Equine

Better Nutrition for a Better Horse

CRF
LEADERS IN ADVANCED NUTRITION

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Introduction

Horses – and their close relatives such as ponies, donkeys and mules – are integral to cultures around the globe. Brought to North America by European explorers and settlers, the history of the horse ties both Old World to New.

The famous draft horses of France, the Percherons, served in battle during the Middle Ages and settled into farm work in the centuries afterward. Similarly, no picture of the American West would be complete without the cattle cutting and herding abilities of the Quarterhorse or the pre-telegraph messaging service, the Pony Express.

Today, horses and ponies are most likely considered companion animals. Their average lifespan of 25 – 30 years means they are with us for much of our lives, enabling us to build a long-term bond that we can't with our other animals.

Because your horse will be a part of your life for years to come, it is important that you help ensure your friend's longevity by proper care and feeding.

CRF's Long-Range Commitment to Equine Research

Our mission is to ensure that CRF research supports the development of equine feeds that address the needs of both the companion-horse owner and the professional horse industry alike. CRF has taken as its over-arching objective to improve the performance, health, economics and experience of horse ownership via CRF research-based programs. We take that mission a step further by transferring economic advantages to our customers and the nutritional benefits of our research to the horses they feed.

The Equine & Specialty Research Team has identified five specific equine categories that would provide the greatest benefit to our customers. We commit to sponsoring research in each of these areas over the next three to five years: • Performance Horses • Pleasure Horses • Breeding • Growing Horses • Senior Horses

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Digestive Physiology

The digestive tract of the horse consists of the mouth, esophagus, stomach, small intestine, cecum, small colon, large colon, rectum and anus. Each segment of the horse's digestive tract performs specific functions that are important in the digestion and absorption of nutrients as well as to the general well-being of your horse.

Food is ground in the mouth by cross action of the jaws. Saliva, which aids in moistening the food for mastication and helps food move down the esophagus to the stomach, is secreted into the mouth. There are three salivary glands in the horse's mouth, which can produce up to ten gallons of saliva daily. Saliva contains bicarbonate, which buffers or raises the pH of the stomach contents, providing protection from ulcer formation. Saliva also contains a small amount of the enzyme amylase; this enzyme breaks down starch and complex sugars into simple sugars for absorption in the small intestine.

The esophagus is a simple muscular tube that is between four and five feet long in the mature horse. Its function is to convey food from the mouth to the stomach. When a large piece of an improperly chewed feedstuff lodges in the horse's esophagus, it is called a choke.

The equine stomach is a weakly muscled organ and is used primarily as a holding vat. The capacity of the stomach depends on the size of the horse, but generally the range is from eight to 16 quarts. Hydrochloric acid and pepsin are secreted into the stomach; both initiate the breakdown or digestion of protein. Approximately 70 percent of the feed leaves the stomach within eight hours after it is eaten; the stomach empties completely within twelve hours after eating. However, large grain meals result in more rapid gastric emptying and food can begin leaving the stomach in as quickly as fifteen minutes after ingestion.

Because of the stomach's relatively small capacity and the rate at which food passes through it and the small intestine, it is advantageous to feed the working horse more than twice a day.

The small intestine is approximately 70 feet in length. It is divided in to three major segments – the duodenum, jejunum and ileum. Most digestion of sugars and starches from cereal grains such as oats, barley and corn occur in the first portions of the small intestine. The protein from cereal grains as well as that from protein supplements, such as soybean meal, flaxseed meal and cottonseed meal is also digested here. Vitamins and minerals from cereal grains, protein sources and vitamin/mineral supplements are also broken down in this part of the tract, Specific enzymes break down starch, sugar, fat and protein to smaller constituents, which are then absorbed across the intestinal wall in to the blood or lymph (fat) in the latter portion of the small intestine, along with the vitamins and minerals.

High starch/sugar feeds cause dramatic increase in blood glucose (glycemic response), causing dramatic increase in blood insulin levels and numerous adverse effects. Often the capacity of the small intestine to process sugar and starch is surpassed, resulting in sugar and starch passing into the cecum and large intestine, where the fermentation can lead to diarrhea, shifts in the microbial population and pH changes which can cause colic and laminitis.

The rate of flow in the small intestine is related to intake level of feed (large meal faster than small meal) and the physical form of feed (pellets faster than coarse grains and forage).

The cecum, or uppermost segment of the horse's large intestine, has a capacity of eight to ten gallons. It is here that microbial digestion, where bacteria and protozoa break down fibrous feedstuffs through a fermentation process, begins.

Microbial digestion continues in the large colon, which comprises right and left ventral colons and the dorsal colon. The ventral colons have a sacculated construction, which means they are made of a series of pouches. These structures are designed to efficiently digest large amounts of fibrous materials,

but these pouches can fill with gas and become twisted during the fermentation process if something upsets its proper function. The result can be a serious case of "twisted gut" or strangulation colic.

The microbial population of bacteria and protozoa become specific for digestion of the type of feed ingredients that the horse regularly ingests. Therefore, it is very important to change a horse's diet gradually in order to allow the microbes sufficient time to adjust to new dietary ingredients, or a digestive upset or colic can occur.

The cecum and large colon are important areas for transforming feed into energy for the horse. In both areas, large quantities of volatile fatty acids (acetic, propionic, butyric) are produced by bacterial action on carbohydrates. It is estimated that 30 percent or more of the energy requirement is provided by these volatile fatty acids for a horse on a typical hay/grain diet.

Bacteria and protozoa in these organs also create B-complex vitamins during the fermentation process, supplying some 30-40 percent of the horse's requirements for these important nutrients. B-complex vitamins and some minerals are absorbed in the large colon.

Protein that enters the lower digestive tract is broken down to ammonia and volatile fatty acids which are used to make microbial protein. There is no conclusive evidence to indicate that microbial protein is available to the horse.

The small colon is mainly the site of water absorption and formation of fecal balls or manure that are then passed out through the rectum and anus, completing the digestion process.

The amount of feed required for maintenance, growth and reproduction depends on how digestible it is. Processed cereal grains and protein concentrates such as soybean meal have the highest digestibility followed by good quality forages and then poor quality forages. However, the quality of the feed is more important than the physical form. In fact, CRF research shows there is no difference in the utilization of alfalfa hay when fed as long hay or pellets. It usually costs more to feed a poor-quality diet than one of higher quality because the horse receives fewer usable nutrients from the lesser- quality feed. In addition poor-quality grain may cause digestive upsets and other problems due to the presence of mycotoxins (mold toxins), and poor-quality forages have a greater risk of causing impaction colic.

Horses are susceptible to a variety of ailments, including colic, if they ingest toxic materials. The reason is a basic difference between the horse and ruminant animals, like cattle and sheep. With ruminants, food is passed from the esophagus into the rumen, where microbial activity can detoxify many toxins before they reach the small intestine for absorption. With the horse, the toxic material reaches the small intestine and is absorbed into the bloodstream before it can be inactivated by microbial action in the large intestine.

Feeding Guide

1. Establish a feeding program for the horse based on sound nutrition. Do not over-supplement. Too much supplement is wasteful, and some "tonics" may be harmful. Your cooperative's horse feeds contain adequate vitamins and minerals when fed as directed.

2. The feeding of horses requires good judgement. Each horse should be fed according to its individual needs and responses. Adjust the amount of grain fed for work, performance and body condition.

