AGRI-FACTS
Practical Information for Alberta's Agriculture Industry

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Nutrients for Cattle

The use of adequate, well-balanced diets can maximize profits – or minimize losses – in a feeding program. An animal's diet must contain the essential nutrients in appropriate amounts and ratios. This factsheet outlines the nutrients that are basic to good cattle nutrition and how well Alberta feeds succeed in supplying these nutrients. However, to better understand how feeds are used, it is important to understand the digestion process in animals.

Digestive systems – In the monogastric or single stomached system, e.g. the pig and man, the digestive tract is essentially a muscular tube extending from the mouth to the anus. Its function is to ingest, grind, digest and absorb food, and to eliminate the waste products of the process.

Monogastrics are in most cases omnivores meaning they eat both meat and plant materials. In the monogastric, food is taken into the mouth and mixed with saliva, which starts to break down the starch. The food then goes to the stomach where gastric juices break it down into its component nutrients. Further digestion occurs in the small intestine before nutrients are absorbed into the blood stream and carried to every cell in the body. The watery mass remaining is propelled by means of the muscular movement of the digestive tract into the large intestine which has the important function of absorbing water from it. The large intestine terminates in the anus through which waste products are expelled as feces or manure.

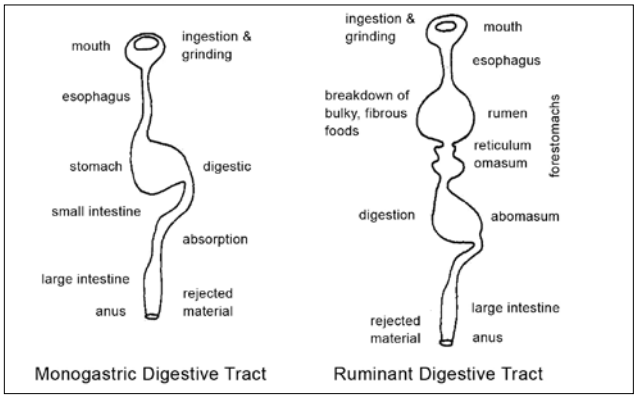

Figure 1. Diagramatic comparison of monogastric and ruminant digestive tracts.

The diet of a **ruminant** animal normally consists mainly of fibrous plant material that is difficult to digest. Unlike monogastric animals, the ruminant swallows its' food after very little chewing. After the animal has finished eating; it then "ruminates" (the ingested material is regurgitated from the rumen back into the mouth as "cud") where additional chewing breaks down the larger pieces into small particles. Saliva, and enzymes are added to the feed particles during the chewing process. After swallowing the feed the second time, it again enters the first of three forestomachs; the rumen – a large 275 litre fermentation vat; where hay, silage, grain, straw and other feedstuffs are fermented by bacteria, protozoa and enzymes.

The breakdown of feed particles is a prolonged process which must occur before nutrients can be digested and then absorbed by the animal. The feed particles are passed from the rumen into the reticulum and omasum prior to entering the true stomach, the abomasum.

The reticulum acts in concert with the rumen and serves to trap foreign materials such as nails, or wire that could cause injury to the animal. Food passes from the rumen into the reticulum and then the omasum. Projections which radiate from the omasum walls further grind the feed particles into smaller pieces. These minuscule particles then pass into the abomasum where digestion proceeds; much like it does in a monogastric.

The microbe populations responsible for digesting the fibre and other components must be maintained at adequate levels to break down newly ingested feeds. If the quality of the feeds are not adequate to sustain microbial populations, it takes longer to digest the fibre and feed intake drops. The animal will not be able to maintain levels of performance which may result in reduced weight gains (or weight loss), reduced milk production and impaired reproductive performance.

Microbes obtain nutrients from the feeds they are breaking down. These nutrients are used to maintain microbial populations. Some species have a 20 minute

life span and nutrients must be available at all times and at adequate levels to keep the cycle functioning properly. The dead microbes are in turn passed through the digestive system and are used as extra energy, high quality protein and other nutrients to help meet the animal's needs.

