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FEEDING THE ENDURANCE HORSE

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Introduction

To understand how to feed an endurance horse and ultimately how to manufacture a feed for endurance horses, it is necessary to understand the sport of endurance riding and the nutritional needs of the endurance horse. The following paper will provide a brief description of endurance riding while outlining the nutrition opportunities and critical nutrients for endurance horses. Finally, information will be presented on feeding management strategies and tips for manufacturing an endurance horse feed.

Endurance riding - the sport

The sport of endurance riding began many years ago as a pursuit by military groups to establish the "best" horse for cavalry purposes. The first modern endurance ride, held in 1955, was a one-day, 100-mile race from Lake Tahoe, California to Auburn, California. From this beginning, thousands of endurance rides are held annually throughout the world. Most endurance rides range in distance from 25 to 100-plus miles per day, over a multitude of different terrains. The ride with the reputation for being one of the most demanding is the "Tevis Cup." This one-day ride covers 100 miles through the Sierra Nevada Mountains with total changes in elevation amounting to nearly 40,000 feet (Figure 2).

The basic rules for endurance riding are simple: the first horse to finish, in acceptable condition, is the winner. There is no minimum amount of time allowed for the race, giving horse and rider the opportunity to set a quick pace. The rides are supervised by veterinarians and open to any breed of horse. Most breeds have been tried as endurance horses. Many competitive endurance horses are Arabian or Arabian crosses. Other breeds, including Thoroughbreds, Quarter Horses, Mustangs, Appaloosas, Morgans, Standardbreds and Mules, have been used successfully. Endurance horses have a physical look which could be described as small and wiry, without excessive muscling. Typical body weight measurements would be in the range of 850 to 1050 pounds. From a body condition standpoint, most endurance horses are moderately thin, resembling human endurance runners. The small, lightly muscled physique of endurance horses is advantageous both for reducing thermal load and for traveling up and down mountains.

The people involved in endurance riding also are unique. Any person who would ride a horse for 40 to 50 miles/week, and then ride for 100 miles on Saturday, could be classified as “determined.” Endurance riders are very serious about both their horses and their sport. They have a genuine desire to do the best for their horses, and most feel that they have a personal bond with the animal. They have formed many of their nutrition opinions based on what others in the sport have told them, and on personal experience.

Nutritional opportunity

An endurance horse ridden at a medium trot (250 meters/min) could potentially complete a 25-mile endurance course in about 3 hours, a 50-mile endurance course in just over 5 hours and a 100-mile course in approximately 11 hours. Given these estimates for “competition time,” a tremendous opportunity exists for nutrition to influence the performance of an endurance horse. In addition, endurance horses are routinely rested and fed during the ride further increasing the impact that proper nutrition would have on performance. Contrast this with the racing Quarter Horse which completes a 440 yard sprint in less than twenty seconds, or the competitive Thoroughbred racehorse which can complete a 1 1/4 mile race in just under two minutes. There have been volumes of information published regarding manipulating exercise performance in horses doing relatively short bouts of exercise. However, the real opportunity for a diet and dietary manipulation to influence performance lies in events which last longer than a few minutes.

The speed at which the exercise bout is performed also will influence the ability of diet to modify performance. In the case of short, intense (anaerobic) bouts of exercise, the animal is forced to generate energy for muscle contraction as fast as possible. This limits the type of fuel a muscle can utilize and the method by which the fuel is burned. The endurance horse, on the other hand, performs an extended exercise bout at a much slower (aerobic) speed. This provides an opportunity for the muscles to select a fuel and obtain the maximum energy production from that fuel. In endurance situations, fuel (feed) can actually be ingested, absorbed and circulated to the muscle for conversion to energy while the exercise is still being performed.

Critical nutrients

There are several key nutrients which will directly influence the performance capability of the endurance horse. These nutrients include: energy, electrolytes and water.