3. Regularity of feeding time is very important. Establish a routine for feeding the horse, preferably equal amounts of feed at least two times daily and at the same times each day. Feeding two or three times a day avoids overtaxing the horse's digestive system.

4. The total amount of ration fed each day should not fluctuate drastically. A rule of thumb is not to increase the horse's grain feeding by more than one pound per day.

5. A change in ration should always be gradual to avoid digestive disturbances. During the transition, integrate some of the new grain or hay into some of the present ration being fed, replacing 25percent of the old with new for the first two to three days, 50percent for the next two to three days, 75percent for another two to three days, so that by a week to 10 days, you have effected a total change in the feeding program.

6. Feed only top-quality feeds. Hay should be free of dust and molds.

7. Provide free access to clean, fresh water and salt at all times. Horses drink the most water when it is kept at temperatures between 45 and 65º F.

8. Feed boxes, hay racks and watering equipment should always be kept clean and sanitary. Unconsumed feed should be removed from the feed box before the next feeding.

9. Observe the horse's eating habits; most horses usually consume all of their grain portion within 30 minutes. If the horse does not readily begin eating, it should be watched closely for signs of problems. Spending a small amount of time each day observing your horse will help you detect problems early.

10. Some horses have the habit of eating their feed too rapidly which can lead to choking. This can be controlled by using large feed troughs, spreading the feed over the entire trough, lowering the height of the feed trough or placing a few large smooth rocks or salt bricks in the feed trough so that the horse is required to eat around them.

11. Before working your horse allow feed to be digested. If a horse is to be worked soon after feeding reduce the grain portion by one-half.

12. Do not feed grain to a heated horse nor allow uncontrolled water consumption until the horse is properly "cooled out". It is fine to offer the horse hay.

13. Be sure your horse's teeth have no sharp edges that may injure the inside of the mouth. Drooling, slobbering of grain or quidding of hay of feed are tell-tale signs. Consult your veterinarian.

14. To help save feed, improve body condition and reduce colic problems, consult with your veterinarian for a parasite control program.

15. If horses are group fed, separate timid ones from the group and give them special encouragement to eat.

Nutritional Requirements

A balanced horse feeding program must supply nutrients needed for one or more of the following: maintenance, growth, reproduction, lactation, and work or physical activity.

Body Maintenance

The basic requirement for maintenance is defined as the feed needed to maintain normal body functions at rest. The amount of feed needed for body maintenance is related to the horse's weight. A large horse requires more feed to maintain its body weight than a small horse. In addition to maintenance, extra feed must be supplied to support activity.

Exercise and ambient temperature fluctuations will alter the amount of feed necessary to maintain body weight. Carbohydrates and fats are the prime energy sources in horse feed. Work increases the need for specific vitamins, minerals and amino acids (protein) so your horse to metabolize carbohydrates and fats. The amount of feed is dependent upon the level of activity as illustrated below in Table 1.

Table 1 —
Suggested Daily Feeding Levels for Maintenance, Light, Moderate and Heavy Exercise[1] *(Per 100 lb. body weight)*

	Hay (lb)	Horse Feed[2] (lb)
Maintenance (minimum) Examples: stall confinement, docile temperament	1 to 1½	¼ to ½
Maintenance (average) Examples: moderate voluntary activity	1 to 1½	¼ to ½
Maintenance (elevated) Examples: nervous temperament, high voluntary activity	1 to 1½	½ to ¾
Maintenance + Light Exercise Examples: pleasure, occasional trail or show	1 to 2	½ to 1
Maintenance + Moderate Exercise Examples: schooling, frequent show or trail, light training	1 to 2	½ to 1
Maintenance + Heavy Exercise Examples: ranch work, polo, race training	1 to 2	1 to 1½
Maintenance + Intense Exercise Examples: racing, endurance, 3-day eventing	1 1½	1 to 1½

1 Based on Nutrient Recommendations of Horses, 6th Revised Edition, 2007.
2 Formulated with adequate protein, minerals and vitamins to meet requirements when fed with hay.

Growth

A young, growing horse requires more protein (amino acids), minerals and vitamins per unit of body weight than does a mature horse. Muscle development also requires good quality protein. High quality, well-fortified feeds are necessary for proper development.

Creep feeding a nursing foal will provide extra nutrients to support growth, and it accustoms the foal to eating dry feed. Creep feed could be started at three to four days of age. This is another example where daily observation will help make good judgements. You may need to increase the creep feed to the foal based on what you see. For example: a foal nursing a good milking mare will not need as much creep feed as a foal nursing a poor milking mare. Appetite and consistency of manure are good indicators of the foal's capacity to eat more feed. Avoid scouring, which may occur if too much creep feed is consumed. It is not recommended that intake of creep feed exceed 1.5 percent of body weight per day.

Approximately eight weeks after foaling, the mare's milks starts to decrease in quantity and quality. At the same time, the foal's nutritional requirements continue to increase.

Foal feed that contains 14 to 18 percent protein (with balanced amino acids) and is fortified with minerals and vitamins, will allow proper muscle and bone development. By 12 months of age, you can safely lower the foal's ration a 12- to 15-percent protein content.

The recommended daily amount of feed and forage for a foal is shown below in Table 2. At two years of age, the horse can be fed as a mature horse as outlined in Table 1.

Table 2 —
Daily Feeding Guide for Growing Horses

(Reasonable amounts of feed to offer)

Body Weight (lb)	Foal Feed1 (lb)	Good Quality Hay2 (lb)
200	2-3	1-4
400	4-6	2-8
600	6-9	8-12
800	9-12	12-15

1 High-quality horse feeds fortified with adequate protein, minerals and vitamins are necessary for proper development.
2 Offer hay free choice. Amounts listed are expected consumption levels.

Reproduction

1. Breeding – Balanced nutrition has a positive effect on breeding efficiency. A mare that is gaining weight or has a body condition of 4.0 - 7.0 is more likely to conceive than a mare that is under condition (body condition score less than 4.5) or losing weight. Obesity should be avoided. During the breeding season, the stallion may need additional feed due to increased activity.

2. Gestation – During the first nine months of gestation, the broodmare should be fed close to maintenance level to avoid obesity, but particular attention should be paid to the protein quality of the diet, as well as the balance of calcium and phosphorous and the levels of copper and zinc fed. Most fetal growth occurs during the last 2½ months of gestation. Increased fetal growth requires more energy, protein (amino acids), vitamins, minerals and water. It is important that the mare receives an adequate amount of a well-balanced diet to help ensure a strong, vigorous foal. Deficiencies of nutrients during gestation may impair fetal skeletal development and may also have an effect on the mare, leaving her in a thin condition. A lowered body condition, in turn, may reduce milk production for the growing foal. Excessive feeding in early gestation may result in obesity, which may increase the incidence of foaling difficulties. Mares should be kept fit and not fat, with a maximum body condition of 6.0.

3. Foaling Time – It is important that the foal receive colostrum soon (within 12 hours) after birth to help develop immunity against infectious diseases.

4. Lactation – This is one of the greatest nutritional stresses a horse will ever have. To help ensure maximum milk production, the lactating mare will require more feed of higher digestible energy and protein content than at any other time of its life. Mares can produce over 40 pounds of milk per day during peak lactation. Failure to meet the lactating mare's demand for all nutrients results in decreased milk production and weight loss. Mares are susceptible to colic after foaling. Therefore it may be wise to limit the feed for up to five days after foaling.

