutrition and disease interact. He notes Vitamin A and D toxicities. for example, usually result from a mixing error. “This happens where one to a hundred times too much vitamin A or D was added because the formulator thought milligrams, but used grams instead.” he explains.

Wagenknecht claims excessive iron levels also are dangerous because they can decrease the availability of vitamin E and selenium as well as impact negatively on zinc or other minerals. “We must refrain from the ‘if a couple cups is good, then three cups must be better’ attitude. The fact is, it may not be better. We have to look at the impact of any one nutrient on the other nutrients to keep a balance,” he says.

The availability of vitamin E and selenium mentioned above is a problem Wagenknecht believes we have not fully understood. “The government was part of the problem when it would not let us use more selenium. However, that has been somewhat overcome by increasing approved levels,” he reports.

MANY PRODUCERS UNINTENTIONALLY ABUSE CALCIUM BECAUSE IT IS SO INEXPENSIVE.

Another common problem is excessive calcium. According to Wagenknecht, many producers unintentionally abuse calcium because it is so inexpensive (about $.25 to $.30 / ton of feed). When a producer sees a leg problem, for example, he is likely to add more calcium. Unfortunately, this extra calcium tends to tie up zinc, resulting in a zinc deficiency. Too much calcium also impacts palatability. “Pigs will just back off and grow slower,” he says. Excessive levels of B vitamins also may adversely affect palatability.

While it is easy to overload on calcium, just the reverse is true for energy. “Not getting the right amount of energy into a sow at gestation and lactation probably is the most common nutritional-disease interaction,” notes Wagenknecht. Low energy intake, coupled with an unsuitable temperature in the gestation house, may cause abortions. An under-conditioned sow that is improperly handled also could give birth to small, poor doing pigs that cause problems in the farrowing house.

Energy in the lactation diet is important too. If piglets don’t receive protective immunity from the sow’s production of colostrum and milk, the chance for scours and laid-ons increases. This, coupled with low birth-weights and lack of uniformity, intensifies.

If sows are not fed the proper amount of energy in lactation, they are slower to rebreed. They also become susceptible to skin infections. “If mange happens to be in a herd and spreads to these sows, you would never be able to control it. I have seen herds where we increased feed. If we had not tackled that mange problem early we would have never been able to get sows back into good condition,” says Wagenknecht.

“The problem with energy is that if it is improperly supplied in the beginning, pathogens take hold, causing the animal to require higher levels of energy to compensate. It’s a vicious circle,” he warns.

EQUALIZING INTAKE LEVELS

How can producers be sure the desired feed intake level matches the actual feed intake level? Wagenknecht suggests they first must ask themselves whether they are going to feed sows individually or in groups. “You can successfully handle both,” he says.

Individually housing sows in crates or tethers facilitates individualized feeding. “I am continually surprised, however, at the producers who individually

crate their sows, yet feed them all the same ration. You lose the whole advantage if you do this," he reasons.

Curbing feed wastage is another means of closing the gap between desired and actual feed intake. "Look at the amount of feed on the floor. How much do you think moves across the slats and into the pits?," asks Wagenknecht.

He suggests evaluating the feeder space. If a sow has too little room she will take some feed, back up and chew, then return to the feeder. "I bet those sows are losing a third of the feed they are given. The amount of feed waste is phenomenal in many of our herds. I think we can figure 15 to 20% of many situations," he says.

While individualized feeding may be preferred, Wagenknecht believes producers can do a good job of ensuring actual feed intake in group feeding as well. According to him, the key is keeping those groups small and uniform. "You have got to watch how long you leave those sows at the feeders. Pay attention to the details of group dynamics," he advises.

One of the details, of course, is uniformity. Wagenknecht suggests looking for this in groups of sows that are an every third day feeding program. Feed equipment, temperature, humidity and drafts also must be checked as they all impact on what kind of feeding level is needed. Wagenknecht also suggests distinguishing genetic variables, or what he calls the "easy keeper" or "hard keeper" sows. They will differ on how much feed is required.

If sows are treated with a reasonable amount of care in the first 2/3 of gestation and pampered during the last 1/3 of pregnancy, disease problems related to nutritional deficiencies should be minimal.

"The best thing to do is go home and evaluate your own situation," says Wagenknecht. Balancing ingredients and regulating feed intake are the producer's safest bet.

The preceding article was adapted from a presentation at the 1983 International Pig Management Seminar, Atlanta, GA.

The only accurate method of assuring the proper balance of nutrients in swine rations is the use of laboratory analysis of water and grains to be used with the ration, then truly balancing the various nutrients to truly provide a balanced ration. TCI PERSONALIZED RATIONS FOR SWINE TRULY PROVIDE BALANCED RATIONS.

Reprinted from PIG AMERICAN Magazine, May 1984.

DO ANIMALS COMPETE WITH MAN FOR FOOD?

