Feeding horses

FEEDING HORSES

Feed costs are nearly half the cost of owning a horse. However, a sound scientific feeding program is the foundation of your horse's wellness program. The knowledge about horse nutrition has increased significantly over the past 40 years. This bulletin incorporates information from equine nutritional studies conducted in Western Canada, as well as global data that were used to develop the *Nutrient Requirements of Horses, 6th edition* (National Research Council, 2007) and incorporates data relevant to Saskatchewan as available.

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DIGESTION

Horses are herbivores. As this name implies, the horse's digestive system was designed to process forages (grass or hay). Grain was not a component of the feral or wild horse diet. The horse's natural behaviour is to graze throughout the day, consuming small amounts of feed with each bite. The digestive tract (also called the gut) is designed to accommodate this method of feeding.

Digestion is the process by which feed is broken down physically, by chewing, and biochemically, by enzymes, to simpler molecules or compounds that can be absorbed across the gut wall into the blood stream for use by the cells of the horse's body. This activity occurs in the digestive tract, which is about 33 m (100 ft) long in the average light horse.

The journey of feed through the digestive tract of the horse begins in the mouth where large pieces of grass, hay or grain are chewed into smaller pieces. At this stage, impediments to chewing are immature teeth (foals) or missing and misaligned teeth (old horses). Horses do not have a full complement of teeth until they are about four years old. This makes it more difficult for foals to chew coarse, fibrous hays and unprocessed grains compared to mature horses. For this reason, leafy hays and ground grains are recommended for foals. Old horses are often provided with "senior feeds," which are processed for easier chewing and digestion.

Abrasions or sores in the mouth caused by long teeth or feed awns (e.g. wild barley) make eating uncomfortable. Signs of mouth discomfort include quidding, excessive salivation, foul smell in the mouth and facial swelling. Quidding is the process of forming a ball of feed then spitting it out. This is often seen in horses with dental problems, but can occur in some horses with normal mouths. Dental problems should be addressed by equine dental veterinarians. Dental evaluation should begin early in a horse's life, but floating a horse's teeth should be performed only when necessary. Diet can determine how often a horse will need dental work. Grass and hay contain silica, which can wear down the surface of the teeth, but pelleted feeds generally do not. Over-ambitious tooth floating can smooth and remove the irregular surface of the teeth, which is needed to grind feed.

Feed chewed and moistened by saliva is swallowed then travels down the esophagus into the stomach. Saliva is not only needed to moisten feed before swallowing, but is also an important buffer of stomach acid produced by the horse. Saliva is only produced when the horse is chewing feed. More saliva is produced by horses fed hay than horses fed grain or pelleted feed because chewing times are at least four times longer on diets of forage.

Boluses of feed can sometimes be seen along the left side of the horse's neck when it swallows. The muscle in the esophagus only moves in one direction – from the mouth toward the stomach - and this is the reason why horses do not vomit. Feed that is poorly chewed or not moistened with saliva can

lodge in the esophagus, leading to a condition called choke. Certain feeds and greedy-eating can predispose to choke.

The stomach volume of a mature 500 kg (1,100 lb) horse is estimated at 8 to 9 L (2 gal). Foals have a very small stomach capacity. If necessary to tube-feed a foal that is not sucking, only small amounts of milk or fluid (250 to 350 ml) should be administered at one time.

Horses produce acid continuously, regardless of whether they are fed or not, and so are prone to gastric ulcers. The stomach has two types of lining: non-glandular (squamous) and glandular. The non-glandular portion is subject to ulcers from the acid produced by the glandular portion, except for protection by saliva that is produced during eating, and by feeds such as alfalfa hay, which have a high buffering capacity. For this reason, having hay available is important in preventing gastric ulcers because it keeps the horse chewing and producing saliva.

Gastric ulcers are not uncommon in horses and have been linked to intensity of training and some management practices. Horses kept confined in box-stalls, fed diets high in grain or fed straw as the sole forage, and under high levels of training are predisposed to ulcers. Management practices that can help prevent or lower the incidence of gastric ulcers include providing constant access to forage (hay or pasture), reducing the amount of grain in the diet, and keeping a consistent feeding routine. High grain diets have been reported to cause cribbing and gastric ulcers in weaned foals and yearlings.

Chewed, acidified feed particles move from the stomach into the small intestine. The intestine in a mature light horse is about 21.5 m (70 ft) long and has a volume of about 70 L (15.5 gal). The small intestine is where the semi-digested feed material is further broken down by enzymes secreted by the intestine, liver and pancreas. Starch in grains is converted to glucose; protein to amino acids, and fats to fatty acids. Most minerals, except phosphorus, are absorbed here. About 65 to 70 per cent of protein in a grain-based diet is absorbed in the small intestine. Only one-third of hay protein is absorbed in the small intestine; the remainder is digested in the hindgut. Internal parasites such as strongyles mainly affect digestion and absorption of nutrients by the small intestine.

Only 60 to 90 minutes after the feed has entered the small intestine, it passes into the cecum, which is the start of the section of the intestinal tract known as the hindgut. The digesta from the cecum then flows into the large colon, the small colon and the rectum, and, finally, fecal pellets pass through the anus into the outside environment. The hindgut is populated by large populations of bacteria and protozoa, collectively called microflora, that produce unique enzymes able to break down coarse fibrous material such as cellulose and hemicelluloses in forage. Without these microbes, horses could not digest forages. Horses have fewer bacteria and protozoa than cattle so are less efficient at digesting mature hays than cattle.

The cecum holds about 15 L (3 to 3.5 gal) of digesta. The cecum can enlarge or reduce in size in response to diet. A horse fed a high grain diet has a smaller cecum than those fed indigestible feeds such as mature hay or straw. Pot-belly in weaned foals is often attributed to parasites, but can equally develop in weaned foals due to the distension of the hindgut after transitioning from a diet of dam's milk and grass to a diet of hay, which is less digestible. Passage by digesta through the hindgut takes about one to three days. This relatively slow transit allows the microbes to do their work.

The large colon holds up to 90 L (20 gal) of digesta. The digesta is a reservoir of fluid during periods when water is not readily available. A significant amount of water is reabsorbed from the digesta as it passes through the large colon. From the large colon, the digesta passes into the small colon where more water is reabsorbed and the digesta is formed into fecal balls. The whole journey of feed from lips to anus typically takes 65 to 72 hours in the horse. This is about 24 hours less than it takes a cow to digest the same type of feed.

How Much Can a Horse Eat?

Dry matter is the plant tissue remaining after all of the moisture has been removed. As fed (AF) hays and grains usually have about 10 per cent moisture content, so in tables the nutrient data may be reported as "as fed" or 90 per cent dry matter (DM) basis. Forages with greater than 15 per cent moisture are more prone to mould. Silages can have up to 50 per cent moisture content. One kilogram of feed that is 50 per cent moisture provides ½ kg of dry matter and ½ kg of fluid. Pastures can range from 40 (fall) to 80 per cent (spring) moisture content. The more moisture in a feed, the more of that feed the horse has to eat to meet its dry matter and nutrient needs.

Feed intakes by horses are often expressed as percentage of body weight (BW). For example, a horse eating 2.5 per cent BW of brome hay is eating 2.5 kg for each 100 kg of its body weight. To convert this amount to a daily intake for your horse, multiply the predicted intake times the horse's body weight. A 500 kg horse in this example will eat 2.5 kg X (500 ÷ 100) or 2.5 X 5 = 12.5 kg brome hay.

Mature horses fed hay-only diets eat about 2.2 – 2.5 kg/100 kg BW in hay. Horses fed hay free-choice plus 1 to 2 kg grain consume slightly less hay, usually about 2 to 2.2 kg/100 kg BW. Growing horses (weanlings, yearlings) have been reported to eat up to three per cent of body weight in feed dry matter.

Horses eat to meet their energy needs, so the type of feed, its energy content and the palatability of the feed will affect the total amount of feed the horse will eat. Horses eat less of an energy-rich diet to meet their energy needs. For example, horses will need to eat less grain than hay to get the same number of calories because grain is an energy-dense feed.

Free-choice feeding is the term used to describe the feeding method whereby feed is available at all times. Typically, hay intake is provided free-choice. Grain should never be fed free-choice but always in pre-determined, measured amounts.

NUTRIENTS

Energy

The energy contained in a feed is its calorie content. A calorie (properly called a kilocalorie) is the amount of heat needed to raise the temperature of one kilogram of water one degree Centigrade. The energy requirement or, more simply, the calories needed by a horse or human depends on its age, weight and activity. For example, a 55 kg (120 lb) human needs roughly 1,500 calories to maintain body weight whereas a 545 kg (1,200 lb) gelding needs ten times this amount or about 15,000 calories. The large numbers of calories needed by horses is a cumbersome notation, so in horse nutrition, calories are usually converted to megacalories whose notation is Mcal. One megacalorie is equal to 1,000 (kilo) calories. In the example above, the human's energy needs would be recorded as 1.5 Mcal and the horse's energy needs as 15 Mcal.

There are various ways to describe the energy content of feed. Gross energy is the total energy in a feed determined by chemical methods in a bomb calorimetre. However, not all of the gross or total energy of a feed can be digested by the horse. The digestible energy (DE) is the amount of the feed's total energy content that is actually utilized or absorbed. Because horses are fed large amounts of feed compared to humans, the DE content of a horse's feed is expressed in Mcal per kg of feed. For example, rather than cite the DE content of oats as 3,000 calories/kg the notation used in feed analysis reports would be 3 Mcal/kg. Rarely, energy content in feed analysis reports may be listed as TDN (Total Digestible Nutrients). TDN is measured as a percentage and can be converted to DE values (in Mcal/kg) by multiplying the percentage TDN value by 0.044. For example hay with a 50 per cent TDN has a DE content of 2.2 Mcal/kg hay.

Carbohydrates, fats and protein in feed can be converted to energy when digested and metabolized by the horse. Carbohydrates supply about 80 to 90 per cent of the dietary energy required by the horse. Feed carbohydrates include the sugars, starch, cellulose and other polymers of sugar and other molecules that make up the plant cell walls. Glucose molecules are the basic carbohydrate units of starch and cellulose. However, the linkage of the glucose molecules in starch and cellulose differ. These

linkages determine how and where in the gut these complex molecules are digested. Enzymes produced in saliva and the small intestine readily digest the glucose that comprises the starch molecule. But, the glucose units that make up cellulose can only be digested by enzymes produced by the bacteria and protozoa (microflora) in the horse's hindgut. Microflora in the cecum and colon produce enzymes that break down cellulose to volatile fatty acids instead of glucose. Volatile fatty acids are absorbed and converted in the liver to glucose and other energy storage molecules. The conversion efficiency of volatile fatty acids produced from hay digestion to energy is lower than obtained from digestion of grain to glucose. This is the reason that grain is often added to the diets of horses with a high energy demand, such as race horses.

Starch, the main energy component of grain (60 to 80 per cent), is easily digested and accounts for the high calorie content of grains (see Table 1). Feeding excessive amounts of grain to horses unadapted to high grain intakes can cause founder (laminitis). This occurs when too much starch enters the small intestine causing some grain spill-over to occur into the hindgut. The hindgut is populated by two types of bacteria; some digest cellulose in forage and some digest starch, fructans and sugars present in grains and some types of forage. Spill-over of large amounts of grain starch causes over-growth of the bacteria that digest starch, which results in the rapid fermentation of the starch to lactic acid, resulting in acidosis of the hindgut and the kill-off of the normal bacteria that digest cellulose. The die-off of these normal bacteria leads to production of endotoxin, exotoxin and vasoactive amines, which can cause colic and laminitis (founder). Whole grain, especially whole barley, wheat and corn, is more likely to spill over into the hindgut and lead to this scenario of colic and founder.

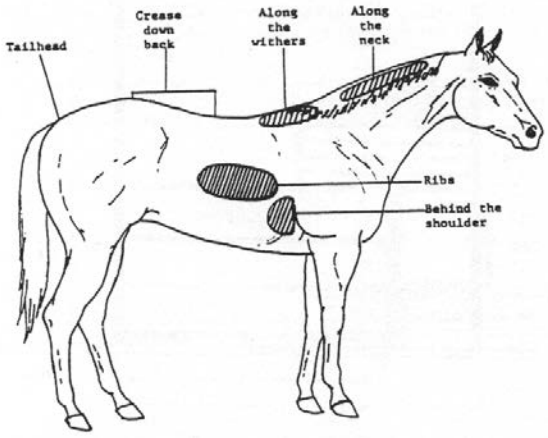
The main structural units of forage or plant cells are structural carbohydrates, which include cellulose, hemicellulose and lignin. The plant cell can contain varying amounts of non-structural carbohydrates (NSC) including simple sugars (glucose, fructose), sucrose and storage carbohydrates (starch and fructans), depending on plant maturity. Structural carbohydrates and fructans can only be digested by enzymes produced by microflora in the hindgut. Structural carbohydrates are digested to volatile fatty acids and fructans, to fructose.

Structural carbohydrates increase as the forage matures, which makes the hay harder to digest. Table 1 shows the difference in digestibility of alfalfa hay as it matures.

Table 1. Effect of maturity of alfalfa hay on its digestibility by horses

Stage of forage maturity	Digestibility (%)
Pre-bud	83
Bud	72
10% Bloom	66
100% Bloom	59

The best way to assess whether the horse has an adequate intake of energy or calories is to evaluate its body condition (see Table 2). Horses that are fat or obese are eating too much feed or high-energy feeds such as grain, which provides calories in excess of requirements, leading to weight gain. A horse that is thin or losing weight is energy deficient. The most likely causes are poor quality, indigestible feed or a lack of feed. Poor teeth or heavy parasite loads can effectively lead to poor digestibility of the allotted feed, even if it is provided in adequate amounts. Hierarchies exist in group-fed horses, so dominant horses will sometimes prevent subordinates from eating sufficient feed. Diseases that cause inappetence can result in weight loss.



Equine metabolic syndrome (EMS) is a condition that may occur in some obese horses. Horses with this condition have prolonged elevations in blood insulin and glucose concentrations, which makes them prone to laminitis (founder). Characteristics of EMS horses are: generalized obesity (body condition score of seven or more) or regional obesity (neck crest fat accumulation), a high resting insulin, an abnormal response to glucose challenge, current laminitis, or founder lines indicating chronic founder. Managing obesity in horses is difficult because it requires regulated feeding and exercise of the horse. To reduce body weight by one body condition score, the horse must lose about 20 kg (44 lb) of body weight (in a 500 kg (1,100 lb) horse). To lose 1 kg (2.2 lb) of body weight requires the expenditure of 20 Mcal of energy. Rates of weight loss of 0.5 per cent of body weight per week are realistic goals, so to lose one body condition score may take up to eight weeks of dietary control and exercise.