Table 3 —
Daily Feeding Guide for Mares During Gestation and Lactation[1] *(Percentage of Body Weight)*

	Hay (lb)	Horse Feed[2] (lb)
First 9 Months of Gestation	1 1/4 to 2	¼ to ½
Last 2½ Months of Gestation	1 to 1 1/2	½ to ¾
Lactation	1 to 2	¾ to 1½

1 Based on Nutrient Recommendations of Horses, 6th Revised Edition, 2007.
2 Formulated with adequate protein, minerals and vitamins to meet requirements when fed with hay.

Body Condition Scoring

Body condition is estimated based upon body fat, which is an indicator of stored body energy. The condition score system enables a comparison of animals based upon their relative differences in fat content. Knowledge of the animal's body condition or fat content enables a more accurate estimation of body weight.

Although primary scoring decisions are based largely on visual appearances from all four views (front, rear & sides), palpation is also helpful when determining a score, especially for horses with long hair coats. Under normal circumstances, all seven evaluation areas are given equal emphasis. The condition scoring system evaluates fat content and not quality or conformation. However, due to unique conformation problems such as: prominent withers, fat loins, weak top lines, injuries and the like, one or more criteria may be eliminated. In such instances, additional emphasis should be placed on remaining evaluation sites.

In 1983, Don R. Henneke, Ph. D., developed an objective, nine-category scoring system to evaluate a horse's body condition. Based on both visual appraisal and palpation of body fat, scores range from one for poor or emaciated to nine for extremely fat or obese (Table 4). Scores can be assigned on 0.5 unit increments. Veterinarians consider horses that fall between 4 to 7 on the Henneke scale to be in the acceptable range, with a 5 being the ideal score. All conditions for a given score must be met in order for an animal to be assigned that particular score. If one or more conditions for a given score are not met, the score should be adjusted upward or downward as indicated.

Regardless of the method used to determine body condition, remember the importance of maintaining a consistent record of your horse's weight. Knowledge of weight gain or loss is a valuable aid when evaluating your horse's body condition from a health and nutritional standpoint

Table 4 —
Body Condition Scoring System for Horses[1]

Score	Description
1 – Poor	Extremely emaciated; spinous processes, ribs, tailhead, tuber coxae and ischii projecting prominently; bone structure of withers, shoulder, neck easily noticeable; no fatty tissue can be felt.
2 – Very Thin	Emaciated; slight fat covering over base of spinous processes; transverse processes of lumbar vertebrae feel rounded; spinous process, ribs, tailhead, tuber coxae and ischii prominent; withers, shoulders and neck structure faintly discernable.
3 – Thin	Fat buildup about halfway on spinous processes; transverse processes cannot be felt; slight cover over ribs; spinous processes and ribs easily discernable; tailhead prominent, but individual vertebrae cannot be identified individually; tuber coxae appear rounded but easily discernible; tuber ischii not distinguishable; withers, shoulders and neck accentuated.
4 – Moderately Thin	Slight ridge along back; faint outline of ribs discernible; tailhead prominence depends on conformation, fat can be felt around it; tuber coxae not discernable; withers, neck and shoulders not obviously thin
5 – Moderate	Back is flat (no ridge or crease); ribs not easily distinguished but easily felt; fat around tailhead beginning to feel spongy; withers appear rounded over spinous processes; shoulders and neck blend mostly into body.
6 – Moderately Fleshy	May have slight crease down back; fat cover over ribs spongy; fat around tailhead soft; fat beginning to be deposited along the side of withers, behind shoulders, and along the sides of neck.
7 – Fleshy	May have crease down back; individual ribs can be felt, but noticeable filling between ribs with fat; fat around tailhead soft; fat deposited along withers, behind shoulders, and along back.
8 – Fat	Crease down back; difficult to feel ribs; fat around tailhead very soft; area along withers filled with fat; area behind shoulder filled with fat; noticeable thickening of neck; fat deposited along inner thighs.
9 – Extremely Fat	Obvious crease down back; patchy fat appearing over ribs; bulging fat around tailhead, along withers, behind shoulders, and along neck; fat along inner thighs may rub together; flank filled with fat.

1 Adapted from Henneke et al. (1983)

Equine Nutrition Guidelines for Life Stages

Foals

Foals should be allowed to nurse or be provided with sufficient high-quality colostrum to provide a blood antibody concentration of 800 mg/dl or higher by 12 to 24 hours of age. High-quality creep feed, fed at the rate of one pound per 100 pounds of body weight daily, should be provided to foals by three to four weeks of age. Soft, high-quality hay should also be provided by one month of age. Foals that are creep fed for at least one month prior to weaning may be weaned when the foal is 1) consuming at least four pounds of a high-quality commercial horse feed and 2) is at least three months old. This feeding recommendation is for light horse breeds.

Orphan Foals

An orphan foal can be the result of the dam's death, rejection, illness or lack of milk production. Sufficient colostrum should be provided within 24 hours of birth. For the first three months of the foal's life, feed a high-quality foal milk replacer as a substitute for mare's milk. Foal milk pellets can also be provided, as can a high-quality commercial horse feed can be fed. The weaning process may be started if the foal is at least three months of age and consuming at least two pounds of foal pellets or four pounds of high quality commercial horse feed. This feeding recommendation is for light horse breeds.

Weanlings and Yearlings

Maintain a steady growth rate to avoid developmental orthopedic disease (DOD). Use feeds with quality protein sources (soybean meal and guaranteed amino acids), high levels of trace minerals and vitamins, proper levels of calcium and phosphorus and low, controlled starch levels from feeds with fixed formulas. Provide a horse feed with an adequate protein level to meet total dietary protein requirements with available hay or pasture. Total dietary protein levels should be 14 percent for weanlings and 12 percent for yearlings.

Provide growing horses (three to 12 months of age) feeds with added fat and digestible fiber and a low level of non-structural carbohydrates or NSC (NSC = sugar plus starch), since high-NSC feeds have been linked to developmental orthopedic disease (DOD).

Higher fat feeds with added biotin, lysine, rice bran, flax seed, yeast culture and other digestive aids are recommended for weanlings and yearlings that are prepared for sales (increased weight gain, greater muscle development, improved hair coat and hoof condition).

Two-Year-Olds

Increase digestible energy intake from added fat and digestible fiber, control or limit NSC intake and provide sufficient levels of calcium, phosphorus and magnesium for bone remodeling. Total dietary protein level should be between 10 and 12 percent.

Pleasure Horses

Feed according to age and activity level to maintain desired body condition. Total daily feed intake (hay/pasture and concentrate) should be 2.0 to 2.5 percent of body weight, with at least 1 percent of this amount as forage (hay/pasture). Increase protein levels for more active horses, with a maximum dietary protein level of 12 percent for hard-working horses.

Feeds with added soy oil, biotin, rice bran, flax seed, yeast culture, organic trace minerals and other digestive aids are recommended to improve hair coat and hoof condition; they also reduce stressful conditions in the horse's hindgut.

Broodmares

Maintain proper body condition at all times with feed well fortified with vitamins and minerals. Feed slightly above maintenance requirements for digestible energy and protein until last trimester of pregnancy, at which time increase dietary protein to at least 12 percent through foaling and early lactation. Use a supplement or balancer pellet if less than four pounds daily of feed is needed to maintain good body condition.