Microbes (bacteria, protozoa, fungi and other micro-organisms) break down feeds into Volatile Fatty Acids (VFA's) and other components. These are then absorbed through the upper digestive tract and intestines into the blood stream. Bacteria produce B vitamins and can convert urea or ammonia from non-plant sources into protein.

Feeds for beef cattle must supply energy, protein, certain vitamins, macro and trace minerals. Although animals in different stages of production require different amounts of each nutrient; all requirements must be met for the animal to be productive and healthy. If all but one nutrient are supplied in adequate amounts, the limiting nutrient will reduce performance to the level that is supported by the limiting nutrient. All other nutrients that are in "excess" of what can be used will either be stored for future use (such as fat) or excreted by the animal in the urine or feces.

There are two components in the feed. Dry matter and water. The dry matter is what contains the nutrients and all ruminant diets are calculated on a dry matter basis.

Water is essential in the transport of metabolic products and wastes throughout the body and for most chemical reactions. The amount of water required varies with the amount of feed consumed, body size, species, temperature, wind speed and stage of production. If water consumption is limited, feed intake will be reduced as well. Poor quality water quality can interfere with nutrient absorption or increase the requirements of certain nutrients because of the interaction between two or more nutrients.

Energy

Animals require energy for maintenance, growth, work and for the production of milk and wool. Feeds are evaluated in terms of the amount of energy an animal can obtain from them. The digestible energy (DE) is the gross (total) amount of energy in the hay and grain fed an animal less the amount lost in the feces. Energy is usually reported in megacalories (Mcal) per kilogram. (One kilocalorie is equal to 1,000 calories. One megacalorie is equal to 1,000,000 calories).

Amount of DE needed by an animal per day varies according to body size, weight gain, milk production and work. Environmental conditions such as cold or wind or extremely high temperatures can also increase energy requirements. The amount of energy required to maintain an animal for one day without loss of body weight is called the maintenance energy requirement. Most symptoms of slight energy deficiency are not very noticeable: slightly reduced gains, less than maximum milk production and small increases in calving interval. The more severe the energy deficiency, the more noticeable are the symptoms described. Excess energy is stored as fat.

The most common energy source is from the carbohydrates contained in feeds. These are the sugars, starches, cellulose and hemicellulose which have been stored in plant tissues. Chemical reactions and microbial activity in the digestive system release the energy in the feed (originally trapped from the sun by the plant) and are converted into VFA's which the animal can use.

Lipids are another energy source found in plants. They are fats, and fat derivatives. These compounds contain about two and a half times more energy on a pound per pound basis as carbohydrates.

Table 1 provides the digestible energy and protein content of some common feeds.

Table 1. Average Energy and Protein Values of Some Alberta Feeds (Dry Basis)

Feedstuff	Digestible Energy (Mcal/kg)	Digestible Energy (Mcal/lb)	Crude Protein (%)*
Hay			
Alfalfa	2.60	1.18	17.7
Alfalfa-grass	2.46	1.12	14.5
Native	2.13	0.97	9.0
Brome	2.24	1.02	9.9
Greenfeed			
Barley	2.64	1.20	10.0
Oats	2.53	1.15	9.4
Silage			
Barley	2.64	1.20	10.9
Oats	2.53	1.15	10.9
Straw			
Barley	1.98	0.90	4.7
Oats	2.16	0.98	4.5
Wheat	1.80	0.82	3.9
Grains			
Barley	3.65	1.66	12.3
Oats	3.34	1.52	11.6
Wheat	3.87	1.76	15.8

* Since protein is listed in percentage, 1 lb of alfalfa hay will contain 0.177 lb of protein 1 kg of alfalfa hay will contain 0.177 kg protein.

Proteins

Proteins are composed of amino acids, which contain carbohydrates, nitrogen and sometimes sulphur. Ten amino acids are essential to monogastrics, whereas ruminants only need a source of nitrogen, or a poor quality protein, from which the microbes in the rumen can then construct the essential amino acids.

Protein is absolutely essential for growth, reproduction and maintenance in all animals. Maintaining mature animals (non-pregnant) require less protein on a percentage basis compared to animals that are growing, pregnant or lactating. Excess protein in a diet is converted into energy that is used by the animal.