Table2 Description of the Body Condition Score System

Number	Score	Description
1	POOR	Animal extremely emaciated. Spinous processes, ribs, tailhead, and hooks and pins projecting prominently. Bone structure of withers, shoulders and neck easily noticeable. No fatty tissues can be felt.
2	VERY THIN	Animal emaciated. Slight fat covering over base of spinous processes, transverse processes of lumbar vertebrae feel rounded. Spinous processes, ribs, tailhead, and hooks and pins prominent. Withers, shoulders and neck structures faintly discernible.
3	THIN	Fat built up about halfway on spinous processes; transverse processes cannot be felt. Slight fat over ribs. Spinous processes and ribs easily discernible. Tailhead prominent, but individual vertebrae cannot be visually identified. Hook bones appear rounded, but easily discernible. Pin bones not distinguishable. Withers, shoulders and neck accentuated.
4	MODERATELY THIN	Negative crease along back. Faint outline of ribs discernible. Tailhead prominence depends on conformation, fat can be felt around it. Hook bones not discernible. Withers, shoulders and neck not obviously thin.
5	MODERATE	Back level. Ribs cannot be visually distinguished but can be easily felt. Fat around tailhead beginning to feel spongy. Withers appear rounded over spinous processes. Shoulders and neck blend smoothly into body.
6	MODERATELY TO FLESHY	May have slight crease down back. Fat over ribs feels spongy. Fat around tailhead feels soft. Fat beginning to be deposited along the sides of the withers, behind the shoulders and along the sides of the neck.
7	FLESHY	May have crease down back. Individual ribs can be felt, but noticeable fat fill between ribs. Fat around tailhead is soft. Fat deposited along withers, behind shoulders and along the neck.
8	FAT	Crease down back. Difficult to feel ribs. Fat around tailhead very soft. Areas along withers filled with fat and behind shoulder filled in flush. Noticeable thickening of neck. Fat deposited along inner buttocks.
9	EXTREMELY FAT	Obvious crease down back. Patchy fat over ribs. Bulging fat around tailhead, along withers, behind shoulders and along neck. Fat along inner buttocks may rub together. Flank filled in flush.

From Henneke, D.R., G.D. Potter, J.L. Kreider, and B.F. Yeates. 1983. Equine Veterinary Journal 15: 371-372

Protein

Proteins are the basic structural unit of most animal tissues, except body fat. Proteins in horses are based on 21 known amino acids. All amino acids, therefore all proteins, contain nitrogen.

To synthesize protein, amino acids must be present in the correct amounts. Amino acids are classified as dispensable (non-essential) or indispensable (essential). Dispensable amino acids can be synthesized by the horse's body. Indispensable amino acids have no metabolic pathway for synthesis, or not enough is produced to meet the horse's requirements. Indispensable amino acids must be provided in the diet. Ten amino acids are considered indispensable (essential) but only one amino acid, lysine, has been proven to be necessary for protein synthesis in growing horses. Threonine and methionine may be limiting, but generally are available in sufficient amounts in typical Prairie horse feeds.

Protein can also be described as high quality and low quality. High quality proteins have a good distribution of essential amino acids, which do not limit production. Soybean meal, canola meal and skimmed milk powder are considered high quality protein supplements because they have a high lysine content relative to their protein content. Linseed meal and corn grain are low in lysine, so are considered to be low quality proteins.

Growing horses require 0.6 to 0.7 per cent lysine in the total diet. Saskatchewan legume and legume-mixed hays and grains are generally high in lysine content and meet the needs of almost all classes of horses except, perhaps, growing foals. When a diet of grain mix (processed feeds) containing soybean meal is fed with good quality legume-mixed hay to growing horses, lysine deficiency should not be a problem.

Crude protein is measured in a feed either chemically, by determining nitrogen content, or through extrapolation using infrared analysis. Both analytical techniques only give the per cent of protein in the diet. This number does not indicate how much of the protein can be digested by the horse. Hay protein digestibility is affected by the hay's maturity. Overmature hay has a low protein content and the protein in the hay is also poorly digested.

Protein requirements depend on the horse's age and function. Young growing horses need more protein than adults because their protein-containing muscles and organs are developing at a rapid rate. Mature horses, even those in vigorous training, have only a modest protein turnover. A mare in early pregnancy (less than five months pregnant) requires very little more dietary protein than she did when she was not pregnant, because the fetus is small at this stage and creates no huge demand on the mare. After the fifth month of pregnancy, protein demands increase as the fetus becomes larger. Recommendations in the current National Research Council (NRC) (2007) are to increase the protein intake by about three to five pre cent for each month of pregnancy after the fifth month. At five

months of pregnancy, a 600-kg mare requires 822 grams of protein compared to 1,072 grams at term or 11 months of gestation. Protein deficiency is not common in pregnant mares fed typical diets.

Lactating mares require more dietary protein (and energy) than pregnant mares. Mares producing milk require twice the protein they needed at three months of pregnancy and 70 per cent more than needed just before foaling. Mares that are lactating lose about 250 g of protein in milk daily, which can only be met by feeding the mare a diet containing a higher protein content.

Table 3. Suggested Dietary Protein Content for Various Classes of Horses (As fed Basis)

Class of Horse	% Dietary Crude Protein
Suckling foal (creep feed)	16
Weaned foal	13 - 16
Yearling – 2 yr old	10 -11
Mature idle	7
Mature, Average Work	8.5
Early Pregnancy (0 -5 months)	7
Late pregnancy	10
Lactating mare	12 – 16

Many idle horses are given more protein than they need. This is wasteful, because horses only use as much protein as they require. Extra protein is broken down to ammonia, glucose or fat. The ammonia is excreted in urine. Overfeeding of protein contributes to the distinctive smell of ammonia and urea in poorly ventilated stables. Feeding more protein than required increases urine output. However, it is better to feed more protein than not enough.

Young horses under a year of age are the likeliest class of horse to experience protein deficiency. Poor weight gains and stunted growth are the most common signs of insufficient protein intake by foals and yearlings. Mature horses may have slow weight gains or may lose weight. Mature horses must be severely underfed for this to occur.

Fats

Fats added to horse diets have included vegetable oils such as canola, corn, soybean, flaxseed (linseed) or rice bran oils, and occasionally lard or rendered tallow. Stabilized rice bran is a by-product of the rice industry and contains a high fat (20 per cent) content; it is sometimes used for horses that cannot be fed grain diets. The only nutritional benefits of fats are the provision of calories and for absorption of fat-soluble vitamins (A, D, E, and K). Fat provides 9 kcal/g or about 2.25 times more calories per gram than carbohydrates or protein, so fat is useful in the diets of mature, heavily worked horses, such as endurance horses, as a supply of energy. Fats are also added to diets of horses that cannot be fed grain, such as horses with a genetic muscle disease called polysaccharide storage myopathy (PSSM). It is also considered a “safer” source of energy compared to grain because it is less likely to cause founder. A typical hay-grain diet has less than three per cent fat. Diets for endurance horses can contain up to 10 per cent fat. The upper limit of added fat should not exceed 3.5 g/kg dry matter diet. For example, the maximum amount of oil to add to a diet of a 600 kg horse is about 500 ml (two cups).

Fats and oils added to horse diets are mostly derived from seed oils such as canola oil, soybean oil or linseed oil, but some commercial products use stabilized rice bran as the fat source

Some commercial pellets add fat to control dust. Essential fatty acids found in vegetable oils may improve hair coat. The usual feeding rate to improve the hair coat is –two to four tablespoons (30 to 60 ml) oil top-dressed on grain. Caution should be taken with use of unsaturated fat (vegetable) oils in hot weather. Unless refrigerated, unsaturated fats or oils are prone to rancidity in hot weather, which may then increase the horse's Vitamin E requirements.

Minerals

There are two classes of minerals: macro- minerals (major) and micro-minerals (trace minerals). The terms, mineral and element, are sometimes used interchangeably. Macro- and micro- refer to the amount of mineral in the diet. Macro- implies the mineral is usually present in gram amounts. Typically, on a feed label a macro-mineral will be listed as percentage of mineral. Micro- denotes presence of a mineral in microgram amounts. On a feed label, trace minerals will be listed as present in ppm (parts per million) or mg/kg amounts.

Major or Macrominerals

The main major minerals needed by horses are potassium, magnesium, sodium, chloride, calcium and phosphorus. The relative importance of macrominerals in equine ration formulation in the Prairies is: important (calcium, phosphorus and sodium); somewhat important (potassium, magnesium, chloride); and rarely problematic (sulphur). Similarly, the relative importance of microminerals is: important (iodine, copper, zinc and selenium); and rarely problematic (iron and manganese).

<u>Potassium and Magnesium</u>

The horse's potassium requirement is about 0.4 to 0.5 per cent of the diet. Forages are abundant in this mineral. Saskatchewan grass and legume hays contain one to three per cent potassium; grains contain about 0.5 per cent potassium. If the diet contains 70 per cent forage, potassium deficiency should not be a problem. Excess of potassium is rarely a problem, except for horses that carry the gene for hyperkalemic periodic paralysis. A high intake of potassium will precipitate seizure-like episodes.

Horses need about 0.1 per cent magnesium in the diet. Hays and grains contain 0.15 to 0.4 per cent magnesium. Straw is low in magnesium. Deficiency is not likely to occur on most diets, but, very rarely, magnesium deficiency has occurred in horses grazed on early spring pastures. Signs of magnesium deficiency include staggering, nervousness and convulsions, but are uncommon in horses.

Sodium and Chloride

Normal nerve and muscle function requires sodium and chloride. Some sodium is stored in the horse's body, but cannot be mobilized if the diet is deficient. As a result, sodium supplies must be replenished daily. Sodium balance is regulated by a "sodium centre" in the brain. As a result, sodium is one of the few nutrients for which horses have a "true appetite" (i.e., a natural drive to eat salt). Horses will travel long distances to obtain salt if their diet is sodium deficient. Sodium is generally deficient in Prairie feeds, except those grown in some alkali areas where sodium content can be as high as 0.2 per cent sodium. Chloride is generally sufficient in Prairie feeds.

Salt is composed of sodium and chloride. Based on molecular weight, sodium is about 40 per cent of the weight of salt. The salt requirement in a light horse's diet is about 20 to 50 g per day (0.7 to 2 ounces). This amount provides about 8 to 20 g of sodium daily. Salt intake varies considerably among individual horses. Some horses eat as little as 10 gm while others can consume 100 g or more of salt per day. Salt intake increases during hot weather, with vigorous exercise (losses in sweat) and during lactation. Lactating mares can eat twice as much as non-pregnant mares.

A deficiency of sodium or salt in horses will result in a rough, dry hair coat, a tendency to lick dirt and metal objects, and a reduced appetite or water intake. The maximum tolerable concentration for salt is six per cent. Typically, horses do not voluntarily consume excessive amounts of salt

Common salt is the normal source of sodium and chloride. Either block or loose salt can be provided. Loose salt may be consumed in greater amounts than block salt. Various types of salt blocks are available. Iodized salt (red) is most common. Cobalt-iodized (blue) salt is also used; cobalt is not detrimental or beneficial to horses. Trace mineral salt blocks (brown-red) contain iron, zinc, copper, manganese, cobalt, selenium and iodine plus salt. Trace mineral fortified salt can be used to help offset the low trace mineral content of Prairie feeds (see below), but should not be relied on as the sole method to combat dietary trace mineral deficiencies.

Loose salt can be top-dressed on grain for horses housed indoors or incorporated into commercial grain mixtures or pelleted feeds. Salt feeders should be at a height suitable for the horse. Two-day-old foals will lick salt, so for mares and foals, mineral and salt feeders should be at the foal's height. Salt can be provided outdoors in mineral feeders placed in an area where horses congregate. On large pastures, the mineral feeder can be placed near the water source. Salt should be constantly available so the horse has the option of consuming it or not. Check the salt

supply every few days to make sure it is present. New supplies of loose salt should be placed out every four to five days. Check that the salt has not been washed away after a rain or snowfall.

Although most Prairie hays and grains are low in sodium, some feeds grown in alkali areas can contain up to 0.2 per cent sodium. Water in some Prairie regions can contain up to 800 mg sodium/L water (3.6 g sodium/gal water). At normal water intakes when water sodium exceeds 355 mg/L, the horse's requirement for sodium will be met by water alone. Similarly, horses grazing on alkali pastures or fed hays containing high sodium may refuse to eat salt. This does not pose a sodium problem, but may lead to iodine deficiency (see below) because the usual method of supplementing iodine is by feeding iodized salt. Alternate sources of iodine can be provided in non-salt mineral mixes.

Calcium and Phosphorus

Calcium and phosphorus are needed for sound bone and for normal muscle function. Rapid bone development begins when the fetal foal is about five months old. After it is born, the foal's bone growth is most rapid from birth to six months of age, gradually slowing up to two years of age. Bone growth is nearly finished by the time a horse is three years old. Thus, dietary calcium and phosphorus requirements vary with the age and function of the horse (Table 4). Young horses undergoing rapid bone growth require high amounts of calcium and phosphorus. Mares in early pregnancy need no more calcium and phosphorus than idle, mature horses. However, after the fifth month of pregnancy, fetal bone growth increases dramatically, which increases the mare's dietary calcium and phosphorus requirement Milk contains a substantial amount of calcium and phosphorus, so lactating mares need more calcium and phosphorus in their diets to compensate for calcium and phosphorus lost through milk.

Table 4. Dietary Calcium (Ca) and Phosphorus (P) Content Suggested for Horses (As Fed)

Class of Horse	% Ca	% P
Suckling (creep feed)	0.80	0.55
Weanling (4-6 months)	0.60	0.45
Yearling to 2 year old	0.40	0.30
Mature, idle	0.27	0.18
Mature, average work	0.27	0.18
Mares, late pregnancy	0.45	0.30
Mares, lactating	0.45	0.30

Horses digest calcium and phosphorus differently than other livestock. Calcium is absorbed in the small intestine, whereas phosphorus is absorbed farther down the gut in the large intestine. Horses absorb 50 to 85 per cent of dietary calcium. Less calcium is absorbed if the diet is high in phosphorus (high grain diets), is deficient in vitamin D or is high in oxalate.