Stallions

Feed a low NSC diet with added fat to maintain body condition and decrease colic risk and hyperactivity. Provide a feed highly fortified with vitamins and minerals during breeding season. Added fats with high omega-3 fatty acid content (soy oil, rice bran, flax seed and fish oil) can improve sperm quality in older stallions. Maximize feeding of good quality hay and pasture to maintain good body condition. Ensure a dietary protein level of at least 12 percent during the active breeding season.

Older Horses

Provide high calorie intake from feeds with added fat and digestible fiber to maintain good body condition with reduced hay consumption. Control NSC levels to minimize insulin resistance and colic risk and provide a dietary protein level of 12 percent. Provide processed hay (chopped hay or hay cubes) to allow consumption by older horse with reduced dentition.

Feeds with added soy oil, biotin, rice bran, flax seed, yeast culture and other digestive aids are recommended to improve fiber digestion, hair coat and hoof condition.

Performance Horses

Maximize caloric intake and muscle function with high fat, controlled NSC diets and high levels of antioxidants (vitamin E, vitamin C and selenium) to maintain active muscle tissue and immune system function. Increase nutrient utilization with digestive enzymes, yeast culture, organic trace minerals, probiotics and lecithin compounds. Good quality hay should be fed to maximize caloric intake. Provide additional electrolytes, two to four ounces daily to hard-working, heavily sweating horses. For timed events where excess weight can be a problem, limit hay to only 1 percent of body weight for three days prior to competition and feed hay in smaller, more frequent portions.

Draft Horses

Feed a low NSC diet to minimize colic risk with well-fortified vitamin and mineral content due to lower feeding rate than light horse breeds. Provide grass hay instead of alfalfa hay for horses with maintenance needs to provide fewer calories for prevention of excessive body condition.

For growing draft horses, provide a diet with low NSC content. A supplement or balancer pellet may need to be added to the overall feeding program to increase nutrient density (increased protein, vitamins and minerals) because of reduced grain feeding rate to maintain proper growth rate. Avoid excessive calorie intake and high starch diets.

For horses with PSSM (polysaccharide storage myopathy – also called EPSM) feed a diet with low NSC content, high digestible fiber and high fat content. Added fat or vegetable oil may be necessary for prevention of symptoms. Alfalfa and alfalfa/grass hays are preferred due to a lower NSC content than most grass hays. Avoid small grain hays such as rye, wheat, oat and barley and brome due to higher NSC content.

Ponies and Miniature Horses

Feed a low NSC diet with moderate fat levels due to high incidence of insulin resistance and easy weight gain. High levels of vitamin and mineral fortification are needed due to reduced feeding rates. Supplemental feed products with lower feeding rates and more concentrated vitamin and mineral levels provide for requirements without excessive caloric intake. Weight management programs with reduction of hay or pasture may be necessary.

Testing Hay and Balancing Rations

Forages vary widely in nutritional values. Two variables have the greatest impact on quality—the type of forage (legume, small grain, etc.) and amount of degradation during storage. It is important that you know the quality of the hay you're feeding, as well as how to use this data to properly balance your horse's diet. After all, how can you determine how best to supplement if you don't know what your horse is getting in the first place?

It is important that you provide a representative hay sample for an accurate nutrient analysis. For instructions on how to properly sample hay for analysis, go to www.equi-analytical.com for directions or consult your local CRF member feed supplier or local Extension agent. Some CRF member horse feed suppliers will have a hay probe that can be used to sample your hay.

Once you have a complete analysis of your hay samples, your CRF feed provider or local Extension agent will help you determine how best to balance your horse's ration.

Diseases of the Horse

Your horse's well-being requires regular care beyond proper nutrition. Pay close attention for any signs of ill health and report these to your equine veterinarian immediately. Symptoms for specific conditions are outlined below, but in general, consult your veterinarian if your horse exhibits any of the following:

- Abnormal discharges from the eyes, nose or other body opening
- Foul breath
- Limping
- Loss of appetite or condition
- Violent head shaking or scratching, licking or biting any part of the body
- Roughened coat or hair loss
- Lumps or open sores

For further information on metabolic disorders, internal diseases, infectious diseases or parasitic diseases, go to the CRF website, www.crfarms.org. For developing a complete anthelmintic program based on local conditions, you should always see your veterinarian.

CRF recommends visiting the American Association of Equine Veterinarians' website, www.aaep.org, for complete guidelines on caring for horses of all ages and stages. Search for a health topic, ask a question in their "Ask a Vet" section or sign up for their online newsletter. As the world's largest professional association of equine veterinarians, the AAEP is committed to providing resources for the benefit of the equine industry and the backyard horse owner alike.

Nutritional Guidelines for Specific Conditions

Equine Metabolic Syndrome (EMS) and Equine Cushing's Disease (ECD)

Feed a low NSC diet (for reduction of hyperglycemia and hyperinsulinemia) for horses with EMS and ECD; feed should include high levels of antioxidants (vitamin E, C and organic selenium) to support immune system function, especially for ECD horses. Consider supplementation with extra magnesium (two grams per 100 pounds of body weight) and chromium (one milligram per 100 pounds of body weight) for horses exhibiting insulin resistance. A total diet with a low level of soluble carbohydrates is recommended, especially for horses where occurrence of laminitis is severe. Overweight horses should be kept off lush pastures, muzzled or managed with limited hay in a dry lot. Routine exercise and turnout are essential recommendations, as they will help to decrease insulin resistance and normalize blood glucose and insulin levels.

Diseases

Colic and Laminitis (Dietary Related)

Control NSC intake and provide additional calories from fat and digestible fiber sources. Limit pasture consumption during spring and early fall seasons due to high levels of plant sugars (fructans). Avoid small grain hays and pastures (oat, rye, wheat and barley) and fescue due to greater sugar content than other cool-season grasses (timothy, orchard grass, and Bermuda grass) and alfalfa.

Tying Up Diseases

Tying up can occur in any breed of horse, and there are many causes. The most common cause is sporadic tying up, which occurs in horses that are exercised beyond their level of fitness. This is usually seen when horses are not regularly exercised and then are overworked. Other causes of sporadic tying up may occur from electrolyte and hormonal imbalances, overfeeding without regular activity, and vitamin E and selenium deficiencies.

Genetic causes of chronic forms of tying up disease include Polysaccharide Storage Myopathy (PSSM), which occurs mainly in draft, Quarter Horse, and warm blood breeds. This type of tying up disease has been recently identified as an inherited autosomal dominant trait and is also known as Equine Polysaccharide Storage Myopathy (EPSM). PSSM causes defective carbohydrate storage and utilization and symptoms include muscle stiffness and cramping when exercised, lack of energy, poor performance, difficulty in backing, hind limb weakness and abnormal gait, and muscle loss, especially in the rear.

Recurrent Exertional Rhabdomyolysis (RER) is a separate autosomal dominant genetic form of tying up disease. RER occurs in Thoroughbreds and produces tying up symptoms due to abnormal muscle contractility that involves a disruption in availability of intracellular calcium. Symptoms include muscle stiffness and cramping when exposed to excitement or exercise.