ENERGY

The main productive function in endurance horses is work. This work may vary from relatively slow speed exercise over long distances, common in 100-mile rides, to exercise conducted at faster speeds over the shorter (25- to 50-mile) endurance courses. Energy is the dietary nutrient which will directly influence whether an endurance horse can go the distance. Energy is not a nutrient per se, but rather a measure of a feed's potential to fuel body functions and muscle contraction during exercise. Muscle contraction, in turn, will move the legs and ultimately the horse across the ground during the ride. The endurance horse takes in, via the gastrointestinal tract (GI tract), a variety of feed types (fiber, starch, fat, protein) which can be used to fuel muscle contraction (Figure 1). Since horses are not able to eat continuously during a ride, feed must be digested and stored within the body to be used later as fuel during exercise. These different fuels are transferred between blood, liver, adipose tissue and the muscle cell. Stored energy in the form of muscle and liver glycogen (sugar), intramuscular and adipose triglycerides (fat) along with feed taken in during the ride will provide energy for muscle contraction.

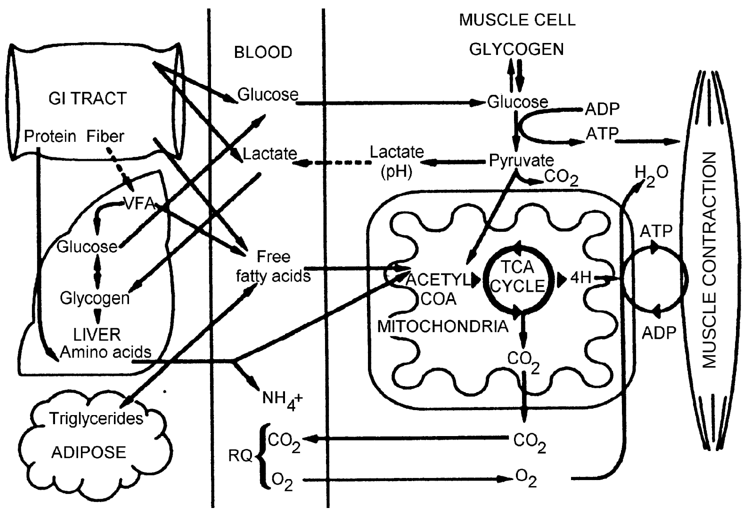

Figure 1.

For muscle contraction to occur, the chemically bound energy from feed must be converted into mechanical energy. This conversion process occurs in the muscle cell, and utilizes adenosine triphosphate (ATP) as the "currency" for muscle contraction (Figure 1.) The most direct method to form ATP is by the breakdown of another compound, creatine phosphate (CP). However, since muscle contains only a small amount each of CP and ATP, the supply of ATP is quickly depleted with the onset of exercise. For an endurance horse to exercise for a prolonged period of time, ATP must be resynthesized at the same rate at which it is being used. Two fundamental reactions resynthesize ATP: 1) Oxidative phosphorylation, breaking down carbohydrates, fats and protein, in the presence of oxygen, producing energy (ATP). The involvement of oxygen qualifies this as an aerobic reaction. 2) Glycolysis, breaking down glucose or glycogen into lactic acid. This reaction does not use oxygen and is considered anaerobic. There are several factors which will determine both the choice of fuel and the pathway used to generate ATP. These factors include: muscle fiber type, the speed and duration of exercise, type of feed provided, and animal fitness.

The horse has three basic types of muscle fiber (Table 1): Type I, IIA and IIB. These fiber types have different contractile and metabolic characteristics. Type I fibers are slow-contracting fibers while Types IIA and IIB are fast-contracting. Type I and IIA fibers have a high oxidative capacity and thus can utilize fuels aerobically while Type IIB fibers have a low aerobic capacity and depend on anaerobic glycolysis for energy generation. All three fiber types store glycogen, while only Types I and IIA have significant triglyceride storage. It is not surprising that different breeds of horses will have different percentages of the muscle fiber types. For example, racing Quarter Horses typically have more Type IIA and IIB fibers and fewer Type I fibers than Arabian horses. This would help explain why one breed, the Arabian, is known for endurance. Unfortunately, within a breed, the differences in muscle fiber type distribution are so small that muscle fiber typing as a predictor of performance is of limited value.

Table 1. METABOLIC CHARACTERISTICS OF DIFFERENT MUSCLE TYPES.