A horse's diet must always provide more calcium than phosphorus and must always provide a sufficient total amount of calcium and phosphorus. The calcium to phosphorus (Ca:P) ratio is the amount of calcium in the diet divided by amount of phosphorus in the diet. A rule of thumb is that the

diet should provide about twice as much calcium as phosphorus, or a Ca:P ratio of 2:1. The ratio is only a rough estimate of adequacy. The Ca:P ratio does not confirm that there is enough total calcium and phosphorus in the diet. For example, a diet with 0.1 per cent calcium and 0.05 per cent phosphorus has a 2:1 Ca:P ratio, but the calcium and phosphorus contents are not high enough to meet the absolute needs of any horse.

The target Ca:P ratio in a foal diet is about 2:1, but can range from 1.5:1 to 3:1. The Ca:P ratio is of more concern in diets of young horses because foals are forming new bone, which contains calcium and phosphorus in roughly a 2:1 ratio. It is not necessary, and is impractical, to try to balance a mature horse's diet to exactly a 2:1 Ca: P ratio. For mature horses, Ca:P ratios of 1:1 to 6:1 (and wider) are acceptable. In practice, horses fed alfalfa hay diets will have wider ranges than these. When formulating rations for horses, ensure that sufficient total calcium and phosphorus are present in the diet and that the Ca:P ratio shows that calcium exceeds phosphorus in the diet.

Calcium and/or phosphorus deficiency will produce leg abnormalities in horses. However, deficiencies must be severe and prolonged to cause symptoms in adult horses. In foals, bone abnormalities can occur more rapidly. Few, if any, cases of dietary calcium deficiency in horses have been reported in western Canada in recent years. Several years ago, herd problems were reported in young horses fed high grain diets with no calcium supplement. Grain has little calcium; therefore calcium supplementation is needed in a diet that is high in grain.

An excess calcium intake is not detrimental to horses. Horses fed high-calcium diets can absorb most of the calcium from the diet, and then excrete any surplus calcium through the urine. Excess calcium is excreted as calcium carbonate, which causes a white sediment in the urine.

Feeding diets with high phosphorus content when calcium intake is low can lead to a condition known as nutritional secondary hyperparathyroidism, or bighead. Signs of this disorder include lameness, a rabbit-hopping gait and enlargement of facial bones. This disorder is rare in Saskatchewan.

The rule of thumb regarding calcium and phosphorus for horses is: hays and forages are good sources of calcium; grain and grain by-products (protein supplements) are good sources of phosphorus. Forages, especially legume hays such as alfalfa or clover, have higher calcium concentrations than grass hays. Calcium content tends to be higher in leaf than in the stem, so harvesting prior to heading or bloom formation is desirable. Saskatchewan-grown hays and pastures are low in phosphorus content (often less than 0.2 per cent). The mineral content of feeds should be known so that appropriate mineral supplementation can be chosen for the horse's diet.

Micro-minerals or Trace Minerals

Iodine, copper, zinc, manganese, iron and selenium are trace minerals that are needed by horses. Soils in Western Canada lack sufficient copper, zinc, iodine and selenium, so Saskatchewan grains and hays are often deficient in these minerals. The recommended and maximum allowable content of trace minerals in the horse's total diet are given in Table 5. Mineral content that exceeds the maximum allowable mineral content are toxic. Most mineral supplements have very concentrated amounts of minerals. However, these products are fed in only small amounts to offset the subnormal trace mineral content of the hay and grain used in the diet.

Table 5. Suggested and Toxic Trace Mineral Concentrations for Horse Diets (mg mineral/kg diet)

Trace Mineral	Recommended Amount	Toxic Amount
Copper	9 – 15	>250
Zinc	40	>500
Iron	40 - 50	>500
Manganese	40	>400
Selenium	0.1 - 0.2	2 - 5
Iodine	0.35 – 0.45	5

<u>Copper</u>

Horses require 9 to 15 mg copper/kg diet. Prairie feeds are copper-deficient; typical values range from 2 to 8 mg/kg feed. Copper is needed for cartilage, bone and melanin synthesis and for mobilization of iron stores. Copper deficiency used to be implicated in leg development disorders such as physitis in foals. Studies in New Zealand confirmed that providing adequate copper to the diet of pregnant mares reduced the incidence of leg problems in their newborns but did not totally eradicate the problem. Direct copper supplementation of the foal's diet does not prevent or cure bone growth disorders. Copper toxicity in horses is rare. Horses can tolerate more than 250 mg copper/kg diet. However, high copper feeds can kill sheep and cattle, so high copper supplements used for horses should be carefully stored.

<u>Zinc</u>

An adequate amount of zinc in a horse's diet is 40 mg/kg diet. Most Saskatchewan feeds have less than half of this required amount. Zinc is needed in many enzyme reactions, especially those involved in protein metabolism. For this reason, zinc deficiency can affect skin, bone and muscle development and can impair the immune response. Experimental zinc deficiency caused poor growth, recurrent infections, poor wound healing, abnormal skin and hair growth in growing horses, but no naturally occurring zinc deficiency has been identified in horses.

Although unlikely to occur in Saskatchewan, excess zinc (more than 500 mg/kg diet) interferes with calcium and copper metabolism, which can lead to bone and tendon abnormalities. Naturally occurring zinc toxicity associated with zinc smelters was reported to cause flexural limb deformities (contracted tendons) and joint lesions in foals.

Iodine

Dietary iodine requirement is 0.35 mg/kg; higher requirements (0.4 mg/kg diet) are needed for mares in late pregnancy. North American feeds including those grown in Saskatchewan contain little iodine. Most of the body's iodine is found in the thyroid gland, where it is used in the synthesis of the hormone thyroxin. Both iodine deficiency and iodine excess inhibit thyroxin production, which then results in a thyroid enlargement called goiter.

Iodine deficiency in mature horses is difficult to detect clinically. However, iodine deficiency in pregnant mares affects their unborn foals. At birth, the newborn may be stillborn, may be unable to stand and suckle, and may have an enlarged thyroid gland (goiter). A condition called thyroid hyperplasia and musculoskeletal deformity (TH-MSD) has been described in foals in western Canada. This condition is speculated to be caused either by a direct iodine deficiency or by a dietary antagonist to iodine in the mare's diet, which interferes with iodine uptake by the fetal foal. Foals are born after a prolonged gestation (often greater than one year), with undershot jaws and severely contracted knees and fetlocks due to ruptured extensor tendons. Even though iodine-deficiency in mature horses is rarely diagnosed, iodized salt or iodine-containing minerals should always be available, especially for pregnant mares.

Care should be taken not to provide too much iodine. Excess iodine fed to pregnant mares has been reported to cause abortions and goiter in foals. Some cattle mineral mixes, especially those used to treat foot rot and lumpy jaw in cattle, may contain iodine in amounts that exceed the safe limit of iodine for horses.

Selenium

An adequate amount of selenium is 0.1 to 0.2 mg/kg of diet. Selenium coupled with vitamin E is needed for normal muscle function. Selenium deficiency causes white muscle disease. Foals are born weak with impaired locomotion and difficulty breathing, suckling and swallowing. Sudden death can occur after exercise. Although selenium deficiency is suggested to reduce fertility in mares and increase retained placentas after foaling, treatment with selenium is often unrewarding.

Selenium toxicity occurs when diets exceed 5 mg/kg diet. Selenium in the plant or organic form is more toxic than inorganic selenium. A sudden high overdose of selenium causes blind staggers in horses. Chronic overfeeding of selenium results in alkali disease. The symptoms of alkali disease include lameness, loss of mane and tail hair, deep rings, and sometimes sloughing of the hooves.

Selenium deficiency occurs in many Prairie areas. Your local Ministry of Agriculture Regional Services representative will know if your area is deficient. Feed selenium content can vary from farm to farm and from field to field. Mineral supplements generally contain 10 to 25 mg selenium/kg of mineral mix. It is important to follow the directions given on the feed tag so that selenium overfeeding does not occur. If you feed many different supplements, ensure that the total amount of selenium does not exceed the maximum allowable intake.

Iron

An adequate amount of iron in the horse's diet is 40 mg/kg, which is generally found in Saskatchewan feeds and soils. Iron is a component of muscle (myoglobin) and blood (hemoglobin). Hemoglobin is needed to carry oxygen. Iron deficiency causes anemia, but horses reared on Saskatchewan feeds and housed with access to soil are rarely iron deficient. Iron deficiency, if it occurs, is usually due to internal (bloodworms) or external (lice or ticks) parasites.

Excessive iron usually causes no serious effects, but this depends on the iron source and how it is administered. High iron in hays and grains when eaten generally does not cause toxicity, although it may interfere with absorption of other trace minerals such as copper. However, iron injections (iron dextran) and oral pastes containing high amounts of iron in the ferrous fumarate form are potentially fatal to foals.

Manganese

Manganese is needed at 40 mg/kg diet to support fat and carbohydrate metabolism and cartilage synthesis. Most Saskatchewan forages and grains have ample manganese. Dietary deficiency of manganese has not been diagnosed in horses. Horses tolerate high intakes of manganese.

Other Trace Minerals

Chromium, fluorine, silicon, boron and nickel are minerals needed in diets of other animals, but no data has established their requirements, deficiencies or toxicities in horses. Fluorine is the exception. Toxicity can occur with ingestion above 40 mg fluorine/kg diet. Reported symptoms of fluorine toxicity in horses are discoloured teeth, bone lesions and unthriftiness.

Mineral Supplements

Calcium, phosphorus and trace mineral supplementation may be needed in diets of Saskatchewan horses. Salt must always be available. Limestone, dicalcium phosphate, monosodium phosphate, defluorinated phosphate and sodium tripolyphosphate are compounds that supply only calcium, only phosphorus, or both calcium and phosphorus. Rarely are these sources of calcium and phosphorus top-dressed. Typically, they are incorporated into a mixture with trace minerals, vitamins and a palatable carrier that can be top-dressed, or they are incorporated into a grain pellet or mix.

Mineral-vitamin mixtures are often described for ration formulation purposes by their calcium:phosphorus ratio, that is, 3:1, 2:1, or 1:1 products. If it is a 3:1 mixture, there is three times more calcium than phosphorus. In a 1:1 mixture, calcium and phosphorus are supplied in equal amounts. When buying a mineral, both the ratio and the absolute amount of mineral should be assessed. For example, a mineral with 18 per cent calcium and nine per cent phosphorus has a 2:1 ratio and has a good amount of each mineral. A mineral with six per cent calcium and three per cent phosphorus also is a 2:1 mineral but would have to be fed at three times the rate to provide the same amount of mineral. A mineral mix should be selected on the basis of a ration evaluation.

Mineral supplements can be added to the grain mix, top-dressed or fed free-choice.Intake of mineral fed free-choice can be improved by mixing a carrier with the mineral at the rate of three parts mineral to one part carrier. The carrier can be salt, rolled grain or dried molasses. Since salt is needed by all horses, the horse will voluntarily eat the salt-mineral mix to get its daily salt supply. Mineral-dried molasses mixes are palatable to horses and may encourage a higher intake than salt-mineral mixes.

Horses consume about 30 to 60 g (1 to 2 oz) of typical mineral supplement daily. Enough mineral should be put into the feeder to supply all horses for about a week. Check the feeder daily, if possible, but at least weekly, and note whether the mineral is being eaten and is still in a palatable state. Some mineral mixes will harden into an inedible mass after being dampened. Mineral is best fed in open, shallow containers. Horses normally dislike putting their heads into dark narrow spaces that limit their vision. Feeders in broodmare operations should be low enough that foals can access mineral. Locate the mineral feeder together with the salt supply near a resting or lounging area or near a water source. Feeders can be fixed along fence lines, but be aware of any injury risk this may create.

Vitamins

Vitamins are required to maintain normal metabolism for a variety of functions. Vitamins are complex unrelated compounds that are classified by how they are absorbed and stored by the body. Vitamins are either fat-soluble or water-soluble. Fat-soluble vitamins include vitamins A (carotene), D, E and K. Fat-soluble vitamins are absorbed with fat and stored in body fat or lipid. Because fat-stored vitamins are slowly mobilized, fat-soluble vitamins are present in the horse's body for extended periods. For this reason, toxicity (hypervitaminosis) can occur by over-feeding or through excessive use of injectable vitamins, especially vitamins A and D. Vitamin E metabolism toxicity has not been yet identified.

Vitamin C (ascorbic acid) and the B-complex vitamins are water-soluble vitamins because their absorption is water-based. Water-soluble vitamins are not stored in body tissues and must be

replenished daily. Water-soluble vitamins, if fed in excess, are simply excreted in urine. Horses fed mature hay, poor-quality hay, or high amounts of grain may benefit from B-vitamin supplementation. Yeast is a good supply of B-vitamins.

Vitamin A (carotene)

Vitamin A is a group of compounds called retinoids. The active retinol or retinal forms are used in the eye in the process of sight, cell development and immunity. Retinols (Vitamin A) are important in reproduction and fetal development. Although the retinoids are the active component of vitamin A in the horse's body, the precursor to these compounds in feed is beta-carotene (β-carotene). One mg β-carotene is equal to about 400 IU of vitamin A. Pregnant mares may have a higher ability to convert β-carotene to vitamin A (1 mg = 555 IU), and growing horses may have a lesser ability (1 mg β-carotene = 333 IU vitamin A). Lush green pasture contains the highest amount of β-carotene, which gradually declines as the forage matures. β-carotene is better retained in haylage and dehydrated alfalfa than in cured hay. Properly cured hay is a good source of vitamin A for horses, but hay that has been rained on, is mouldy or has been over-cured by prolonged sun exposure will have a lower vitamin A value. β-carotene in hay "weathers" in high heat and humidity, resulting in lowered vitamin A concentrations. Cold winter temperatures have a preservative effect, resulting in negligible losses of vitamin A. Grains have very little β-carotene. Retinyl palmitate and retinyl acetate are the forms of Vitamin A in supplements and are less likely to degrade during storage than the unconjugated forms.

Unlike other nutrients, requirements for fat-soluble vitamins are based on the horse's body weight, not on the amount needed in the horse's diet. The estimated requirement for idle horses is 30 IU vitamin A /kg BW. Growing horses and working or exercising horses require 45 IU/kg BW. Stallions, pregnant and lactating mares require 60 IU/kg BW.

Vitamin A deficiency is hard to create experimentally and has only been produced in young horses after many months of deficiency. In horses that developed Vitamin A deficiency, symptoms can include a rough hair coat, reduced growth, night blindness, lowered immune response and bone abnormalities. Although a lowered reproductive capacity has been suggested, no convincing data for this exists in the horse. Deficiency might occur when high-grain diets or weathered forages are used, especially if the diets are protein and/or zinc deficient. The ration should be evaluated for vitamin A sufficiency if the horse's diet is comprised of poor-quality, weathered forages, is high in grain or if the horse has been grazed on pastures during a prolonged drought.