Minerals

The major minerals in cattle nutrition are calcium, phosphorus, sodium, chlorine, magnesium and potassium. They are required at comparatively high levels described as per cent of diet or grams per day.

An essential mineral performs specific functions in the body and must be supplied in the diet, but too much of any mineral may be harmful or even dangerous.

Calcium (Ca) and **phosphorus (P)** are the most abundant minerals present in the animal. They are also the ones most often added to ruminant diets. Both are found in the teeth and bones, but calcium is also found in milk. In addition, Ca is necessary for the clotting of blood and the contraction of muscles. Ca works in conjunction with phosphorus and other nutrients to perform numerous biochemical reactions in the body. Phosphorus is required in all biochemical reactions including the conversion of feed energy into a form that is utilized by the animal.

Animals require a minimum of 1.5 parts Ca for every part of P. The optimal ratio is 2 parts Ca for every part phosphorus. Diets high in legume hay usually require supplemental P only, while diets high in grain often require supplemental Ca. Young animals, including humans, that do not receive adequate amounts of Ca or P may develop rickets, which in cattle show up as arched backs. A deficiency of vitamin D may also contribute to the problem. Older animals fed inadequate amounts of vitamin D develop osteomalacia, the symptoms of which are weak and easily fractured bones. Animals having diets low in Ca and P will show a drop in milk production. A low level of P in the diet may also cause poor reproductive performance in females and lower the availability of vitamin A.

The calcium:phosphorus ratio is very important. It should be more than 1.5:1 but less than 7:1. If possible, add the proper amounts of Ca and P to cattle diets, or feed it free choice. Mineral supplements formulated for free choice feeding can have Ca and P present in 1:1, 2:1 or up to 4:1 ratio.

Research has shown that animals on range need supplemental P. In pastures with limited amounts of legume, additional calcium and phosphorus may be required. Evaluate the mineral on the recommended intake and P and Ca content to establish the grams of P and Ca supplemented by the product.

Sodium and chlorine are found together as sodium chloride (NaCl or common salt) and serve to maintain proper acidity levels in body fluid and pressure in body cells. The hydrochloric acid found in the stomach contains chlorine.

Even though some feeds may contain enough sodium and chlorine to meet the requirements of cattle, supplemental salt that contains cobalt and iodine along with other trace minerals should be available at all times.

Potassium (K), like sodium, serves to maintain proper acidity levels in body fluids and pressure in body cells. It is also required in a number of enzyme reactions in carbohydrate metabolism and protein synthesis. Forages normally contain more than adequate amounts of potassium. Supplemental potassium may be necessary for high-grain feedlot diets.

Magnesium (Mg) is necessary for the utilization of energy in the body and for bone growth. Cattle fed on lush, immature pasture may have a low level of Mg in the blood, which can result in **grass tetany**, a disease characterized by convulsions, twitching of muscles, staggering gait and falling. Magnesium is a co-enzyme that acts as a catalyst in all metabolic functions. This improves the energetic efficiency of the animal. Research conducted in Europe indicates that a minimum level of 0.2% should be maintained in all cattle rations.

Sulphur (S) is a component of body protein, some vitamins, and several hormones. It is involved in protein, fat and carbohydrate metabolism as well as blood clotting and the maintenance of proper body fluid acidity. Most feeds contain adequate amounts of S for cattle. Supplemental S may be necessary when non-protein nitrogen sources are being utilised in high grain feedlot diets. Brassica species such as canola greenfeed or silage, turnips, swede or kale can contain high levels of sulfur. Total diet sulfur levels above 0.4% can result in animals coming down with polio.

Trace minerals

Feeding trace minerals is not a simple matter. They are required only in very small amounts. Some minerals fed in excess amounts may cause a deficiency in others;

a slight deficiency or excess may cause a decrease in performance that is hard to pinpoint. Even though the level in the diet appears adequate, an animal may occasionally respond to an increased supply of a particular mineral because other dietary factors may have decreased its availability.

Feed test results from Alberta indicate that most, if not all trace minerals found in Alberta feedstuffs are 50 to 90% deficient compared to animal requirements (see Table 2). There are some areas of the province that can provide excess amounts of certain trace minerals. The only way to determine what supplementation is required is to have a trace mineral analysis completed on submitted samples. It is unusual for trace mineral levels to change significantly from year to year.