	Type I	*Type IIA*	*Type IIB*
Classification	*Slow Twitch*	*Fast Twitch High Oxidative*	*Fast Twitch*
Speed of contraction	slow	fast	fast
Maximum tension developed	low	high	high
Oxidative capacity	high	intermediate to high	low
Capillary density	high	intermediate	low
Lipid (fat) content	high	intermediate	low
Glycogen content	intermediate	high	high
Fatiguability	low	medium	high

The speed of muscle contraction determines how fast the animal is able to move. Since the amount of ATP used by a muscle depends directly on how fast it is contracting, the faster an animal moves the greater the ATP requirement. While walking, the muscles contract very slowly and expend relatively small amounts of ATP. During this type of exercise, Type I fibers are primarily recruited and energy generation is entirely aerobic. At this speed, the muscle burns predominantly fat. Fat stores are plentiful, and they can be mobilized fast enough to regenerate what ATP is used for muscle contraction. As speed increases from a walk to a trot to a canter, Type I fibers alone are no longer capable of contracting rapidly enough to propel the horse. At this point, Type IIA fibers are also recruited. These fibers are also aerobic, but they use a combination of glycogen and fat for energy generation.

Glycogen (glucose) can be metabolized twice as fast as fat for ATP generation, and as speed increases, fat becomes simply too slow a fuel for energy generation. As the horse increases speed to a fast gallop, Type IIB fibers are recruited and energy generation no longer remains purely aerobic. At these speeds, the requirement for ATP has exceeded the ability of the horse to deliver enough oxygen to the muscle to produce the energy by aerobic means. Anaerobic glycolysis takes over as a rapid metabolic pathway to generate ATP. Anaerobic glycolysis results, however, in lactic acid accumulation, and fatigue soon develops as the pH in the muscle begins to fall.

The speed at which endurance horses typically travel is within the range which can be maintained almost entirely through aerobic energy production. Only during the "controlled runaway" some riders use at the beginning of a ride, the "end of race" sprints and during hill climbing would the energy production shift toward anaerobic means and then, only for a short time. Therefore, fatigue in an endurance horse is much more likely to result from depletion of glycogen and/or triglyceride stores than lactic acid accumulation.

Dietary energy is usually expressed in terms of kilocalories (Kcal) or megacalories (Mcal) of digestible energy. Digestible energy (DE) refers to the amount of total energy in the diet that is actually absorbed by the horse. The DE requirements for different types of horses are calculated based on the horse's maintenance DE requirements plus the additional energy expended during exercise. Table 2 lists the amount of DE required above maintenance at various speeds. For example, a 450 kg (990 lb) endurance horse would have a maintenance DE requirement of 14.9 Mcal/day (DE = 1.4 + 0.03BW, NRC, 1989). Using the values in table 2, this same endurance horse ridden at a medium trot (250 meters/min) by a 75 kg (165 lb) rider for 3 hours, would have an additional energy requirement of 14.9 Mcal/day (Pagan and Hintz, 1986). The total energy requirement would be nearly 30 Mcal of DE/day, a value the NRC, 1989, would classify as intense work. The total DE requirement (maintenance + exercise) can be provided by four different dietary energy sources: starch, fat, fiber and protein.

Table 2. DIGESTIBLE ENERGY (DE) REQUIREMENTS ABOVE MAINTENANCE AT VARIOUS SPEEDS

Gait	*Speed (meters/min.)*	*DE (Mcal/Kg BW*/hr)*
Slow walk	59	0.0017
Fast walk	95	0.0025
Slow trot	200	0.0065
Medium trot	250	0.0095
Fast trot/slow canter	300	0.0137
Medium Canter	350	0.0195

*Weight of horse plus rider and tack

STARCH

Starch, a carbohydrate composed of a large number of glucose (sugar) molecules, is the primary component of cereal grains, making up 50 to 70% of the grain's dry matter. Of the grains commonly fed to endurance horses, corn has the highest starch content, followed by barley and then oats. Horses break down starch into glucose units in the small intestine, where it is absorbed into the blood. Once in the blood, these glucose units can be used for a number of different purposes including: 1) being oxidized to produce ATP or 2) being used to make muscle glycogen, liver glycogen or body fat.