Too much vitamin A must be avoided. Toxicity is much easier to create than deficiency and occurs when vitamin A is fed at 10 to 15 times the requirement. Intake or injection of vitamin A that exceeds 16,000 IU/kg BW can cause toxicity. Accidental over-supplementation of oral vitamin mixes or

repeated injection of vitamin A preparations are the causes of most vitamin A toxicities. Toxicity causes a rough hair coat, hair loss, skin ulcers and abnormal bone growth.

Vitamin D

Vitamin D is necessary for normal bone growth through its interaction in calcium and phosphorus metabolism. Vitamin D has two forms: Vitamin D_2 (plant-based called ergocalcifierol) and Vitamin D_3 (animal form or synthesized by the horse's skin called cholecalciferol), which is the most common supplemental form. Vitamin D_3 is converted to active forms in the body. The two most common sources of vitamin D are obtained through: sunlight on skin (most vitamin D_3 is produced by ultraviolet light in the two hours around noon); and sun-cured hays (vitamin D_2). Ultraviolet light exposure at latitudes above 50° (Saskatchewan is north of 49°) may be ineffective in producing sufficient vitamin D.

The true requirement for vitamin D is unknown. For mature horses, the requirement has been set at 6.6 IU/kg BW. Vitamin D requirement is estimated at 22 mg/kg BW for suckling and weanling foals and 14-17 IU/kg BW for horses aged six month to two years old. Additional vitamin D must be provided to pregnant mares in the last trimester of pregnancy.

Clinical vitamin D deficiency is hard to produce, but subclinical vitamin D deficiency may reduce calcium and phosphorus absorption, leading to mild, shifting leg lameness in horses. The upper safe limit of vitamin D is 44 IU/kg BW. Toxicity of vitamin D occurs at four to five times the requirement and is often the result of frequent and repeated injection of vitamin D preparations or errors in use of concentrated vitamin pre-mixes. Horses are less tolerant of vitamin D_3 excess than Vitamin D_2 (plant form). Toxicity causes weight loss, bone abnormalities, and abnormal mineral deposits in the heart, kidney and muscle.

Vitamin E

Vitamin E is a fat-soluble vitamin that exists in nature as eight different entities: 4 tocopherols and 4 tocotrienols. Vitamin E functions as a cellular anti-oxidant and is involved in selenium-dependent enzymatic reactions. In addition to actions in the body, Vitamin E is added to feeds, especially those containing significant amounts of fat to prevent auto-oxidation and rancidity.

The horse's requirement for vitamin E is 1 IU/kg BW for horses at maintenance. Foals, working horses, stallions, and pregnant and lactating mares require up to 2 IU/kg BW. Fresh forage and early harvested hays contain the highest amounts of vitamin E (30 to 100 IU/kg feed). Vitamin E content declines as plants mature and during storage of hay. Grains have 20 to 30 IU/kg feed.

White muscle disease occurs with a deficiency of selenium and vitamin E, but not vitamin E alone. Equine degenerative myeloencephalopathy (EDM) may be a vitamin E deficiency disease in some families of horses. Equine motor neuron disease (EMND), which causes trembling, hind leg shifting and

muscle wasting, has been correlated to a low blood vitamin E status in horses with little to no access to green grass for a period of one to two years and receiving diets low in vitamin E concentration. This condition has been diagnosed in the Prairies.

Vitamin E is safe for horses. A maximum upper safe limit has been set at 1,000 IU/kg DM feed or about 200 times higher than requirements. No report of vitamin E toxicity has ever been made.

Vitamin K

The vitamin K requirements for horses are unknown. Vitamin K is involved in a complex of vitamin K–dependent proteins called Gla proteins needed for blood to clot normally, as well as in bone and cardiovascular metabolism.

Vitamin K occurs naturally in plant material (forages) in the form known as phylloquinone, which is the most common source for horses. Intestinal bacteria produce a vitamin K compound called menaquinone. The synthetic form (vitamin K_3) is called menadione and is the form used in feed supplements.

Vitamin K deficiency rarely occurs, except when vitamin K antagonists are present in feed, such as dicoumarol found in mouldy sweet clover or when warfarin (a synthetic coumarin derivative) is used in medical treatment. Symptoms of vitamin K deficiency include delayed blood clotting. Toxicity due to over ingestion of vitamin K has not been reported. Injectable products, however, should be used with caution; phylloquinone injectables may be safer than menadione forms.

Vitamin C

Vitamin C or ascorbic acid is an anti-oxidant. Dietary requirements for horses have not yet been established. Horses synthesize about 72 g of vitamin C per day, so vitamin C supplementation is not needed if the horse's diet contains good-quality feed. Neither deficiency nor toxicity of vitamin C has been described in horses.

Thiamin (Vitamin B_1)

Thiamin is required in carbohydrate (starch, glucose) metabolism. The requirement for thiamin is 3 mg thiamin/kg feed for all classes of horses except working horses. Working horses require 5 mg thiamin/kg feed because their diets are higher in starch-type carbohydrate (grain). Deficiencies are rare, but may occur if thiamin antagonists (brackenfern, horsetails, amprolium) are ingested. Deficiency symptoms include ataxia, exaggerated steps, noise sensitivity and blindness. Thiamin toxicity has not been reported.

Biotin

Biotin is involved in carbohydrate, fat and cholesterol metabolism and is essential for cell proliferation. The amount of biotin needed in the diet is unknown. Biotin is produced by bacteria in the hindgut. Good feed sources of biotin are fresh alfalfa and alfalfa hay. Grain is an intermediate supplier of biotin.

Biotin deficiency is speculated to cause poor hoof wall structure and strength. However, extended feeding of high biotin supplements has shown only small improvements in hoof quality in a small percentage of treated horses with no benefit to hoof growth. No biotin toxicity is known.

Vitamin B_{12}

Vitamin B_{12} or cyanocobalamin is utilized in red blood cell formation and is also required in fat, carbohydrate and protein metabolism. Although Vitamin B_{12} is not found in feeds, it is synthesized by microflora in the horse's hindgut. No deficiencies or toxicities of vitamin B_{12} have been reported in horses. Cobalt is a component of vitamin B_{12}, but horses can live on cobalt-deficient pastures, which have killed cattle. This confirms that vitamin B_{12} deficiency is very difficult to create in the horse. Vitamin B_{12} tonics have proven of little benefit in improving performance of horses, likely because deficiencies seldom occur.

Vitamin Supplements

Typically, only vitamin A and D supplementation is considered in ration formulation. Vitamin E is added in association with these two vitamins. Aggressive vitamin E supplementation may be needed in clinical cases of EMND. Read the label on vitamin products, as there is a wide range of available vitamin concentrations. Follow the manufacturer's instructions for top-dressed vitamin mixtures. Vitamin pre-mixes contain greater than 2,000,000 IU vitamin A and 200,000 IU vitamin D per kilogram and are meant to be incorporated at the rate of 1 kg per tonne of grain mixture. They are not intended to be top-dressed.

Water

About 70 per cent of a horse's body is water. An adequate amount of good- quality water is basic to the horse's good health. The horse's instinct to drink water is only exceeded by its need to breathe. Water is involved directly or indirectly in nearly every metabolic process in the body. Body water reserves are temporary, so horses do not tolerate water deprivation. Horses can die when dehydration is greater than 15 per cent, or water deprivation exists for about a week.

Horses acquire fluid by drinking liquid water and by getting a small amount from the moisture in their feed. There are four ways that extra water is eliminated from the body: in the manure (main route); in the urine; or through respiration (in each breath). The fourth route of fluid loss exists only in the lactating mare, where fluid is lost through milk secretion. Diet affects the pathway by which fluid is lost. High-fibre hays of low digestibility increase fluid loss through manure. Digestible, high-protein hays such as alfalfa hay result in more absorbed water, the excess of which is excreted through urine, and a decreased manure moisture content (Table 6).

Idle horses fed hay drink about 5 L of water per 100 kg of body weight, but volumes vary greatly from horse to horse. Size matters. A 500 kg idle Quarter horse drinks 25 L (5.5 gal) water daily compared to a 900 kg Percheron horse whose water intake is about 45 L (10 gal). Idle, pregnant mares drink similar amounts of water as non-pregnant, idle horses, but a lactating mare drinks two to three times more water than she did in pregnancy because she is losing fluid through milk. Working horses and horses exposed to hot weather lose fluid in sweat and may drink two to three times more water than idle horses kept at mild ambient temperatures (20°C). Foals drink water within a few days of birth, so water troughs should be low enough for them to drink. Cold weather reduces water intake by horses by about 15per cent.

Table 6. Effect of Diet on Route of Fluid Loss (L/day in a 500 kg horse)

	Alfalfa	Brome
Water intake	27	27
Fecal water	10.4	14.5
Urine water	12.2	6.8

Another way to view water requirement is based on feed intake. A rule of thumb is that horses drink about 4 L of water per kg hay eaten (0.5 gal/lb hay). Horses drink less water when fed high-grain diets (2.5 L/kg diet). High protein, salt and fiber content in the diet also increase

water intake.

Horses housed in barns drink about –two to eight times daily in drinking bouts of 10 to 60 seconds. Horses visit water troughs less often when pastured on lush grass, which is high in moisture content, and drink less often when outdoor temperatures are cold. Water temperature affects water intake by horses only when outdoor temperatures are cold. Horses prefer warmed over icy water when ambient temperatures are cold. At warm ambient (above 15°C) temperatures, horses will drink cool or warm water. Horses prefer drinking from buckets and troughs to drinking from small water bowls. Snow is inappropriate for use as a water source. Horses simply cannot eat enough snow to adequately hydrate themselves.

Horses have to eat about 10 units of snow to equal one unit of water.

Table 7. Water characteristics of horse farms and maximum acceptable and unacceptable thresholds of water quality (units in mg/L)

Item	Ave	Range of Values		Maximum Acceptable Limit	Unacceptable
		Min	Max		
TDS	1127	360	1880	3000	7000
Sulfate	497	54	1380	<2000	3500
Nitrate	2.5	0	29.9	100	400
Chloride	50	10	150	1500	3000
Sodium	123	12	469	<1000	2000
Calcium	153	5	403	500	1000
Magnesium	75	2	153	250	500
pH	7.6	7.1	8.5	6 – 8.5	< 5.5 & > 9.0
Coliforms (mpn/dl)	5	0	48	Unknown	Unknown

Water deprivation causes dehydration. Signs of dehydration include the following: sunken eyes, dry skin and gums, and dry manure. The easiest way to diagnose if a horse is water-deprived is to offer it a bucket of water. Deprived horses will drink eagerly. Horses seldom drink too much water.

Water quality matters to horses. Table 7 shows current guidelines of acceptable and unacceptable limits of components for water consumed by horses.

FEEDS

Pastures

Pastures are a useful feed source for horses, but in Saskatchewan, the season is short and pasture quality can be unreliable, depending on weather conditions or forage type. Pastures can be native or improved. Mixed prairie is the largest native grassland in Saskatchewan and contains grass species,

herbs, forbs, sedges and weeds. Wild grasses include wild fescues, northern, western and slender wheatgrass, blue grama, green needlegrass, Junegrass, reed canary grass, and wildryes. Palatability of native pastures depends on plant type and stage of maturity.

The type of forages used in improved pastures in Saskatchewan varies with soil and climate. Climate dictates rainfall and length of the pasture season. Improved pastures are typically grass, legumes or grass-legume mixes. Grasses used in pastures include timothy, meadow and smooth bromegrass, orchardgrass, domesticated wheatgrass, and creeping red fescue. Legumes used include alfalfa, clover and bird's foot trefoil. Grasses and legumes complement each other over the growing season. Grasses grow well in the spring and late fall, while legumes are typically more productive in summer, so improved horse pastures should include at least one species of a legume and a grass. Usual seeding ratios are 50:50 grass-legumes. Improved pastures generally yield more forage than native pastures.

The animal unit month (AUM) is a standardized measure of forage consumed on rangeland over a month. The AUM is based on a 450 kg (1,000 lb) cow with a calf at foot. In pasture usage, all other animals are compared to this cow and calf. A mature, light horse has an AUM of 1.5, which means it eats (and tramples) 50 per cent more pasture than the cow and her calf on the same pasture. A draft horse that weighs about 1.5 to two times as much as some light horses will have an AUM of about two. In addition to the weight of the horse, there are several other factors that should be used to determine how much pasture a horse will need. These factors are: forage type (improved or native), growing conditions (dry, normal or wet) and season of the year (spring, summer or fall). Native pastures do not tolerate a dense population of horses per acre.

Horses eat about 2.5 to three per cent BW pasture daily in hay equivalent (10 per cent moisture). A useful rule of thumb is that a horse eats, tramples or soils 1 to 2 kg of dry matter forage for every 1 kg of body weight (1 to 2 lb forage/1 lb horse) per month. For every mature Quarter horse, a pasture needs to provide 600 to 1,200 kg of forage per month. For a draft horse, the pasture needs to provide 1,000 to 2,000 kg forage per month. This assumes that there is a uniform pasture yield from spring through to fall. However, growing intensity and moisture content vary considerably during the pasture season.

Pastures typically have 80 per cent moisture content in late spring/early summer, which declines to about 50 per cent by fall. A 600 kg horse needs to eat more than 80 kg of early spring pasture to get 18 kg dry matter feed per day. The moisture in the forage will supply 72 kg fluid to the horse. In the fall, the horse will be eating a more mature, drier pasture and may only need 33 kg to get the same amount of dry matter. The high water content of early spring pastures is the reason horses spend less time at the water trough than in the fall. They simply get water from feed rather than having to drink liquid water. Conversely, spring pasture has little dry matter so the horse may have to spend up to 18 hours grazing to get the dry matter they need.

One of the important management considerations of horses on small pastures is fecal soiling of the pasture. Horses prefer not to eat grass adjacent to their manure piles. The area of grass around manure is called a “latrine”. Horses avoid latrines so will overgraze areas beyond the latrines, sometimes causing irreparable damage to the grass. For most people, vacuuming manure off pastures is impractical, so to avoid over-grazing, a larger pasture area will be needed to sustain sufficient feed for the horse.

The highest nutritional value of pasture forage is early in the growing season. Immature grasses are more digestible and palatable to horses than mature plants. As the plant ages, energy, protein and phosphorus content decline, as does the digestibility of these components. Many late August pastures are scant and have little nutritional value.