Shivers is a neuromuscular disease that typically occurs in draft horse breeds, but can also present in Warmblood, Quarter-horse and Thoroughbred horse breeds. A high fat, low NSC diet provides better muscle function and produces fewer symptoms for these horses.

With all forms of tying up disease, feeds that are based on digestible fiber and fat with low NSC content are recommended. Alfalfa and alfalfa/grass hays are preferred due to a lower NSC content than most grass hays.

Minimize NSC intake by increasing caloric intake from fat and digestible fiber for horses affected with PSSM. This includes low NSC horse concentrates or feeds high in fat and fiber content, rice bran and vegetable oils. The most effective way to decrease dietary NSC content is to add vegetable oil. Keep increasing the fat content until the horse is free of symptoms for PSSM or shivers. A supplement or balancer pellet may be required to meet the vitamin and mineral requirements due to the low rate of concentrate provided due to the large amounts of oil fed.

Provide a diet low in NSC for horses with RER to reduce excitable behavior and incidence of symptoms. Feeding additional calming agents above required levels (magnesium and vitamin B1) might also reduce excitable behavior and symptoms in horses with RER.

Chronic Obstructive Pulmonary Disease (COPD) or Heaves

Minimize or eliminate dust and mold from the diet by utilizing feeds that reduce the amount of hay fed. Complete feeds with a high fiber content based on beet pulp or soy hulls, with a crude fiber guarantee of at least 15 percent can be fed safely with a minimum of hay (0.5% of body weight daily). Feed high quality hay soaked in water, chopped hay or hay cubes. Reduce environmental dust and mold by replacing straw bedding with wood shavings or provide pelleted wood bedding or processed paper-based bedding material. Increase ventilation in the stall and provide for as much turnout as possible. Complete feeds or supplements containing higher levels of omega-3 fatty acids (found in rice bran, soy oil, flax seed and fish oil) competitively inhibit activity of the cyclooxygenase enzyme, which is necessary for eicosanoid or prostaglandin production, and can be helpful in decreasing inflammation of the respiratory system.

Hyperkalemic Periodic Paralysis (HYPP)

A horse suspected of being N/H or H/H forms of HYPP should be on a low potassium diet. Select feed and hay with low potassium content (1.2% or less for total diet). Oats may be fed with a supplement pellet or a high fiber complete feed can be fed along with a limited amount of hay. Avoid potassium-containing electrolytes and mineral supplements, as well as molasses, orchard grass hay, alfalfa hay (baled, cubed or pelleted) or wheat bran, as they contain high levels of potassium.

Excitable Behavior

The exact mechanism or cause for excitable behavior in the horse is not known. Horses that are overfed and underworked can exhibit excitable behavior, as well as those that are stabled for long periods of time (as compared to horses allowed to graze for 16 to 18 hours daily). Horses may also exhibit stereotypic behaviors such as cribbing, wood chewing and stall weaving as a means to relieve stress. Feeding large amounts of grain is associated with increased gut acidity. High grain diets may cause pain due to increased gut acidity and ulcer formation, which can serve as a stimulus for stereotypic behavior. Excess grain can also lead to starch overload in the hindgut and can result in serious metabolic disorders such as colic, laminitis and insulin resistance. Reducing NSC and adding fat to the diet has resulted in lowered blood glucose and insulin levels and often effects calmer behavior in the horse. Feeds high in fat and digestible fiber are recommended, as fat and fiber do not increase blood glucose or insulin levels; neither do they contribute to increased lactic acid from fermentation in the hindgut. Select a horse feed with a low level of NSC and based on digestible fiber sources such as beet pulp, soy hulls, rice bran and alfalfa meal.

Equine Protozoal Myelitis (EPM)

EPM is a neurological disease. Diagnosis of EPM is based upon finding antibodies, or more recently, a DNA detection test from blood or cerebrospinal fluid. A feed low in NSC with a high content of digestible fiber and fat is recommended since there is an increased incidence of diarrhea as a side effect of treatment. High-quality forage is indicated also as weight loss is a common symptom of horses afflicted with EPM. High levels of folic acid and vitamin E should be present in the feed, or added as a supplement to help rebuild damaged nerve and muscle tissue. A horse feed with quality protein (soybean meal as protein source) and high levels of limiting amino acids (lysine, threonine and methionine) is also recommended to rebuild damaged muscle tissue.

Gastric Ulcers

Higher intensity levels of training and competition are correlated with an increase in the incidence of ulcers. Horses suffering from ulcers should be treated immediately. Allowing the horse to be turned out and graze 24 hours daily will help to alleviate ulcers as the stress level will be reduced and increased saliva production will help reduce stomach acidity and prevent further damage. Fermentation of fat and fiber will not produce lactic acid, selection of a horse feed with high levels of fat and digestible fiber and low levels of NSC will reduce fermentation and acid production in the stomach and small intestine where ulcers form. Providing enough hay in the diet is important to insure adequate salivary bicarbonate to buffer stomach acidity. Feeding a daily buffer or antacid product may be required to maintain an ulcer-free condition. Alfalfa or a legume\grass mixed hay may be preferred due to the higher calcium content and potential stomach buffering capacity. Increasing the frequency of feeding can be helpful in keeping stomach pH less acidic with more constant saliva production and the dilution effect of a more consistently full stomach.

Diseases

Colonic Ulcers or Right Dorsal Colitis

Like gastric ulcers, colonic ulcers are found more often in performance horses than in horses not in performance activities. There is also a strong association with the use of non-steroidal anti-inflammatory drugs (NSAIDs) and colonic ulcers. Colonic ulcers with symptoms including mild colic symptoms, lethargy and partial anorexia can progress to Right Dorsal Colitis (RDC) with anorexia, fever and diarrhea causing dehydration and weight loss.

Treatment of RDC includes discontinuing use of NSAIDs, decreasing gut fill to allow the colon to rest, reducing inflammation and restoring normal colon absorptive function. Reduce gut fill by decreasing the amount of long-stemmed hay in the diet. Replace most of long-stemmed hay with a high-fiber (15 percent crude fiber or greater) complete feed. Feeding a complete feed at one percent of body weight daily and chopped, cubed or baled hay at 0.5 percent of body weight daily will meet or exceed the maintenance requirements of most horses. This feeding program reduces gut fill and decreases the mechanical load on the colon. The horse can also be allowed to graze small amounts of fresh grass for short periods (10 to 15 minute intervals up to six times daily) to assist in weight gain. The dietary changes should be made over a week's time to allow the gastrointestinal tract time to acclimate. The complete feed diet should be continued for three to four months or until hypoproteinemia and hypoalbuminemia has been resolved.

Psyllium husk can also be added to the diet to shorten transit time of ingesta and increase water content of the GI tract. Complete feeds or supplements containing higher levels of omega-3 fatty acids (found in rice bran, soy oil, flax seed and fish oil) competitively inhibit activity of the cyclooxygenase enzyme, which is necessary for eicosanoid or prostaglandin production, and can be helpful in decreasing inflammation of the colon.

Minimizing stress will also be helpful in controlling RDC. Stall rest, reduction in strenuous exercise or training and reduction in transport activities are ways to reduce stress. Horses should also have adequate amounts of clean fresh water and provided a complete mineral with salt to ensure adequate water intake.