Table 2: Percent of Feeds containing less than the recommended amounts of trace minerals*

	Copper	Manganese	Zinc	Selenium
	Less than 10 ppm	Less than 50 ppm	Less than 25 ppm	Less than 200 ppb
Alfalfa	88.5	97.3	87.4	43.7
Grass	93.6	96.7	42.5	69.0
Alfalfa – grass	96.9	98.7	76.7	45.0
Oat forage	95.8	95.7	58.3	67.2
Timothy	88.9	88.9	48.0	69.3
Grains	93.6	87.2	89.0	84.3

* Source: Average Analysis of Alberta Feeds, 1976 – 1986 (AgDex 100/81-6)

Iron (Fe) is an essential part of hemoglobin, a compound that carries oxygen in the blood. A deficiency of Fe may cause anemia and reduce growth. Virtually all feeds in Alberta contain enough iron for cattle, according to analyses done at feed testing laboratories.

Zinc (Zn) affects growth rate, skin conditions, reproduction, skeletal development and the utilization of protein, carbohydrates and fats in the body. A zinc deficiency can cause mange-like skin condition called paraketosis.

Recommended dietary allowance (RDA) is 50 parts per million (ppm), while average concentration in Alberta feeds is 30 ppm. If a supplement is required, it could be supplied in trace mineralized salt, mineral or protein supplement.

A **Copper (Cu)** deficiency can result in anemia, depigmentation in hair, infertility, scouring, and cardiac failure. Feed testing laboratories find that 80% to 95% of submitted samples contain less than the estimated RDA of 10 ppm. Although the symptoms of copper deficiency are rarely evident, improved growth and performance is often seen after Cu supplementation.

Manganese (Mn) is essential for the utilization of carbohydrates. Symptoms include retarded bone growth and reproductive failure. The RDA for Mn is 50 ppm. Manganese content in feeds is extremely variable based on the type of feed; grain compared to hay, along with the soil type that the feeds are grown in.

Cobalt (Co) is necessary for the microorganisms in the rumen to synthesize vitamin B12.

Iodine (I) is needed in trace amounts by the thyroid gland, which influences the rate of metabolism in the body. A deficiency causes goitre. As the Prairie Provinces are deficient in both cobalt and iodine, a supplemental source must be fed at all times. These nutrients can be supplemented by a salt, mineral, or pelleted supplement.

Molybdenum (Mo) forms an essential part of some enzymes. It may also have a stimulating effect on fibre-digesting microorganisms in the rumen.

Excessive quantities of Mo interfere with the utilization of Cu and may cause a Cu deficiency, symptoms of which include severe scours and loss of body weight. If the diet is high in sulphur, the problem is more severe. Mo-induced Cu deficiency is not common in Alberta.

Selenium (Se) is deficient in some regions of the province and surplus in others. “Alkali disease” or “blind staggers” occurs when cattle eat feed containing toxic or excess amounts of Se (10 ppm) over a long period of time. Chronic toxicity results in loss of weight, dullness, sloughing of hooves and lameness. Toxicity is rare but occasionally found where cattle on overgrazed pasture are forced to eat a milk-vetch that accumulates selenium. The best cure is to remove the animal from the pasture. Selenium deficiency may result in “white muscle disease” in calves. A vitamin E deficiency increases the amount of selenium required to prevent this form of nutritional muscular dystrophy. Cows on Se deficient diets may have lower fertility and an increased incidence of retained placentas. The RDA for Se is 200 parts per billion. Se deficiency is quite common in west-central and northern Alberta. Se can be added to salt or mineral mixes, or injected. Selenium supplementation is limited to 3 mg per day according to the Canadian Feeds Act. There have been instances where this level of supplementation is not adequate to meet requirements. Work with a nutritionist and veterinarian if a selenium deficiency is suspected at these supplemented levels.

Chromium (Cr), **tin (Sn)** and **nickel (NI)** appear to be present in sufficient quantities to meet the requirements of most farm animals.