Alfalfa is a nutritious pasture for horses, but is easily trampled and wastage is high. Horses do not bloat on pastures as cattle may. White and red clovers have been used but are less palatable than alfalfa. Alsike clover is not recommended for horses because it can cause liver damage, resulting in photosensitization in susceptible horses. Bird’s foot trefoil is rarely used in Saskatchewan horse pastures.

Bromegrass grows well in Saskatchewan and is nutritious and palatable to horses as it matures. Crested wheatgrass is an early-growing, early-maturing forage that tolerates drought conditions, but palatability is low by mid-summer. Ryegrass pasture is palatable early in the growing season, but is less palatable as it matures. Sudan grass should not be used in horse pastures. Reed canary-grass becomes unpalatable to horses as the plant ages. Foxtail barley is an opportunist seen in pastures after a period of flooding. Foxtail is nutritious before it flowers, but the foxtail awn can cause lesions and ulcers in the horse’s mouth.

Pasture Management

Several management practices should be used to maintain pastures. These include:

- Avoid overgrazing – plants should not be grazed below 5 cm (2 inches);
- Avoid grazing legume pasture too late in the fall – allow a recovery period before winter;
- Remove hazardous material such as wire, boards with nails, toxic plants and old batteries;
- Mow mature pasture to stimulate new plant growth;
- Use safe fencing material;
- Provide shade or shelter; and
- Provide water from an easily accessible trough, watering bowl or natural source (pond, lake, or creek).

Fructans in Pasture and Laminitis

Fructan is a carbohydrate comprised of fructose units and can only be digested by the enzymes produced by bacteria in the hindgut of the horse. High fructan content in cool-season forages (hay or pasture) can increase the risk of laminitis in horses prone to pasture-associated laminitis (PAL). Fructan content varies in the pasture, and is higher in the spring and fall at the end of the day. Plant stress such as drought and cool temperatures (below 4°C) can increase fructan accumulation in the plant. Horses sensitive to simple sugars should only be grazed in the morning during summer, when fructan content of the pastures are lower than later in the day.

Hay Selection

The following criteria are used in the selection of hays for horses: hay type; leafiness (leaf:stem ratio); fineness of stem; absence of odour; mould dustiness; and foreign material and stage of plant maturity.

1) Type of hay. Legume hay (alfalfa, clover) harvested at the same stage of maturity has higher energy, protein, and calcium content than grass hays. Legume hays should be cut at the beginning of flowering; grasses should be cut shortly after budding. Flowers on alfalfa and seed heads on grass hays are signs of overmaturity of the hay, which will result in lower nutritional value.

2) Leaf to stem ratio. Leaves contain about 75 per cent of the plant's energy, protein and calcium content. As plants mature, the amount of stem increases, reducing the nutritional value of the hay. A coarse, thick stem is generally unpalatable to horses.

3) Absence of odour. Well-cured hays are fresh and smell clean. Mustiness indicates mould and potential heating of the hay.

4) Colour. Well-cured, newly harvested hay is green in colour. Faded, yellow, discoloured hay indicates old or badly weathered hay, which have reduced vitamin value. Dark brown and black hay has been rained on, is mouldy and is prone to overheating.

5) Foreign material. Weeds and mould can be toxic and make feed unpalatable. Stubble, dirt and foreign matter such as rocks and dead rodents reduce feed value and can be harmful.

6) Nutrient content. The only way to confirm the nutritional value of a feed is to have a nutrient analysis conducted by a reliable laboratory. Yet, a nutrient analysis does not necessarily confirm nutrient availability or feed palatability. For example, weathered, rained-on (mouldy) hays may have a good nutrient profile, but the hay is distasteful and poorly eaten by horses.

Hay can be purchased as small or large square or large round bales. Small square bales are 23 to 34 kg (50 to 75 lbs), which makes them easy to handle by hand and reduces waste if a mouldy or poor-quality bale is encountered. Large square and round bales, which weigh about 365 to 545 kg (800 to 1,200 lbs), can also be used for horses. Large bales have the advantage that the horse can eat hay free-choice, and the owner may only have to provide hay every few days or weeks. The disadvantage of large bales is that large equipment is needed to handle them, and they may be more prone to mould and dustiness when improperly cured during harvest. Large squares are preferred to large round bales for horses because the bale can be opened and assessed for mould before the flakes are placed into the feeder. Horses often burrow into the side of round bales, which increases the risk of inhaling hay

dust and mould spores that contribute to the development of heaves (recurrent airway obstruction). Attention should be paid to the type of large bale feeder used for horses. Some poorly-designed, large bale feeders have been reported to cause serious lower limb injury in horses (pawing at the feeder).

Hays for Horses

Legume Hays

Alfalfa hay is the most common legume hay fed to horses. Clover hays are seldom seen for sale in Saskatchewan. Generally, alfalfa hay is high in energy, protein and calcium content and is very palatable to most horses (Table 8). It is used most often as a feed for weaned foals and lactating mares because of its high quality. Most alfalfa hay is fed in long form, but cubes and pellets are available. Cubes and pellets can be used to feed horses with heaves and aged horses with poor teeth. Processing increases the cost of pellets and cubes compared to long hay.

Poorly cured alfalfa may be prone to mould and therefore may become dusty. Alfalfa does not damage kidneys in normal horses, but may be undesirable for use in horses with liver or kidney disease. Alfalfa-fed horses have urine that may be reddish-white tinged. Alfalfa is high in readily digested calcium. Any excess of calcium that is absorbed is excreted through the urine. This is the white sediment seen in the urine of alfalfa-fed horses. This is normal.

Alfalfa-grass hays are good all-purpose hays. Nutrient content is higher than pure grass hays and risk of mould is reduced, although poorly cured hays will still be at risk of becoming mouldy.

Table 8. Composition of Saskatchewan Hays and Grains Grown for Horses (DM Basis)

	DE(Mcal/kg feed)[a]		Protein (%)		Calcium (%)		Phosphorus (%)	
Feed	Ave	Range	Ave	Range	Ave	Range	Ave	Range
<u>Legume Hays</u>								
Alfalfa	2.36	2.2 - 2.55	15.7	7.4 - 26.2	1.34	0.43 - 2.23	0.19	0.1 - 0.34
Alfalfa-grass	2.34	2.08 -2 .53	12.0	5.0 – 20.7	0.96	0.33 -1.93	0.16	0.05 – 0.31
Dehydrated alfalfa	2.42	2.20 – 2.55	15.7	12.5 – 18.0	1.48	1.19 – 2.17	0.19	0.13 – 0.27
<u>Grass Hays</u>								
Timothy	2.38	2.26 - 2.45	10.5	6.8 - 14.2	0.41	0.34 - 0.8	0.21	0.11 - 0.31
Crested wheatgrass	2.05	1.22 – 2.38	8.5	3.9 - 12.6	0.57	0.23 - 0.97	0.12	0.08 - 0.16
Brome	2.26	2.25 - 2.27	11.2	10.8 - 11.5	0.73	0.54 - 0.91	0.17	0.13 - 0.20
Native hay	2.08	1.69 - 2.36	6.3	2.9 - 8.2	0.45	0.33 - 0.69	0.09	0.04 - 0.14
Green-feed (oats hay)	2.43	2.22 - 2.60	9.57	4.6 – 14.9	0.30	0.14 - 0.75	0.23	0.15 - 0.33
Cereal silage	2.56	2.34 - 2.73	10.2	6.2 - 16.9	0.37	0.09 - 1.30	0.25	0.14 - 0.40
Cereal straw	1.89	1.67 – 2.13	5.3	3.1 – 8.7	0.28	0.17 – 0.40	0.11	0.05 – 0.19
<u>Grains</u>								
Oats	2.91	2.68 – 3.30	10.6	5.7 - 14.6	0.08	0.06 – 0.09	0.31	0.24 -0.39
Barley	3.18	2.68 – 3.56	11.0	6.6 – 18.1	0.07	0.05 – 0.09	0.31	0.17 - 0.370
Corn	3.37	3.08 – 3.52	8.7	6.9 – 10.6	0.08	0.05 - 0.10	0.27	0.22 – 0.35

Grass Hays

The type and quality of grass hay grown in Saskatchewan varies with regional growing conditions. Timothy, smooth brome and crested wheat are the most common grass hays grown in Saskatchewan, but tall fescue and Russian wildrye hays are occasionally available. Premium timothy hay grown in Saskatchewan is largely exported.

Smooth bromegrass is a tall, soft leaf and soft stemmed grass that is easy to cure into good hay and is very palatable to horses. Meadow brome is used more as a pasture grass but can be used for hay, especially if grown in combination with alfalfa. It is a soft, leafy hay that is palatable to horses. Timothy is a favourite horse hay because it is "clean", with a soft leaf and stem that is palatable to horses. Intermediate wheatgrass is tall forage with moderately coarse leafy stems that make dust-free hay. It is palatable to horses but can have a low nutrient content if harvested too late. Crested wheatgrass is fine-stemmed and leafy early in the growing season. If cut early, it makes a dust-free hay. The nutrient content declines after the plant heads out. Over-mature crested wheatgrass has low palatability to horses.

The nutrient value of grass hays depends on when they are harvested. Grass hays, unless harvested early in the growing season, are usually lower in energy, protein and calcium content than legume hays. Mature grass hays generally need to be supplemented with a balanced grain mixture when fed to young horses and horses with higher nutrient demands, such as racehorses.

Green Feed (Oats Hay)

Green feed fed to horses in Saskatchewan usually refers to the oats plant in the late milk to dough stage of growth, which is harvested as hay. Oats hay has good energy and protein content that can be attributed to the immature grain seed with variable nutrient value from the stem. The nutrient value of the stem depends on its leafiness. Fine leafy stems have some nutrient value and are eaten better than stems of mature oats plants. The disadvantage of oats hay is that it can be difficult to cure properly, so it may be more prone to mould. It is easily sorted by horses, so waste can be high.

Other Hays and Roughages

Slough hay and other native hays vary widely in nutrient content and digestibility. Generally, these hays should not be used as the sole feed source for horses. Prairie wool (wild barley, foxtail) is very

nutritious before the flowering stage. Foxtail at the awn stage is unpalatable. Also, awns may embed in the mouth tissue, causing infection and serious oral discomfort.

Silage is rarely used as horse feed in Saskatchewan. Barley and alfalfa silage are used occasionally, but must be processed to sufficient acidity to prevent growth of botulism bacteria. Silage has a very high moisture content, which means the horse must eat substantially more silage than hay to ingest the same amount of feed dry matter. For this reason, silage should not be used for growing horses, or pregnant or lactating mares. Haylage is similar to silage in that it is high in moisture content. Haylage is also known as big bale or grass silage. It is vacuum-packaged, high-moisture hay that is very palatable to horses. The only risk with its use is that if the package tears, the exposure to air can allow botulism bacteria to grow. Botulism can be fatal to horses.

Pelleted forages are used less commonly for horses than long hay in Saskatchewan. Sun-cured and dehydrated alfalfa pellets and cubes are high in energy, protein, calcium and carotene, but may be low in fiber. Compressed timothy is usually used for export. Pelleted forages are consumed much more rapidly than long hays, which can lead to boredom, which may lead to behavioral vices.

Straw has a high fiber content, low digestibility and low nutrient value. Horses generally will not eat straw, but will scavenge through bedding for grain and hulls. Straw should never exceed 10 per cent total in a horse's diet.

<u>Undesirable Hays and Pastures</u>

Tall fescue is grown in Saskatchewan and is infrequently used to make hay. The tall fescue plant is prone to infection with endophyte (fungus), which produces alkaloids called erogvaline and loline. Ergovaline negatively affects pregnant mares, causing abortion or prolonged gestation, thickened placentas, retained placenta, agalactia (failure to produce milk), and weak foals. Endophyte-free fescue can be used for horses if harvested early, before palatability and nutrient content decline.

Clovers infected with mould or fungus can cause toxicity problems for horses. Alsike clover infected with black botch disease is reported to cause dermatitis of white areas of skin as a result of photosensitization and liver damage. Dark-haired horses can experience liver damage without dermatitis. Although rarely diagnosed in the Prairies, mouldy red clover can cause "slobbering" in horses. Mouldy sweet clover can cause bleeding in horses due to the production of dicoumarol.

Sorghum-sudangrass pastures should not be used for horses because it contains prussic acid (hydrocyanic acid), which causes cystitis, incoordination or, rarely, sudden death.

Grains and Prepared Feeds

Oats is the grain most often grown to feed horses in Saskatchewan. Oats used for horses should weigh at least 34 lb/bushel, have a plump kernel, minimal weeds and no wild oats. Newer varieties of oats have a high bushel weight (about 40 lb/bu) and protein content above 11 per cent. All grains are low in calcium but have a modest phosphorus content. Except for corn, grains are low in vitamin A content.

The energy content of grains is almost directly related to weight (Table 9). Racehorse oats typically has a higher bushel weight and energy content than conventional oats. Oats is about 30 per cent hulls with a crude fibre content of about 12 per cent (compared to five or six per cent for barley and wheat). As a result, oats is 10 to 20 per cent lower in energy content than barley and wheat. Corn is grown in some areas of Western Canada but is uneconomical for use as a horse feed. Although corn is high in energy, it has less protein and less lysine than oats and other grains. Whole barley, corn and wheat are higher in energy content and are more likely to spillover into to the hindgut than oats. This makes these grains more likely to cause colic and laminitis compared to oats, but any grain, including oats, when fed in excessive amounts, can cause these conditions.

The importance of the amount of grain eaten in the development of laminitis and gastric ulcers has been proven through research. Grain overload will occur when the starch intake by horses exceeds 4 g/kg BW per meal, but can occur at meal intakes of 2 g/kg BW, depending on the source of the starch (e.g., it is more likely in whole wheat, corn or barley than ground grains). Research supports limiting starch intake to no more than 2 g starch/kg BW per meal to avoid hindgut starch carryover, which can cause laminitis. Limiting starch intake to less than 1 g/kg BW per meal has been recommended as a method of reducing gastric ulcer formation. Any horse with an insulin metabolic disorder such as equine metabolic disease should be limited to less than 0.3 g starch/kg BW per meal, and, in most instances, grain should be avoided entirely.

Some hard-working horses may require high amounts of grain in their diet to meet high energy requirements. These horses should be fed small meals frequently throughout the day. Processing

grains affects how easily and where in the intestine the horses digest the starch in grain. Any process that cooks, steam-flakes, grinds or extrudes grain increases the amount of starch that is digested in the small intestine, which reduces the amount of starch spillover into the hindgut.