Obesity

Reducing caloric intake and increasing caloric expenditure through exercise are the two methods that must be used to reduce excess body weight. The most effective method to keep horses from becoming overweight is to control intake of feed, hay and pasture. Horses on lush pasture may be fitted with grazing muzzles or placed in a dry lot and fed moderate quality grass hay. Weigh the feed and hay to determine the amount fed and adjust the feeding rate to maintain an appropriate body condition score. Weight gains and losses can also be monitored with a weight scale or weight tape. The use of a concentrated feed or balancer pellet allows sufficient intake of minerals and vitamins while reducing calories associated with reducing conventional horse feeds to less than 0.5 percent of body weight (i.e. less than five pounds daily for a 1,000-pound horse). Another way to ensure adequate mineral and vitamin intake when feeding a reduced amount of a conventional horse feed is to provide a mineral/vitamin supplement. Horses in training should be fed a lower-calorie feed but in sufficient amounts to meet dry matter and other nutrient requirements (minimum of 1.5 percent of body weight daily for total diet).

Weight Loss

Feed horses needing to gain weight a diet high in fat and digestible fiber to increase caloric intake safely without a risk of colic and laminitis from a diet high in soluble carbohydrates. Fat contains 2.25 times more calories than any other nutrient, so high-fat feeds and supplements will provide the most calories for weight gain. Digestible fiber sources (beet pulp, soy hulls and alfalfa meal) used in many horse feeds are relatively high in calories and low in starch, and provide a safety margin when fed at high rates to increase weight gain. High-quality forage should be selected, as it is more palatable, allowing greater intake, and has a higher caloric density, providing more calories per pound. Feeds containing yeast culture, probiotic bacteria, digestive enzymes and other feed additives that enhance digestion are useful in adding weight to thin horses.

Kidney Disease

Horses with kidney or renal disease should be maintained on a strict diet to limit protein, phosphorus and especially calcium, as reduced kidney function enables the formation of calcium oxalate stones in the urinary tract. Avoiding feeds or supplements high in protein, calcium or phosphorus for horses with renal disease, means avoiding all commercial feeds. The only grain recommended is a limited amount of whole or crimped oats. Feeding legume hay such as alfalfa or providing a diet with excess protein does not cause kidney disease in healthy horses, but is not recommended for horses with renal disease. Avoid feeding beet pulp and wheat bran due to high levels of calcium or phosphorus. Use caution with salt supplementation as some horses may overeat salt. Instead of allowing free-choice consumption of salt, add one to two ounces of plain salt to the feed daily.

Liver Disease

Horses with liver or hepatic disease should be fed easily digested NSC sources in order to maintain blood glucose levels, and diets high in fat or protein are not recommended. Horses with hepatic failure should be supplemented with B-complex vitamins and ascorbic acid (vitamin C) as the liver is the site of all vitamin syntheses.

During pregnancy and lactation, maternal bone mineral may be used to meet the nutrient demands of the developing fetus and milk production. In other species, a few studies have examined the balance between bone mineralization and bone resorption in pregnant or lactating individuals by measuring biochemical markers of bone turnover. But in equine most studies have involved the skeletal development in growing horses.

Two common markers of bone turnover that can be measured in serum are osteocalcin and carboxyterminal telopeptide of type 1 collagen (ICTP). Increased serum osteocalcin concentration is associated with increased bone mineralization, with the highest concentrations usually reported in young animals. ICTP is released during the breakdown of type-1 collagen and may be a useful indicator of bone resorption.

Three studies were conducted to assess changes in circulating concentrations of osteocalcin, ICTP and bone mineral density in mares with different pregnancy and lactation status; and to determine whether calcium intake affects indicators of bone mineral metabolism during late lactation or after weaning.

In the osteocalcin and ICTP studies all mares received a commercial 14% crude protein concentrate, two times a day. On average, pregnant mares were receiving approximately 30% more concentrate than non-pregnant mares (3 to 4 kilograms per day versus 2 to 3 kilograms per day). In the calcium/bone mineralization study mares were blocked and assigned to either a control treatment (100% of 1989 National Research Council requirements) or high calcium treatment at 150% of the control. The nutrients provided by the forages were also taken into account.

- Blood samples were obtained from each mare for analysis of osteocalcin and ICTP as previously described. Radiographs of the right and left third metacarpal were taken using the radiographic step-wedge method in the calcium study.
- ICTP concentrations did not differ among mares that had varying pregnancy and lactation status. Pregnant mares had lower ($P < 0.05$) osteocalcin concentrations than non-pregnant mares. Pregnant mares that had nursed a foal had numerically lower osteocalcin concentrations than pregnant mares that had not nursed a foal, but the difference was not significant
- Data suggest the possibility that bone resorption is most active during late gestation and early lactation, and then bone mineralization increases in late lactation and after weaning. Bone mineralization may be decreased for pregnant mares compared to non-pregnant mares, but returns to normal late in lactation and after weaning.
- No changes in bone mineral density were detected in this experiment. Radiographs from some mares appeared to show a trend for lower bone density during lactation, but opposite observations were made for other mares.
- While these data indicate that the current National Research Council (1989) recommended calcium intake is adequate for lactating mares, the bone mineralization indicators suggest that pregnancy and lactation do put stress on the bone mineralization status of mares. Consequently, this study emphasizes the importance of feeds designed to meet the increased mineral demands of brood mares.
- Levels of calcium and phosphorus in current horse feed formulations used by CRF member feed companies are adequate for pregnant and lactating mares.

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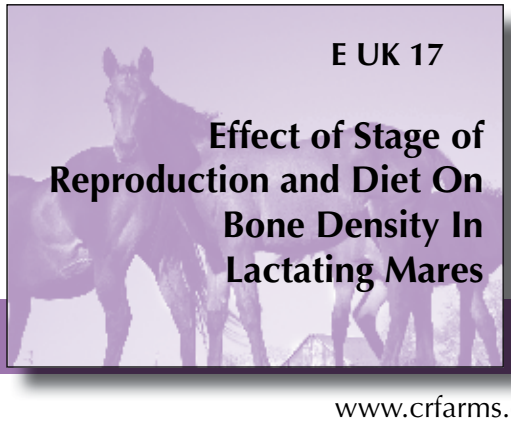


E UK 17

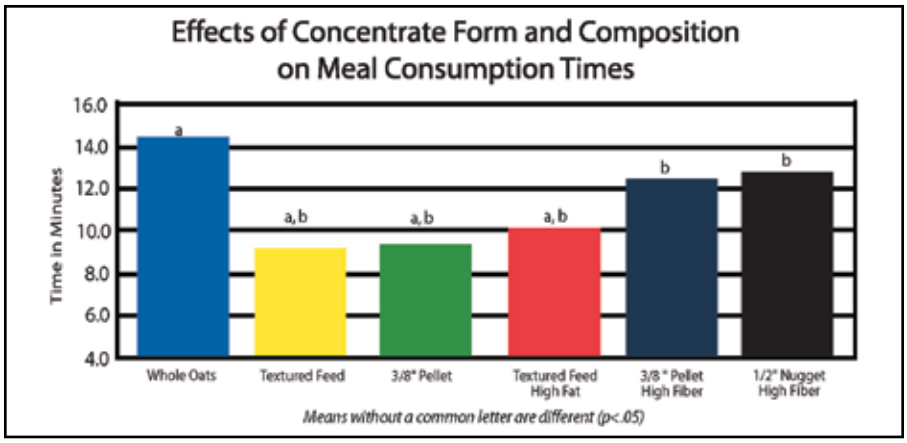
Effect of Stage of Reproduction and Diet On Bone Density In Lactating Mares

The two objectives of this study were to determine the effect of concentrate form and composition on 1) meal consumption time and 2) blood concentrations of glucose and insulin in mature horses.