Fluorine (Fl) is essential for proper bone development but will cause toxicity if fed at too high a rate. Too much Fl causes abnormal bone growth, mottling and degeneration of teeth, and delayed growth and reproduction. To avoid

excessive consumption of Fl, be sure any rock phosphate fed is defluorinated.

Trace minerals can be effectively supplemented in the diets of cattle by using the proper trace mineralised salt.

Vitamins

These organic compounds are required in minute amounts by the body. They are essential to metabolism, and some must be supplied in the feed of ruminants.

Growing green forages typically have sufficient amounts of vitamins A, and E. After forages are cut for hay, the vitamin precursors start to oxidize and 90 days after cutting, up to 80% of the vitamin precursors can be destroyed due to oxidation. The same vitamin losses occurs in forage that is left for dormant grazing. The longer the forage is in storage, the greater the vitamin loss. Supplementation should be provided for stored hay and dormant grazing situations. All vitamin precursors are destroyed during the silage fermentation process.

Vitamin A is the most important vitamin in cattle nutrition. It is necessary for bone development, sight, and maintenance of healthy epithelial tissues (i.e. lining of digestive and reproductive tracts). A deficiency can cause an increased susceptibility to disease, night blindness and reproductive failure.

Vitamin A may be supplied by green forages that contain carotenoids. Carotenoids are broken down in the body to vitamin A. Thus forages are not analysed for vitamin A but carotenoids, which are measured in milligrams per kilogram or pound: mg/kg or mg/Ib.

Cattle can convert 1 mg of carotene to 400 international units (IU) of vitamin A.

Animals on green grass can store vitamin A in the liver and draw on it for 2-3 months.

The average carotene value of alfalfa hay is 24.6 mg/lb, but the range of vitamin A equivalent values supplied by alfalfa would be expected to vary from 120 IU to 35,400 IU per pound. Although Alberta forages may contain sufficient carotene to meet all requirements, it is good insurance to feed vitamin A. Vitamin A is inexpensive. The dry granular product is the most economical source.

Animals may also be injected with a 2 to 3 month supply of vitamin A and D. Animals should be injected twice during the winter if this is the method of vitamin supplementation used.

Water-soluble vitamin A is sometimes added to the water; however, it is difficult to tell whether the animal is getting its daily or monthly quota this way. Calculate the amount of Vitamin A supplied by a mineral or supplement by multiplying the vitamin concentration in the product by the expected intake. Compare the amount of vitamin supplied to the requirement and make adjustments to the ration if necessary.

Vitamin D is called the sunshine vitamin because ultraviolet light acting on a compound on animal skin changes that compound into vitamin D. Vitamin D is found in sun-cured forages. Animals kept outdoors or fed sun-cured hay do not usually suffer a deficiency, whereas animals kept indoors and fed silage may do so. Vitamin D is generally included in minerals, supplements and vitamin products at 10% of the Vitamin A concentration. In most situations, this level of supplementation is adequate.

Vitamin D is involved in the uptake to Ca and P, so that a vitamin D deficiency resembles a Ca and P deficiency: rickets in the young animals, weak bones in older animals, and a decreased growth rate.

Vitamin E is stored in the liver but amounts are only sufficient to meet requirements for a few days. Vitamin E is essential for the integrity and optimum function of reproductive, muscular, circulatory, nervous, and immune systems. Vitamin E acts as an anti-oxidant which helps keep lipid membranes intact. Vitamin E works in conjunction with selenium. If one of the two nutrients is deficient, it reduces the metabolic efficiency of the other. Recent research on vitamin E requirements has shown requirements to be much higher than previously reported.

The combination of selenium and vitamins A and E can help reduce the incidence of retained placentas. This combination is also required for developing the antibodies found in colostrum.

Vitamin A and D injectable products only have sufficient amounts of Vitamin E to prevent oxidation of the other vitamins. A separate injectable product to supply Vitamin E is required if this method of supplementation is used.

Vitamin E is one of the most expensive ingredients in mineral products and supplements. Concentrations of Vitamin E in some mineral and supplements products are not sufficient to meet recommended levels from current research. Commercial products are available that contain only vitamin E.

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