Grains should be fed by weight, not volume. Bushel weights of grains vary widely, so one liter (about one quart) of one type of grain can have quite different energy content than another type of grain (Table 9). For example, a liter of oats weighs about 0.5 kg and supplies about 1.6 Mcal energy compared to a liter of whole barley, which weighs 0.75 kg and supplies 2.4 Mcal energy. It is important to know the weight of the grain in the container you use to feed the horse. Accidental overfeeding of grain will flood the horse's hindgut with starch, causing an acidosis, which can lead to laminitis and/or colic. Horses requiring a high grain intake must be adapted to eating these high amounts. To adapt the horse to grain, the amount of grain it is fed is increased in small increments over a period of a week or more to allow the intestinal microbial population to adjust to a diet high in starch (Table 10).

Processed commercial pellets in Canada are mainly grain products that may contain any of the following ingredients: hay; grain hulls; protein; and mineral and vitamin supplements. Hays and grains incorporated into pellets are altered mechanically either by grinding, pelleting or cubing (hay). Flaking, crimping and rolling are other processes used to break down the outer coat of grain to increase its digestibility, which can then be followed by steaming, micronization or extrusion to further aid digestibility.

Table 9. Weight and DE[a] Content in 1 L Grain (90% Dry Matter)

Feed	Weight (kg)	DE[a] (Mcal)
Oats		
Whole	0.56	1.63
Rolled	0.40	1.16
Barley		
Whole	0.75	2.38
Rolled	0.42	1.37
Wheat, whole	0.91	3.07
Corn, whole	0.86	2.90
Wheat bran	0.24	0.63
Commercial grain pellet	0.51	3.12

[a] digestible energy content (Mcal)

Table 10. Grain Feeding Program to Adapt a 500 kg (1100 lb) Horse to Grain[a]

Day of Grain Feeding	Total Daily Fed Grain or Grain Mix Fed[*b]
Day 1	1.10 kg (2.4 lb)
Day 2	1.38 kg (3.0 lb)
Day 3	1.65 kg (3.6 lb)
Day 4	1.92 kg (4.2 lb)
Day 5	2.20 kg (4.8 lb)
Day 6	2.48 kg (5.4 lb)
Day 7	2.75 kg (6.0 lb)
Day 8	3.00 kg (6.6 lb)
Day 9	3.25 kg (7.2 lb)
Day 10	3.50 kg (7.7 lb)

[a] Feed with hay free-choice
[b] Total amount of grain given daily should be divided into at least two or more meals

In Canada, most “complete” pelleted feeds are meant to be used as grain substitutes, but this is not always the case. Unlike in Canada, feeds in the United States called complete feeds can contain both forage and grain. Registered feeds in Canada fall within strict registration specifications, so they may not exactly balance diet the same way from year to year because the hay that will be fed can vary widely in nutrient content from year to year. When a pelleted feed is used, instructions on the feed tag should be followed carefully. Incorrect use of commercial grain pellets can cause founder similar to any other grains.

Protein Supplements

Soybean meal contains 45 to 47 per cent high-quality protein. It is the protein supplement of choice for horses. Its high lysine content (about three per cent) accounts for its use in prepared feeds for growing foals. Soybean meal can be top-dressed but generally is incorporated into prepared feeds. Canola meal, a more common Saskatchewan protein supplement, has a protein content of about 37 per cent, a lysine content of about two per cent and can be used in prepared feed for horses. Skimmed milk powder is good-quality protein, especially for growing foal feeds, but is too costly for routine use. Linseed meal is derived from oil-extracted flaxseed. In the past, it was a desired supplement for horses because the high residual oil content in the meal gave the hair coat a glossy sheen. Newer processing methods leave only about 1.7 per cent oil in the meal, so the benefit of the oil on hair sheen is less likely to occur. Also, flaxseed (linseed) meal has a low 1.2 per cent lysine content, so should not be used in growing horse diets. Other protein supplements used in horse diets include brewer’s dried grains, corn gluten meal and cottonseed meal, but most are unavailable in Saskatchewan or too costly for routine use.

Other Feeds Used for Horses

Wheat bran is the outer covering of the wheat kernel obtained as a by-product of wheat processing. Wheat bran was used in horse diets for its purported laxative effects, but is used less often now. Studies have shown that neither moistened nor dry wheat bran increases the moisture content of manure.

Molasses is available in a dehydrated or liquid form. It is used as a sweetener, to reduce dustiness and as a carrier for granular minerals. Dried molasses is high in high energy content. Its high potassium content makes it an inadvisable ingredient in diets of HYPP (hyperkalemic periodic paralysis) horses.

Beet pulp is a by-product of sugar beet processing. It has a highly digestible fibre, and a low starch and sugar content. Beet pulp is low in mineral content, except calcium, and contains little to no B-vitamins, carotene or vitamin D. Its popularity is the claim that it fattens horses quickly. Yet, beet pulp has a lower energy and protein content than oats. However, the low starch content makes

beet pulp a useful ingredient in diets of horses with insulin resistance, PSSM or equine metabolic syndrome. Its small particle size makes it easy to chew by horses with poor teeth. Soaking makes the product more palatable and reduces the possibility of choke.

Rice Bran is the outer cover of the rice kernel. It is rich in oil (20 to 25 per cent), has modest amounts of some of the B vitamins and is high in phosphorus. Because the fat in unprocessed rice bran can become rancid during storage, the product must be stabilized through heat and pressure. Only stabilized rice bran should be fed to horses. Although too costly for routine use, rice bran is useful in diets of horses with polysaccharide storage myopathy (PSSM) and those prone to laminitis.

Tonics and Additives

Nutraceuticals, herbs and various other products are widely available. Characteristically, these products obtain a "fad" following, are marketed now through social media and rarely have undergone rigorous testing to verify their benefits or risks when fed to horses. Nutraceuticals are products whose definition as drug or feed is still undetermined. These types of products do not require approval by regulatory agencies to be sold. Manufacturers do not need to prove there is an active ingredient in the product or the amount of the purported active ingredient.

Feeding Programs for Horses

The diet is the feed or feeds the horse is fed. For example, a gelding is fed a diet of hay. The horse's ration is the actual amount of feed provided to the horse in a 24-hour period. For example, a gelding is fed 10 kg of alfalfa hay and 2 kg oats daily. A horse's ration should be based on its age, its ideal weight (if obese or thin), its current weight if it is normal body condition, its potential mature weight if it is a growing horse, its function and use, the available feeds, housing, and management. The minimum recommended nutrient requirements for various classes of horses of different weights can be viewed in Chapter 16 of the NRC Nutrient Requirements of Horses at http://www.nap.edu/openbook.php?record_id=11653. Tables 11 and 12 list the nutrient requirements for horses weighing 500 and 600 kg.

Table 11. Daily Nutrient Requirements of Horses Mature Body Weight of 500 kg (1100 lb)

Type	Weight (kg)	ADG* kg/d	DE Mcal	CP g	Ca g	P g	Na g	Vitamin A IU
Mature – idle	500		16.7	540	20	14	10	15000
Working								
Light	500		20.0	699	30	15	13.9	22500
Moderate	500		23.3	765	35	21	17.8	22500
Stallions, breeding	500		21.8	759	30	18	14.9	22500
Pregnant Mares								
0 - 5 months	500		16.7	630	20	14	10	30000
9 – 11 months	~550	0.53	20.3	845	36	24.3	11	30000
Lactating Mares								
First month	500		31.7	1535	59.1	38.3	12.8	30000
4th month	500		29.4	1398	41.7	24.2	11.9	30000
Growing Foals								
4 months	165	0.84	13.3	669	39.1	21.7	4.2	7600
6 months	236	0.72	15.5	676	34.6	21.5	5	9700
12 months	324	0.45	18.8	846	37.7	20.9	6.9	14500
18 months	387	0.29	19.2	799	37	20.6	8	17400
24 months	429	0.18	18.7	770	36.7	20.4	8.8	19500
24 months, light work	429	0.18	21.8	829	36.7	20.4	12.1	19500

*ADG = Average daily gain (kg per day) , DE = digestible energy, CP = crude protein, Ca = calcium, P = phosphorus, Na= sodium

Table 12. Daily Nutrient Requirements of Horses Mature Body Weight of 600 kg (1320 lb)

Type	Weight (kg)	ADG* kg/d	DE Mcal	CP g	Ca g	P g	Na g	Vitamin A IU
Mature – idle	600		18.2	648	24	14.8	12	18000
Working								
Light	600		24	839	36	21.6	16.7	27000
Moderate	600		28	921	42	25.2	21.3	27000
Stallions, breeding	600		24.1	947	26	21.6	16.7	27000
Pregnant Mares								
0 - 5 months	600		20.0	756	24	14.8	12	36000
9 – 11 months	~660	0.63	24.4	1017	43.2	31.5	13.2	36000
Lactating Mares								
First month	600		38.1	1842	70.9	45.9	15.3	36000
4th month	600		35.3	1677	50.0	31.4	14.0	36000
Growing Foals								
4 months	202	1.01	15.9	803	46.9	26.4	5.1	9100
6 months	259	0.87	18.6	811	46.4	25.8	6	11700
12 months	285	0.54	22.5	1045	45.5	25.1	8.6	17300
18 months	465	0.34	23.1	959	44.5	24.7	9.6	20900
24 months	515	0.22	22.4	924	44.0	24.4	10.5	23200
24 months, light work	515	0.22	26.1	995	44.0	24.4	14.5	23200

Idle, Mature Horses (Maintenance)

Maintenance feeding implies that the horse is being fed to maintain its weight. Maintenance feeding assumes the horse is mature, in good body condition (neither needing to gain nor lose weight), is not worked, is not pregnant or lactating, and is housed in thermoneutral weather conditions. Idle adult horses on pasture or being overwintered fall into this category. The maintained horse only needs to be provided with sufficient energy, protein, minerals, vitamins and water to repair body tissue, maintain body temperature and sustain idle movement. Maintenance

diets can be comprised solely of hay or good pasture fed with supplemental mineral-vitamins. Grain is not needed unless hay quality is poor in energy and protein. Mineral-vitamin supplements and salt are recommended. A diet of pasture in summer or hay fed free-choice in winter, with either a 2:1 (for grass hay) or 1:1 (alfalfa mix hay) calcium-phosphorus mineral fed free-choice, with salt and water available free-choice will meet the needs of most idle horses.

Example: An idle 600 kg QH gelding requires 16.7 Mcal of energy per day. His diet is brome hay containing 2.26 Mcal energy/kg hay and he eats the hay free-choice. A rule of thumb is that mature horses eat about 2 kg brome/100 kg of body weight, so his total hay intake will be 2kg X (600 ÷ 100) = 12 kg of hay. The amount of energy eaten is calculated by multiplying the calories in the hay (2.26 Mcal/kg) times the amount of hay eaten (12 kg) or 2.26 X 12 = 27.1 Mcal digestible energy per day. The horse is consuming 10.4 Mcal more than needed. He may gain weight during warm weather, or if kept indoors in winter. Overwintering the horse outside in Saskatchewan will use up some of the extra energy he is ingesting for use in heat production to keep him warm during cold winter temperatures.

Growing Horses

The most rapid growth of a foal occurs from birth through four to six months of life for light horse foals (Table 13). Draft foals mature more slowly. A newborn foal weighs about 10 per cent of mature weight and measures about 60 per cent of its mature height. The most rapid weight gain and skeletal growth of the foal will occur from birth to weaning, then gradual decline through its first year. For this reason, creep feed provided to the foal during its suckling period (birth to about four months) must be nutrient-balanced and nutrient-rich.

Table 13. Percent of Adult Weight and Height at Various Ages of a Horse

Age	% Mature Weight	% Mature Height
Birth	10	60
Weaned (~ 6 month)	46	83
Yearling	65	90
Long yearling (18 month)	80	95

Milk is the principal diet of foals up to two months old, but foals will begin to nibble pasture or its dam's hay and grain mix as early as a week old. Salt will be consumed within one to two days of birth, and water usually within a week to as late as two months old, depending on water accessibility and the volume of milk obtained from its dam.

Creep feed can be provided as early as a week of age, but in practice most foals consume little creep feed until they are one to two months old. Creep feed is a balanced grain mix comprised of processed grain plus added protein, mineral and vitamin to provide about 16per cent crude protein, 0.8 per cent calcium and 0.5 per cent phosphorus. Special feeders for single foals, or

feeding areas for suckling foals, can be built or bought, which prevents the dam from eating the creep feed. Roofs over the creep feeder reduce feed spoilage.

A rule of thumb for feeding light horse foals is 1 lb (0.5 kg) of foal ration per month of age up to four months old. For example, a one-month old foal should receive 0.5 kg (1 lb) per day; a two-month old foal should eat about 1 kg (2 lb) per day and so on. After four months of age, maintain the feeding rate at a constant amount of 2 to 2.5 (4 to 5 lb) creep feed or commercial 16 per cent foal ration per foal per day. Draft horse foals will typically eat about 50 per cent more creep feed per day than light foals. For example, draft foals would receive 0.75 kg (1.5 lb) per foal daily to maximum of 3 kg (6 to 7 lb) per foal per day at four months old.

Group-fed foals should be fed at the same rate (amount of creep feed required (in lbs or kg) per foal times the number of foals), with the creep feed spread evenly over the feeding area so that all foals have access to the feed. Discard any uneaten creep feed daily and especially if it gets wet. When foals consistently consume all of the creep feed over a period of days, the amount fed can be increased in 0.5 lb (0.25 kg) increments per foal per day every three to five days. The amount of creep feed allotted daily to a foal should be divided into at least two meals. A foal getting a total of 4 lb of creep feed per day can be fed two separate meals of 2 lb creep feed, one in the morning then again in late afternoon. Ideally grain should be fed more frequently than twice daily. Free choice grain feeding, where grain is available at all times, is never recommended for horses, including foals. Overeating of grain by foals can lead to enterotoxemia and sudden death.

Creep-fed foals benefit from less stress at weaning because of an access to a nutrient source as the dam's milk supply wanes in late lactation. Providing the foal with a creep feed or commercial foal ration designed for growing horses helps sustain a uniform growth rate and provides the owner the opportunity to accustom the foal to human contact. At feeding, the foal can be checked for clinical abnormalities, assuring that any health issues are dealt with quickly.

Weanling Horses

Foals are typically weaned between three and six months of age, largely depending on birth date. Foals born early in the year are often left on the dam longer because pasture is available. Foals born in spring are often weaned in late summer and early fall. Weaning during warmer fall weather reduces the dual stress of weaning and cold temperatures. The method of weaning can be abrupt or gradual. Gradual weaning allows visual contact of the foal with its dam with increasing periods of

physical separation of foal and dam so that the foal cannot suckle. Owners of several foals of similar ages often choose abrupt separation of foal from its dam. The presence of companion foals reduces the stress of abrupt weaning seen in single foals.