Starch is the dietary energy source of choice for glycogen synthesis. Starch digestion results in a direct rise in blood glucose and insulin, two of the most important factors involved in glycogen synthesis. Muscle glycogen is a versatile fuel for energy generation during endurance exercise, since glycogen can be metabolized either aerobically (with oxygen) or anaerobically (in the absence of oxygen). In addition, glycogen stored in the liver is available for the production and release of glucose into the blood during exercise. Maintaining blood glucose levels during exercise is of prime importance since glucose is the only fuel that is available to the central nervous system. In endurance horses, hypoglycemia (low blood sugar), as a result of prolonged exercise, can be a cause of fatigue.

FAT

Corn oil and soybean oil along with animal fat are the most common sources of fat in the horse's diet. These fat products contain roughly 2.25 times as much DE as an equal weight of corn, oats or barley. Numerous digestion studies have confirmed that fat is both very palatable and extremely well digested. Fat is a less versatile energy source than starch since it can only be oxidized aerobically to produce energy or be stored as body fat. Fatty acids, derived from fat metabolism, can not be converted to glucose or be used to synthesize glycogen.

Fat is, however, an extremely useful dietary energy source. Research studies have concluded that feeding fat to horses resulted in a greater mobilization and utilization of fat during long distance exercise (Pagan *et al*., 1987). In essence, it appears horses trained their enzyme systems to utilize fat, thereby sparing the use of muscle and liver glycogen. Further, endurance horses in heavy training have a very high daily DE requirement. Often these endurance horses can not or will not eat enough feed to meet their energy requirements. The result is a steady decrease in body condition. In these instances, adding fat will increase the energy density of the diet so that less feed is required to maintain body weight. Hintz *et al*. (1978) did in fact report that endurance horse consuming fat-supplemented diets required less feed to maintain body weight.

FIBER

Fiber (hay/pasture) is an energy source that is often overlooked in horse nutrition. Horses have a highly developed hindgut which houses billions of bacteria capable of fermenting large quantities of plant fiber. Volatile fatty acids (VFA's), the endproduct of fiber fermentation, are absorbed from the hindgut and transported to the liver. Once in the liver, VFA's can be converted to glucose and be stored as liver glycogen or be converted to fat, and be used to fortify the body's fat stores. Fiber, therefore, can be used as an energy source throughout the endurance ride since fermentation of fiber and absorption of VFA's continues long after a meal has been eaten.

An endurance horse's intestinal health is critical to success. Normally, the digestive system of the horse is active, moving feed ingredients through the length of the tract. Inactivity of the digestive system, due to dehydration and/or electrolyte imbalances, can cause severe colic and even death. Research conducted in Germany (Meyer *et al*., 1987) has underscored the importance of fiber in maintaining gut health. Their experiments have shown that a diet high in fiber resulted in an increased water intake. Further, animals supplemented with a simple hay and salt diet had 73% more water in their digestive tracts after exercise and approximately 33% more available electrolytes than animals on a low fiber diet. The additional water and electrolytes in the digestive tract of the high fiber animals is probably due to the high water holding capacity of plant fiber. More importantly, the water and electrolyte pool created by a high fiber diet can be used to combat dehydration and electrolyte imbalances which derail so many endurance horses. Another important attribute of a digestive system full of fiber is maintenance of blood flow to the digestive system during exercise. The physical presence of fiber in the digestive system will help insure that blood is not totally diverted away from the digestive system with the onset of exercise. Duren (1990) reported the percentage of cardiac output (blood flow) distributed to the digestive system was higher in fed ponies compared to fasted ponies during exercise. For an endurance horse, maintenance of blood flow to the digestive system will aid in the ability of gut tissue to remain active and could prevent colic.

Fiber in the form of hay/pasture has been discussed as an excellent energy source for endurance horses. In addition to forage fiber sources, there are so-called "super fibers." These super fibers have the same beneficial aspects of forage fibers for maintaining gut health and fluid and electrolyte balance, but contain more energy. The additional energy is the result of both a high fiber content and a low lignin (non-digestible fiber) component. Therefore, these ingredients have more fiber which is available for microbial digestion. These super fibers (e.g. beet pulp, soybean hulls, almond hulls, oat hulls) contain energy equivalent to oats and barley, but they would be safer to feed because they do not produce the symptoms of grain overload.