By Jo Robinson

Those who argue against the use of livestock, and who feel livestock's future is limited, cite their low conversion rate of feed energy and feed protein into human food. Their argument has a basic weakness in that it does not consider that there are many factors involved in determining future animal production systems besides grain use and the percent of energy and protein conversion. One needs to consider the source of energy or protein when evaluating conversion figures. For example, the beef cow is a very low energy converter, but 95% of its energy comes from forages which are not used as food for man. With protein conversion figures, one also needs to consider that ruminants can convert urea nitrogen to meet at least 25-35% of their protein need, whereas non-ruminants cannot do this.

The adaptability of various classes of animals to alternative feeding programs which are available in specific areas is also an important factor. For example, if no grain whatsoever was available in the U.S., ruminants could produce acceptable quality meat and milk for human consumption on forages alone or on forages plus byproduct feeds and crop residues. Naturally, lower levels of growth and productivity would occur without the use of high energy grain feeds. But animals would be producing "human food" from "non-human food" and thereby rendering a most important service to feeding mankind.

Approximately two-thirds of the world's agricultural land is in the form of permanent pasture, range and meadow--of which about 60% is not suitable for cultivation. In the U.S., 890 million acres were used for grazing in 1969 which amounted to 77% of the agricultural land. Without the use of ruminants to harvest these vast areas, there is virtually no way this acreage can contribute to the world's human food supply.

TCI Individual Free Choice Mineral Program allows animals consuming these forages, grown on various types of soil, the opportunity to supplement deficient minerals and vitamins needed for better utilization of these forages. TCI TALIX PLUS stimulates rumen microbial digestion to achieve even greater production of edible human food from forages.

No, we won't eliminate animals. Rather we will help them by using the TCI Program to convert cellulose plant material to even greater quantities of nutritious food.

CHEMICAL CONSTITUENTS vs. BIOLOGICAL ATTRIBUTES OF FEEDSTUFFS

By Dr. R.L. Preston
Texas Tech University Lubbock, Texas

This article is an excerpt from the August 29, 1983 FEEDSTUFFS magazine and accompanied the 1983 - 1984 typical composition of feeds table. Since Dr. Preston is one of the very few most qualified individuals in the industry, we feel that his remarks prefacing the tables, are particularly appropriate. We hope you find them as interesting and informative as we did.

The ultimate goal of feedstuffs analysis is to be able to predict the productive response of animals when they are fed rations of a given composition. This is the real reason for information on feedstuff composition.

Table values for feedstuff composition: Feedstuffs are not of constant composition. Unlike chemicals that are "chemically pure" and therefore have a constant composition, feeds vary in their composition for many reasons. What is the value, then, of showing compositional data for feedstuffs? No one will argue that tabular data is more accurate than actual analysis of a feed to be used in a ration. Actual analysis should be obtained and used whenever possible. Often, however, it is either impossible to determine actual compositional data, or there is insufficient time to obtain such analysis. So tabulated data are the next best source of information.

When tabulated data are used, it should be understood by all that feeds vary in their composition. Using the data shown in the accompanying table, one can expect the organic constituents (e.g., crude protein, ether extract, crude fiber, acid detergent fiber and neutral detergent fiber) to vary as much as 15 %, the mineral constituents tq vary as much as 30 %. and the energy values to vary at least 10%. Therefore, the values shown can only be guides. For this reason they are called "typical values." They are not averages of published information, since some judgment was used in arriving at some of the values in the hope that the values will be realistic for use in cattle and sheep rations.

Chemical constituents vs. biological attributes of feedstuffs: Feeds can be chemically analyzed for many things which mayor may not be related to the response of an animal when fed the feed. Thus, in the accompanying table, certain chemical constituents are shown. The response of cattle and sheep when fed a feed, however, can be termed the biological response to the feed in question, which is a function of its chemical composition and the ability of the animal to derive useful nutrient value from the feed. The latter relates to the digestibility or availability of a nutrient in the feed for absorption into the body and its ultimate efficiency of use in the animal, depending on the nutrient status of the animal and the productive or physiological function being performed by the animal. Thus, ground fence posts and shelled corn may have the same gross energy value in a bomb calorimeter, but have markedly different useful energy value (TDN, digestible energy, net energy) when consumed by the animal. That means that the biological attributes of a feed have much greater meaning in predicting the productive response of animals, but are much more difficult to accurately determine because there is an interaction between the chemical composition of the feed with the digestive and metabolic capabilities of the animal being fed.

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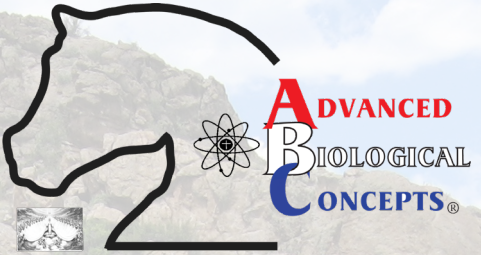

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