A critical management period for the foal is the post-weaning period. Feeding, housing and herd health programs must be considered well in advance of weaning. Unrestricted movement is fundamental in the growth and development of the foal. At weaning, a large paddock with a shed and automatic watering bowl is preferred housing. It is useful to expose the foal to the weaning facility while it is still with its dam. The dam will teach the foal the location of the water source, feed bunk and shed. Group weaned foals appear to learn from each other. Foals require less bunk space and shed space than mature horses because foals have a weak pecking order. For guidance, each mature horse needs about 1 m (3 ft) bunk space and 9 sq m (27 sq ft) shed space.

Grouped foals can be fed large square bales broken into flakes and put into bale feeders. The leafy portion of hay should be readily accessible to the foal, which may require “fluffing” up the hay periodically with a fork. Many designs of bale feeders are available. Plastic tombstone or round bale feeders with no vertical bars work well for foals. Choice of grain feeder depends on number of foals to be fed. Grain can be fed to single foals using wall or fence mount feeders. Grouped foals can be fed using home built or commercial bunk or trough feeders. The feeder should be high enough to prevent knee injuries, have no protruding, sharp edges and should not be easy to tip. Foals will step into feeders that are too low. Feeders made of fragile material will eventually break, leading to the possibility of leg injury.

A feeding program for weanlings should be based on feeding unrestricted amounts of good-quality hay (alfalfa or alfalfa mix) with a controlled amount of concentrate/grain mix. Light horse foals (QH type) grow well when fed a diet of good-quality alfalfa-mix hay with 1.75 to 2.25 kg (4 to 6 lb) grain mix per day. High fat diets (10 per cent) have been suggested for breeds and lines of foals prone to bone developmental disorders. The grain mix fed to weaned foals must contain sufficient mineral and vitamins. In addition to hay and grain mix, weaned foals should receive free-choice access to iodized or trace mineralized salt and access to water.

Foals that have not received creep feed during their suckling period must be slowly accustomed to a high-quality hay and grain mix diet. Good-quality leafy alfalfa-grass hay is palatable to most foals, but foals may reject grain if they are unfamiliar with this type of feed. For foals that reject grain mixtures, incorporating some whole oats with the grain mix or pellet may help start the foal on the grain mix. However, eventually transitioning to the balanced grain mix is desirable.

For light horse foals weaned at about four months of age and unaccustomed to grain, start feeding about 0.5 kg (1 lb) grain per foal in the morning. If this amount of grain is totally eaten by late

afternoon, offer another 0.5 kg (1 lb) grain. When the foal begins to eat the morning and late afternoon grain meals, add a third feeding of 0.5 kg (1 lb) grain at noon or, if that is inconvenient, increase the amount of grain fed to 0.75 kg (1.5 lb) at each morning and late afternoon meal. Feeding more meals per day is more desirable than feeding more grain per meal. When the foal eats up all of the grain offered at each meal, the amount can be increased again by 0.1 to 0.25 kg (0.25 to 0.5 lb) at each meal until the foal is eating 2 to 2.5 kg (4 to 6 lb) grain per day. Show foals are often fed much more grain than this to fit and fatten them. However, a high grain diet increases the risk of bone developmental problems such as physitis, osteochondrosis and flexural limb deformities (also known as contracted tendons) on foals. Average daily gains (ADG) for foals of given mature weights should not exceed those given in the NRC (2007) publication because more rapid daily gains can predispose to bone growth disorders

Yearling and Two-Year-Olds

Most yearling horses in Saskatchewan spend their summers on pasture. The amount and quality of the pasture will determine the growth rate of the yearling. Grain may need to be fed only if the pasture is poor. Mineral-vitamin supplement and iodized or trace-mineral-fortified salt should be fed free-choice. Non-worked long yearlings (18-month-old horses) can be fed good-quality hay (alfalfa-mix hay) alone or good grass hay plus a small amount of grain (2 to 4 lbs) during the winter. Non-worked horses can be maintained on good pasture without grain. Two-year-old horses in training spend little time on pasture and need to be fed hay and a grain mix (Table 13) to meet the extra nutrients needed for work.

Worked Horses

Work by mature horses largely entails the expenditure of energy with minor increases in the requirements for protein, potassium, sodium and chloride to offset losses in sweat. The most difficult aspect of feeding working horses is trying to define what amount of work they do. Work and exercise is often used synonymously for most recreational horses, but not for draft or performance horses. The intensity of and time spent in work/exercise are the main factors that determine energy expended in work. Intensity is affected by speed of work and terrain. Other factors more difficult to quantify are fitness of the horse, ability of the rider, weather conditions, and weight of horse and/or rider.

The 2007 National Research Council Requirements of Horses categorizes exercise or work as light, moderate, heavy and very heavy based on the criteria given in Table 14.

Table 14 : Classification of Work/Exercise Type

Category	Heart Rate (beats/ minute)	Type of Work	Example Event Type
Light	80	1 – 3 hrs/wk mix of walk and trot	Recreational riding Show horses
Moderate	90	3 – 5 hrs/wk, 30% walk, 55% trot some canter, jumping, cutting, reining	School horses Recreational/show riding Ranch work
Heavy	110	4 – 5 hrs/wk, 20% walk, 50% trot, 15% canter, 15% gallop, jumping, pulling events (draft)	Ranch or Farm Work Polo, Show horses Eventing; Racing
Very Heavy	110- 150	1 hr/wk speed work, 6 – 12 hrs slow work (draft horses)	Racing Three day events Farm work (draft) – plowing

Table 15. Daily nutrient requirements needed by a 600 kg horse for maintenance and for exercise

	DE (Mcal)	CP (g)	Potassium (g)	Sodium (g)	Chloride (g)
MATURE HORSE					
Idle	20	756	30	12	48
Light	24	839	34.2	16.7	56
Moderate	28	921	38.4	21.3	63.9
Heavy	32	1034	46.8	30.6	79.8
Very heavy	41.4	1205	63.6	49.2	111.6
TWO-YEAR-OLD – body weight gain 0.22 kg/d, actual weight 515 kg, estimated mature weight 600 kg					
Idle	22.4	924	26.4	10.5	42.5
Light	26.1	995	30	14.5	49.3
Moderate	29.8	1066	33.6	18.5	56.1
Heavy	33.5	1162	40.8	26.5	69.8

Very heavy	39.0	1309	55.2	42.4	97.1

To calculate the amount of grain needed by a working horse, you need to know the age of horse (two years old or mature), and type and duration of work. Using this information, the additional energy needed by the horse is calculated per week based on the amount of work the horse is doing. It is best to calculate energy requirements over a week of activity rather than by day to avoid erratic swings in diet.

Occasionally, a grain meal is missed for some reason. No attempt should be made to make up for the missed meal. Ignore this meal and feed the horse its usual amount at the next meal. Doubling the amount of grain fed can lead to digestive upset or laminitis (founder).

Heavily grained horses should be watched for inappetence or going off-feed. Feed refusal is associated with illness, unpalatable feeds, lack of water or boredom with the diet.

Pregnant and Lactating Mares

Pregnant mares' nutrient requirements are lower than mares that are lactating (milking). The fetus is small until about its seventh month of development, after which its size and weight increase exponentially to term. Up to the fifth to sevent month of pregnancy, mares in good body condition can be fed similarly to mature, idle horses. Mares can be kept on good pasture with a mineral-vitamin mix plus salt. Going into fall and winter, a suitable diet for pregnant mares is good hay, a mineral-vitamin mix appropriate for the type of hay fed and salt. In the last trimester of pregnancy, which often coincides with winter months or early spring, mares will require a diet with slightly more energy, protein, calcium and phosphorus. A good hay choice for late pregnancy is alfalfa-grass hay with a 1:1 calcium-phosphorus mineral fortified with trace minerals and vitamins, and salt. As long as the mare is in good body condition, grain mixtures should not be required. However, thin mares may require grain in addition to good-quality hay.

After foaling, the mare that is producing milk has an increased need for energy, protein, calcium and phosphorus. Milk production by mares is determined by genetics, but a rough estimate is that most light and draft breeds produce about three per cent of their body weight in milk daily. Pony mares produce more milk at rates of about four per cent of their body weight in milk. A 600-kg QH mare is expected to produce about 18 L (about 4 gal) of milk per day. Milk production by the mare peaks at about four to six weeks of lactation, then gradually declines through the third month to nearly negligible by the sixth month of lactation.

Good-quality hay, grain mixtures containing supplemental protein, mineral and vitamin are needed for mares foaling early in the year (winter and spring), whereas mares foaling on lush pasture will

do remarkably with only supplemental mineral-vitamin mixes and salt. If pasture is sparse, supplemental good-quality hay and grain fortified with mineral-vitamin mixture will be needed. Weight loss during lactation may reduce re-breeding success.

SPECIFIC FEEDING SITUATIONS

Orphan Foals

Orphan foals can be reared successfully with diligent care and feeding. It is critical that the foal receive colostrum (first milk) within the first 12 hours after it is born. Some breeding farms routinely collect colostrum from mares and may have spare colostrum available for use. If colostrum is not available, hyperimmunized equine serum should be administered. After the first 12 hours, the orphan can be fed mare's milk if available, but more often two per cent fat cows' or goats' milk, to which 40 ml of 50 per cent dextrose per liter of milk can be used. Mare's milk is high in lactose and relatively low in fat, which is why only low-fat milk should be used. Foal milk replacer designed for foals can also be used, but is often difficult to acquire. High-quality calf milk replacers based on milk products can also be used, but replacers based on soybean meal or distillers grain are not desirable. The composition of the dry replacer should be about 20 per cent protein, 15 per cent fat and less than 0.2 per cent fiber. If possible, grafting a foal onto a surrogate mare is ideal and will reduce the work associated with feeding orphan foals.

A typical feeding regimen for orphan foals is to bottle feed 250 to 500 ml of milk using a lamb nipple with a widened hole every half hour to hour, or whenever it is hungry. The milk can be warmed to room temperature. After one to two days of age, the foal can be fed hourly for about the next week. The foal can be trained to drink milk out of a pan or pail, which will reduce the man-hours needed. As the foal gets older, it can drink cold milk with no adverse effects. Feeding equipment should be washed between feedings to reduce contamination. The foal should be started on replacer or foal ration pellets as early as a week of age, and offered leafy alfalfa hay to nibble on. A companion such as a goat can be invaluable in teaching foals how to eat hay and pellets and to keep it company. Otherwise, foals will imprint on the human, which can create behavioral issues later in life.

Normal Feeding Behaviour of Horses

Horses are first and foremost grazing animals, so they have an innate desire to eat in a position similar to grazing. It is normal for a horse to pull its hay out of the manger or bale feeder and eat it off the floor. The only risk to the horse is fecal contamination of feed, which can increase intestinal parasite transmission.

Horses prefer shorter, younger swards of grass rather than older mature stands. As they graze, they take a bite of feed then move forward a step or two, followed by another bite of grass. Horses can walk up to 3 km a day while grazing. Because horses move so much when grazing, they trample up to 60 per cent more grass than cattle. The grazing rate and time spent grazing by horses are dictated by the quality of the pasture. Horses will graze for 10 to 18 hours daily to meet their nutritional needs. Horses graze for longer periods in a group than alone. Lactating mares spend more time grazing and eating than other classes of horse. Horses spend less time grazing in hot weather, so in summer, dusk (5 to 9 P.M.) and early morning (5 to 9 A.M.) grazing accounts for up to 50 per cent of the time spent grazing to avoid biting flies and mid-day heat. As pasture matures, the amount of time spent on pastures lengthens to meet nutrient needs.

Meal duration in horses depends on the diet. On pasture, meals can last a few minutes to a few hours. Meals of hay or straw are two-and-a-half to three hours long compared to less than a half hour taken to eat hay-grain meals. Horses eat grain about three times more rapidly than an equal amount of hay. Crushed or pelleted grains are eaten more rapidly than whole grains. Diets high in grain are eaten rapidly, which leaves lots of boredom time for stabled horses. Boredom can lead to vices such as wood-chewing and cribbing.

Age affects the amount of feed eaten. Young horses eat more per unit of body weight (up to three per cent BW) than mature horses (usually 2.5 per cent BW). For this reason, hay (or good pasture) should always be available to weanling and yearling horses.

A group of horses is any unit of two or more horses. Horses housed in small paddocks or pens become more aggressive with each other at feeding, so should be separated into appropriate numbers for the area of the pen and according to ages. Weanlings should be fed separately from yearlings, which should be fed apart from mature horses. Lactating mares with their foals should be fed separate from idle horses. Individual feeding containers placed at appropriate distances are often needed when feeding grain to grouped horses. Recommended hay feeder space is 10 to 15 m (30 to 50 ft) for group-fed horses. However, studies have shown that spacing is less important to horses than feeder arrangement. Feeders placed in a triangle allow submissive horses to feed more comfortably than those in rows.

Horses have strong feed preferences. Some tastes are innate: horses prefer sweet to salty and bitter tastes. Thus sugar or molasses is used to mask unpleasant tasting feeds or medicines. Other feed preferences are learned during growth. Mature horses appear to favour oats, but foals reared in regions where corn is fed prefer it to barley, whereas foals accustomed to barley prefer it to corn. Feed preferences are significant for owners who transport their horses to shows or

competitions where local feeds may differ to the feeds the horse is used to, so a few bales of hay should always be carried along for this reason.

Abnormal Feeding Behaviour of Horses

Undesirable behaviours are called vices. Feeding vices include greedy-eating, coprophagia (manure-eating) in older horses and wood-chewing. Greedy-eating can be innate or learned. Horses that must compete for feed in early life may learn to gobble their feed, especially if it is grain. This can reduce digestive efficiency and can cause colic due to excess swallowed air. Adding large rocks to the manager can reduce the speed at which the horse can eat grain. Similarly, meshed hay nets reduce the speed at which horses eat hay. Extruded feeds are eaten more slowly than pellets.

Manure-eating is normal in foals under two months of age. The foal only eats its dam's feces. It is the mechanism by which the foal populates its hindgut with bacteria that will be needed for digestion of forages. The only risk posed with manure-eating is contamination with parasite eggs if the foal's dam has not been treated for intestinal parasites. Manure-eating in older horses is abnormal and signifies one of two things: not enough feed is available to satisfy the horse, or the feed is low in fiber and protein.