This summary only focus on the meal consumption times of the various concentrates forms, and the potential impact on horses. The review of the glycemic response is in another trial summary.

Mature horses from the University of Kentucky research herd were used in a latin square arrangement of treatments, The six treatments were:

1. Whole Oats (Oats);
2. Textured Feed (contains whole or processed grains, possibly pellets, and other ingredients) formulated with 12% crude protein, 3% crude fat and 8% crude fiber (Textured Feed);
3. 3/8" Pelleted Feed formulated with 12% crude protein, 3% crude fat and 8% crude fiber (3/8" Standard Pellet) ;
4. Textured Feed formulated with 12% crude protein, 10% crude fat and 8% crude fiber (Textured Feed - High Fat);
5. 3/8" Pelleted Feed formulated with 12% crude protein, 3% crude fat and 15% crude fiber (3/8" Pellet - High Fiber);
6. 1/2" pelleted feed formulated with 12% crude protein, 6% crude fat and 15% crude fiber (1/2" Nugget - High Fiber).



The trial results showed…

- Meal consumption time was longer for horses consuming whole oats than for the low-fiber textured and pelleted feeds, but was similar to the high-fiber pelleted feeds.
- Longer meal consumption time would be an advantage for prevention of colic from rapid overconsumption; but may be mistakenly viewed by horse feed customers negatively as a palatability problem.

Summary - What does this means to the horse owner?
Cooperative Research Farms is actively involved in equine nutrition research to find more effective and safer products or methods to feed your horse. This study found that horses consumed whole oats at a slower rate than textured or pelleted feeds, except for a high fiber pelleted feed, which had a similar consumption time as whole oats. Rapid consumption of feed may be related to colic in a particular horse, so if you have a horse that eats too rapidly or "bolts" his feed, you may want to use a high-fiber pelleted feed or whole oats and a supplement pellet.

– Dr. Martin Adams, Coordinator, CRF Equine Research Team

E UK18 (Part 1)

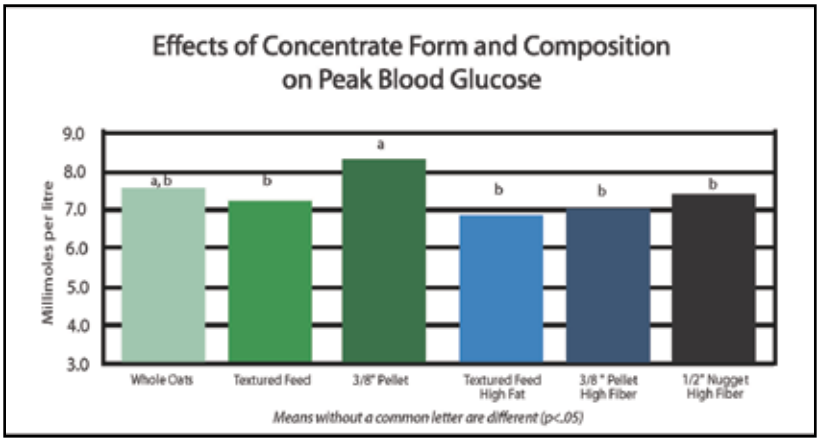
Effects of Concentrate Form and Composition on Meal Consumption and Glycemic Responses of Horses. Part 1 "Meal Consumption Time"

The objectives of this study were to determine the effect of concentrate form and composition on 1) meal consumption time and 2) blood concentrations of glucose and insulin mature horses. This trial summary will review the second part of this study.

Glycemic responses of horses are correlated with the amount of nonstructural carbohydrate (sugar and starch) content and fat content of the concentrate (grain) meal fed. A sustained release in circulating glucose and insulin from a grain meal in growing horses can be a predisposing factor in development of developmental orthopedic disease (DOD). Mature horses from the University of Kentucky research herd were used in a latin square arrangement of treatments, horses and periods. Each horse was fed 15.4 lbs (7 kg) of mixed grass hay and 5.9 lbs (2.7 kg) of concentrate, divided into two equal daily meals.

The six treatments were:

1. Whole Oats (Oats);
2. Textured Feed (contains whole or processed grains, possibly pellets, and other ingredients) formulated with 12% crude protein, 3% crude fat and 8% crude fiber (Textured Feed);
3. 3/8" Pelleted Feed formulated with 12% crude protein, 3% crude fat and 8% crude fiber (3/8" Standard Pellet);
4. Textured Feed formulated with 12% crude protein, 10% crude fat and 8% crude fiber (Textured Feed - High Fat);
5. 3/8" Pelleted Feed formulated with 12% crude protein, 3% crude fat and 15% crude fiber (3/8" Pellet -High Fiber);
6. 1/2" Pelleted Feed formulated with 12% crude protein, 6% crude fat and 15% crude fiber (1/2" Nugget - High Fiber).



The trial results were…

- Pelleting feed causes a higher blood glucose response than textured feed with the same composition suggesting that pelleting facilitates a more complete starch digestion and absorption in the small intestine. This is a disadvantage of pelleted feed for prevention of DOD in growing horses.
- Increasing the fiber level and reducing the starch level in the pelleted feed decreases the glucose response.
- Increasing the fiber and fat levels in a horse feed, with a corresponding reduction in starch content for pelleted and textured versions, would be advantageous for prevention of DOD in growing horses.

Summary - What does this means to the horse owner?

Cooperative Research Farms is actively involved in equine nutrition research to find more effective and safer products or methods to feed your horse. This study found that pelleted feeds had a faster digestion and absorption of starch in the small intestine, with higher blood glucose and insulin levels. This may be an advantage for mature horses, especially performance horses. But this may not be an advantage for growing horses, as high blood glucose and insulin levels have been correlated with an increased incidence of developmental orthopedic disease (DOD). However, this study found that increasing the fiber and fat level and reducing the starch level in a pelleted feed reduces the glucose and insulin levels, which would be an advantage for feeding a growing horse that is prone to DOD. More research is needed in this area to determine the exact level of starch and its site of digestion in the growing horse to prevent DOD problems.

– Dr. Martin Adams, Coordinator, CRF Equine Research Team

E UK18 (Part 2)

Effects of Concentrate Form and Composition on Meal Consumption and Glycemic Responses of Horses. Part 2 "Meal Consumption Time"

Twelve older mares (average age of 18 years) that exhibited physical or metabolic indications of Cushing's Disease, Metabolic Syndrome or Insulin Resistance were selected for this study. The horses were divided into two groups: One group was fed a low starch (15.9% starch) pelleted feed and the other group was fed a high starch (37.2% starch) pelleted feed. Horses fed the low starch pelleted feed had significantly reduced glucose and insulin responses compared to a high starch pelleted feed to a grain meal (refer to Charts 1 & 2). These results demonstrate that a low starch pelleted feed is more effective at maintaining lower blood glucose and insulin levels in horses affected by these metabolic diseases than pelleted feeds containing higher starch levels.

What does this mean to horse owners?

Cooperative Research Farms is actively involved in equine nutrition research to find safer and more effective products to feed your horse. Older horses exhibiting symptoms of three metabolic diseases (Cushing's Disease, Metabolic Syndrome and Insulin Resistance) that were fed a low starch pelleted feed had reduced glucose and insulin responses compared to a high starch pelleted feed to a grain meal. Symptoms of these diseases include chronic high blood glucose and insulin levels, as well as increased and prolonged blood glucose and insulin responses to a grain meal. These symptoms can result in negative health consequences for affected horses. A horse feed formulated with a lower starch level is effective at maintaining more normal blood glucose and insulin levels in response to a grain meal. This could result in better health and longevity for horses with a metabolic disease

Chart 1.

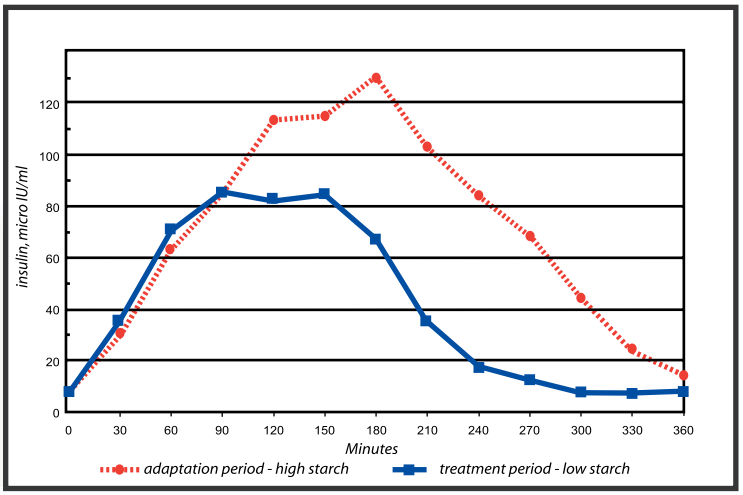


Chart 1.
Blood insulin response to high starch pelleted feed versus low starch pelleted feed.

Chart 2.

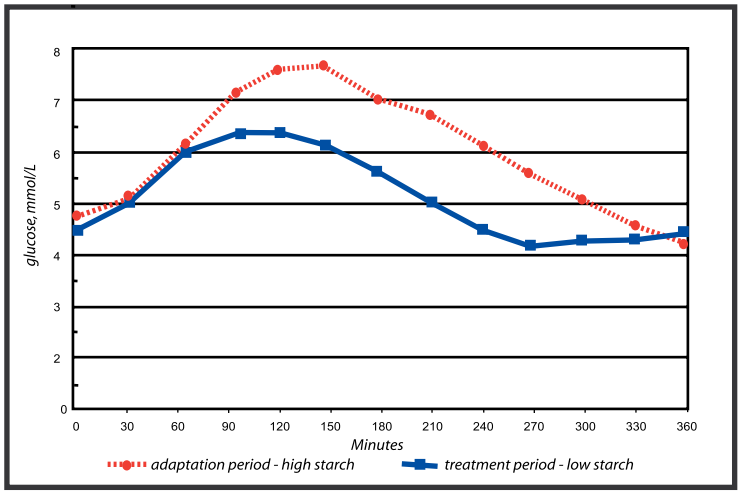


Chart 2.
Blood glucose response to high starch pelleted feed versus low starch pelleted feed.

E UK 21

Effect of Diet on Horses with Cushing's Disease, Metabolic Disease and Insulin Resistance

Cooperative Research Farms

Six 2 and 3 year old fillies were used in this study to evaluate the effects of the physical form and starch level of the concentrate on weight gain, glucose and insulin levels and response to exercise in young horses.

Horses were fed one of three concentrate feeds, 1) a high-starch (37.2%) textured, sweet feed (THS); 2) a high-starch (36.3%) pelleted concentrate (PHS) and 3) a low- starch (21.3%) pelleted concentrate (PLS) and timothy hay.

All diets were able to adequately maintain the horse's body weight during the trial. Charts 1 and 2 show horses consuming the low-starch pelleted concentrate tended to have lower glucose and insulin concentrations after feeding compared to the high starch pelleted concentrate. Horses consuming the high-starch textured concentrate versus the high-starch pellet tended to have decreased glucose and insulin concentrations after feeding. Thus, both starch level and form of the feed tended to affect glucose and insulin concentrations.

Heart rate (Chart 3) was still elevated 15 minutes after the end of exercise when horses received either high-starch concentrate, but was not when they received the low-starch concentrate. These results suggest that horses recovered from exercise more quickly when the low-starch diet was fed. An improvement in post-exercise heart rates for horses on the low starch diet may be due to a calmer disposition and a lower activity rate.

What Does This Mean to Horse Owners?

Providing a lower starch feed resulted in lower blood glucose and insulin levels after feeding and allowed the horse to recover more quickly after exercise, which may be due to calmer behavior and less activity. This could result in better long-term health and performance for your horse. Cooperative Research Farms members are actively involved in equine nutrition research to find safer and more effective products for your horse.

Chart 1: Effect of Feed Type on Blood Glucose

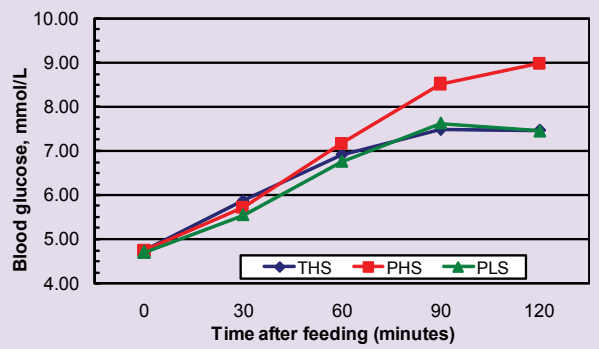


Chart 2: Effect of Feed Type on Blood Insulin.

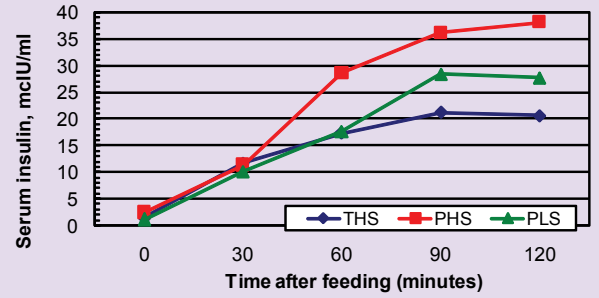
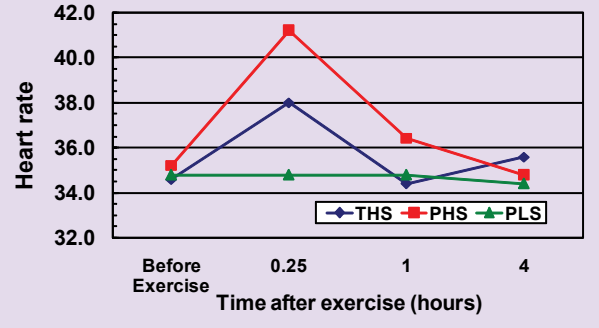


Chart 3: Effect of Feed Type on Post-Exercise Heart Rate.



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Through innovative partnerships and cost sharing. CRF is able to turn its collective knowledge into profits and increase productivity for its members for over 50 years.

This partnership enables CRF members to be the first with an array of patented techniques and products designed to make farming more profitable for you.