Wood-chewing may be normal in young horses whose teeth are erupting. Wood-chewing generally does not involve swallowing the wood. In older horses, it may signify boredom or a diet that is too low in fibre content (pelleted feed). Horses increase wood-chewing during cold, damp weather. Using aversion therapy – for example, painting wood with bitter-tasting products – has low success. If diet is the problem, adding long hay at the rate of at least 1 kg/100 kg body weight may be beneficial. Often there is no underlying cause, but it is wise to check the diet to confirm there are not deficiencies.

Ground-eating is called geophagia and is uncommon. Geophagia may be normal in feral horses. Usually no cause can be determined in domesticated horses, but geophagia has been reported in horses that were deficient in sodium (salt), phosphorus or other minerals.

MANAGEMENT

Management decisions depend on several factors: the number of horses, type of horses, available facilities and land base. One horse will require less decision making than 50 horses. Brood mare facilities require different decisions than racehorse stables. A facility with well-built barns and pens is different than a facility with only a shed. A land base that supports hay and grain harvest differs to one with a limited land base that requires feed purchase.

Housing is one element of management. Horses that will never be worked or used have no fundamental need for barns or sheds. Idle horses in good body condition need protection from wind in winter, but that can be achieved by sheds or even bluffs of trees. South-facing three-sided sheds are suitable for well-fed horses. The shed should be built on high ground to reduce water run-off into the shed. Asphalt tiles are preferred for roofs since tin and aluminum can be noisy during rain and hail storms. Sheds should be bedded with straw. A manure pack for lying on can be a good insulator against the cold ground in winter. No feeding fixtures should be used in sheds used for groups of horses. Injury can occur during feeding and horses can get cast under or on the feeder.

Horses should be checked daily when they are kept outdoors. It is easy to miss illness or injury in outdoor-housed horses. A heavy winter hair coat in winter can mask thinness, so it is a good management practice to palpate the horse's rib cage, neck and spine at least weekly to evaluate body condition. A scruffy, flea bitten hair coat and an increase in self-grooming can signify the presence of lice.

Group-fed horses need plenty of space for feeding and activity. Dominance is an important issue in adult horses. Typically, one horse will attempt to control the feeding and resting areas, so it is important that sufficient area is available for escape by submissive pen-mates. Group horses by size. Weanlings should be separate from yearlings, which should be kept separate from mature horses. Stallions usually are kept alone, although stallions have been grouped successfully during winter when mares are kept at a distance. Ponies often live compatibly with mature light horses, but should be checked regularly. Fillies and colts can be grouped together until about 10 to 11 months of age, but should be separated when sexual activity becomes apparent.

Outdoor mangers should provide about 1.5 m (5 ft) of feeder space per horse. Effective feeders can be made from large tractor tires sliced in half like a bagel. For group-fed mature horses, feeders should be placed about 10 to 15 m (30 to 50 ft) apart. If ground feeding grain or hay, provide as many feeding spots as the number of horses plus one and shape feeding spots into a triangle. This will allow even timid horses to feed. A simple method of feeding grain is to secure shallow rubber buckets to alternate fence posts.

In most instances, a barn is needed for horses that will be ridden or trained. Standing (tie) stalls have been successfully used for mature horses. Usual dimensions of tie-stalls, including the manger used for adult light horses, are 1.5 X 2.7 metres (4.5 to 5 ft X 8 to 9 feet). Box-stalls for light horses can range in size from 3 to 4 sq m (10 X 10 ft, 12 X 12 ft etc). Larger box-stalls are needed for draft horses, broodmares and stallions. Typically, a 4 X 4 metre square (14 X14 ft) stall is desirable. In box-stalls, corner mangers and feeders are most effective.

Mangers for hay should be placed at shoulder height of the horse to reduce inhaling dust. Horses prefer to eat off the floor, but mangers reduce hay waste and fecal contamination. Hay nets can be used but must be hung high enough to avoid having the horse accidentally get its hoof and leg into the net if it paws while it eats. Corner tubs, rubber buckets and tubs with rounded edges help reduce injuries.

Small salt blocks (1 kg) can be fed in the barn using specifically designed feeders that can be hung on the wall at a height easily reached by the horse, including foals. In box stalls, watering bowls are best placed slightly below shoulder level on walls opposite to feeders. This reduces dipping of feed, which dirties the water bowl, but geriatric horses may benefit from having the water close enough so that they can moisten feed during chewing. Automatic watering bowls inside and outside of buildings should be checked daily to ensure they are functional.

Winter Feeding

Cold weather can increase energy and, therefore, feed needs by 25 to 50 per cent. The temperature comfort zone of horses is the temperature to which the horse has been exposed for the past two weeks. In summer, the comfort zone is quite different to mid-winter. As temperatures fall in winter, the horse gradually adapts to the cold over a period of two to three weeks. The comfort zone of the horse in mid-winter can range from +10°C to -25°C. Adaptation by the horse to cold occurs through a change in metabolic rate and by growing a longer and thicker hair coat.

Mature horses in good body condition tolerate cold weather better than weanlings, thin horses and old, thin horses. The skin and hair coat of a weanling are thinner and less dense than adult horses, which reduces their cold tolerance. Fat is a good insulator, which is why skinny horses are less tolerant of cold than those in good body condition. Horses older than 20 years of age typically have poor dentition (teeth), which reduces their ability to chew and digest feed efficiently, which aggravates their tolerance to cold.

The immediate response of the unadapted horse to a sudden drop in temperature is to eat more. Good-quality hay that is leafy and contains at least eight to 10 per cent protein is needed for mature horses. Young horses will need leafy alfalfa-grass hay with at least 12 per cent protein, and thin and old horses will need good leafy hay with 10 to 12 per cent protein content. Over-mature hays have a low digestibility, as well as a low nutrient content.

Winter grazing is inadvisable for horses. Forage, left on pasture and hay fields, is old poor-quality hay, poor in nutrient content and digestibility. The horse has to paw through snow to eat a few blades of this poor hay. The energy cost of work (pawing) is often more than the energy obtained from eating this poor-quality feed. Weight loss is inevitable.

Disorders Related to Nutrition

Laminitis, also known as founder, is a painful disease that is a result of the detachment of the laminae of the first phalanx (toe bone) to the hoof wall. The condition can be acute (sudden) or chronic (long-term). The acute form is a veterinary emergency. There are several causes of acute laminitis, but the main nutritional cause is eating too much grain or other rapidly fermentable carbohydrate. Other causes are equine metabolic syndrome, insulin resistance, Cushing's disease, concussion to the hoof and endotoxemia. Horses can only tolerate high grain intakes if they are gradually given increasing amounts of grain over a period of time to allow the bacterial population of their intestine to adapt.

Grain meals should not exceed 2 g starch/kg body weight (1.2 kg starch per meal for a 600 kg horse). Oats contains about 50 per cent starch and corn about 65 per cent starch, so 2.4 kg oats or 1.8 kg corn are the maximum amounts that a 600 kg horse can be fed per meal. Horses prone to founder (EMS, insulin-resistant horses) should receive less than 0.3 g starch/kg BW or about 180 g starch per meal. This is roughly 0.36 kg (0.8 lb) oats and 0.28 kg (0.6 lb) corn.

All grain bins and containers should be kept tightly closed to avoid accidental over-eating of large amounts of starch. Horses prone to grass founder should be limit grazed to keep intake of non-structural carbohydrates (sugars, starch) and fructans in pastures as low as possible (see energy section). Similarly, soaking hay for at least 30 minutes will reduce non-structural carbohydrate content of hay. The nutritional management of horses who have laminitis or are prone to founder includes: keeping the horse's body weight at a normal body condition score (five to six), feeding minimal amounts of starch (grain) in the diet and limiting access to fructans (lush pasture).

Gastric ulcers are common in performance horses and are frequently diagnosed in horses in training, fed high grain rations and kept indoors. However, gastric ulcers have also been reported in broodmares kept solely on pasture. There are many causes of ulcers, but diet and feeding practices appear to be contributory. Low-roughage, high-grain diets fed intermittently are nutritional conditions that may predispose to gastric ulcers. Grain meals should not exceed 1 g starch/kg body weight (0.6 kg starch per meal for a 600 kg horse) to reduce the incidence of gastric ulcers in horses.

Colic is a symptom, not a disease, and refers to generalized abdominal pain. Symptoms include elevated heart rate, sweating and rolling. Colic can occur from a multitude of causes, but the most common nutritional causes are sudden changes in amount of feed (especially grain) and type of feed provided, high intakes of grain (more than 5 kg per day), insufficient forage or pasture, and use of indigestible feeds. Gas colic can occur with sudden switches in diet such as a sudden increase in grain or an abrupt switch from grass to alfalfa hay. Impaction colic can occur in horses fed poor-

quality hay (straw, overmature hay), especially if sufficient water is unavailable to horses with poor teeth. The dry digesta accumulates in the intestine, compacts, distends the gut and causes abdominal pain.

Heaves**,** also known as recurrent airway obstruction, is a respiratory condition triggered by allergens in mouldy hays and straws. This is a condition of horses older than four years. Symptoms occur most often in winter and spring in horses housed in barns. The most common cause is stable dust, which is made up of airborne fungi, dust mites, endotoxin and inorganic compounds introduced into the stall air from mouldy hay and bedding. Ideally, horses with heaves should be kept outdoors and fed clean hay with little mould and fungi. Allergens in hay can be reduced by soaking hay in water for at least 30 minutes.

Growth disorders in foals can be congenital (at birth) or developmental (during growth). Congenital conditions include angular limb deformities (knock-knees) and flexural limb deformities (contracted tendons). Congenital angular limb deformities occur as a result of incomplete bone formation in the small bones of the knee or hock, joint laxity, or mal-positioning in the uterus. Joint laxity is common in newborns but as supporting structures strengthen over a period of days, most abnormalities disappear or look less apparent. Mild to moderate knock knees are not uncommon in newborns and typically correct over a short period of time. Any severe knee deformity should be seen by a veterinarian to determine if the deformity is correctable or not.

Tendons do not contract so the condition known as contracted tendons is more accurately called a flexural limb deformity (FLD). Congenital FLD are those conditions present at birth and may be the result of mal-positioning of the foal in the uterus, nutritional deficiencies or excesses, plant toxins and, perhaps, infectious diseases. TH-MSD (see iodine section) causes leg deformities due to tendon rupture, as well as abnormalities in jaw development.

Developmental bone disease in weaned foals includes physitis, acquired FLD (contracted tendons) and osteochondrosis (OC). Developmental bone disease (DOD) is uncommon in feral horses but occurs in 25 to 35 per cent of growing horses in North America. It is most commonly described in light horse breeds (Quarter horses, Thoroughbreds, Paints, etc.) and appears to have an inherited predisposition. Physitis usually occurs in the fastest-growing foal in the group. It can occur in suckling foals but most often is seen several weeks after weaning. The joints affected are the fetlock, followed by the knee and the hock. Physitis is observed at the fetlock between –three and six months of age and at the knee from six to 24 months. Clinically, physitis appears as a firm, warm enlargement in the area of the growth plate of these joints. Fetlocks take on a hourglass shape, whereas the distal radius (at the knee) develops a convex contour. The foal will resent full or forced flexion and may show mild lameness. In addition to genetics, nutritional imbalances may increase

the risk of physitis. Excess energy intake, calcium and phosphorus imbalance, and copper deficiency have been implicated. The nutritional management of physitis includes the provision of a normal but controlled feeding program of good-quality hay with limited amounts of grain mix or commercial foal rations balanced in minerals and vitamins. Exercise should be limited, and hooves should be trimmed if needed.

Flexural limb deformities are defined as deviations of the limb in the sagittal (midline) plane with a persistent hyperflexion of joint areas. Acquired FLD often occurs secondary to pain associated with physitis, OC, chronic joint infection or soft tissue damage. It has been observed following compensatory growth, which occurs during seasonal growth spurts and following a period of nutritional deprivation due to inadequate feed intake or illness. A low heel, rapid growth rate and inadequate exercise may predispose to occurrence of FLD. Clinically, acquired FLD usually presents as an upright fetlock/pastern joint, with knuckling at the fetlock, and reduced activity by the foal. The nutritional management of FLD includes controlling hay and grain intake. It is advisable to feed hay containing a moderate energy content; for example, using grass-legume instead of straight legume hay. A balanced grain mix or commercial foal ration should be fed in controlled amounts to allow normal or slightly slowed rates of weight gain. Many foals with FLD and physitis are growing faster than normal, so feeding to grow “normally” will be slowing their current growth rate. Exercise should be controlled but not restricted.

There is no guaranteed nutritional method to prevent congenital or developmental bone disorders in foals, but starting with dams and sires with a known history of producing sound foals is basic. The pregnant mare should be fed a diet adequate in energy, protein, calcium, phosphorus, trace minerals (especially copper), and vitamin A and D that will keep her body condition between five and seven. Avoid high-nitrate feeds such as oat hay, hays with endophyte or mould, and water that is high in nitrate. The suckling foal should have access to creep feed and a vitamin-mineral supplement while suckling. After weaning, high-quality hay with a grain mix containing adequate amounts of vitamins and minerals should be fed. The amount of grain fed should be controlled. Light horse weanlings (mature weight 500 to 600 kg) should be limit fed grain (suggested amount not more than 3 kg grain daily) between the ages of six and 12 months of age in combination with good-quality hay.

FEED SAMPLING METHODS

A representative sample is essential for an accurate sample. Hay samples should be taken with a hay sampler. At least 20 bales in a stack should be sampled and the samples should be taken at many different sites of the hay stack. Sample each stack with different hay sources. Hay analysis may be uneconomical for small, frequent purchase, but is basic to purchases of large amounts of

hay. Grain is sampled with a grain probe or can be sampled by grabbing numerous handfuls of grain as the truck is being unloaded.

Feed samples can be submitted to a commercial feed testing laboratory, which are listed at http://www.agriculture.gov.sk.ca/Default.aspx?DN=4a990f27-0811-4fe1-b891-7c812fc984fa.

CONVERSION FACTORS

Units	Multiplied by equals	Units	Multiplied by equals	Units
pound (lb)	0.454	kilograms (kg)	2.2	pound (lb)
ounce (oz)	28.4	gram (g)	0.0035	ounce (oz)
Canadian gallon (gal)	4.55	liter (L)	0.22	Canadian gallon (gal)
US gallon (gal)	3.78	liter (L)	0.26	US gallon (gal)
Canadian bushel (bu)	36.4	liter (L)	0.0275	Canadian bushel (bu)
calorie (cal)	4.154	joule (j)	0.239	calorie (cal)
mile (mi))	1.609	kilometre (km)	0.62	mile (mi)
acre (ac)	0.405	hectare(ha)	2.47	acre (ac)
ppm	1	mg/kg	1	ppm
ppm	0.0001	%	10,000	ppm