PROTEIN

If the protein intake of an endurance horse exceeds its requirement, then the extra protein can be used as a source of energy. The amino acids associated with the extra protein are broken down by the liver, and the nitrogen is excreted as ammonia. The carbon skeletons that are left can be oxidized to produce ATP or used to make glucose or fat. Excessive protein intake should be avoided in endurance horses for a number of reasons. First, water requirements increase with increased protein intake. This can be devastating for endurance horses which typically struggle to maintain proper hydration. Second, accumulation of nitrogen end-products (ammonia and urea) in the blood can lead to nerve irritability and disturbances in intestinal function and carbohydrate metabolism. Further, increased ammonia excretion in the urine may lead to respiratory problems associated with ammonia buildup in the stall.

ELECTROLYTES AND WATER

Energy metabolism within the body is not 100% efficient. A certain amount of energy is lost from each chemical reaction in the form of heat. In order for the horse to remain healthy and continue to exercise, excess heat must be dissipated from the body. If the horse is unable to rid itself of this heat, body temperature can rise to the point where it becomes life-threatening. For horses, the main route of heat dissipation is through a form of evaporative cooling known as sweating. In evaporative cooling, the sweat gland takes fluid from the circulatory system and secretes it out to the surface of the skin. Once the hot fluid (sweat) is on the skin, it spreads out and evaporates. This takes heat away from the body. Unfortunately, sweating also takes water and electrolytes away from the body.

As water is lost from the blood, the remaining blood becomes thicker. This increased blood viscosity, decreases perfusion potential, and negatively influences tissue oxygenation. With intense exercise, water loss can become so extreme that blood volume is decreased and further sweating is not possible. If the horse is not re-hydrated, death from heat stroke will occur. The National Research Council (NRC, 1989) has cited research that indicates non-working horses require 2-3 liters of water/kg of dry matter intake. This would equate to 20-30 liters (6 to 8 gallons) of water for a 1000 lb. horse. It is thought that exercise conducted in a hot, humid environment may increase the water requirement by 300 percent (Lucke and Hall, 1978 as cited by the NRC, 1989), giving a total water requirement of 90 liters (24 gallons).

Electrolytes are substances that dissociate in solution into electrically charged particles called ions. In horses, electrolytes play an important role in maintaining osmotic pressure, fluid balance and nerve and muscle activity. During exercise, sodium (Na^+), potassium (K^+), chloride (Cl^-), calcium (Ca^{++}) and magnesium (Mg^{++})

are lost in the feces, urine and sweat. Loss of these electrolytes causes fatigue and muscle weakness, and decreases the thirst response to dehydration. Therefore, it is vital to replenish electrolyte losses in competitive endurance horses. For a detailed discussion of electrolytes, exhaustion, and the performance horse, see *Tied Up With Electrolytes - Or Not?* by Pat Harris contained herein.

Feeding management strategies

FORAGE

Of the feeds offered to endurance horses, forage is by far the most important. Horses have evolved as grazing animals and have a unique ability to take in large amounts of forage (up to 3.5% of body weight). The horse, in concert with the bacteria in the hindgut, utilize this forage primarily for energy production. The ability of the horse to effectively utilizes forages is evident if one considers that many horses are maintained on all-forage (hay/pasture) diets. Occasionally, a competitive endurance horse can be maintained solely on good quality pasture, but this is certainly the exception and not the rule. In addition to being a steady source of energy for the endurance horse, forage is essential to maintain intestinal health. A diet containing large amounts of good quality fiber can increase the water consumption, and provide a reservoir for both water and electrolytes. This water and electrolyte reservoir can be utilized throughout the ride to minimize dehydration and electrolyte imbalances. Finally, the presence of fiber in the digestive system can help insure that blood is being distributed to the digestive system during the ride. This maintenance of blood flow to the digestive system will aid in the ability of gut tissue to remain active and could help prevent colic.

A logical question often asked is “What type of forage do I feed my endurance horse?” To actually determine which hay to buy, one should consider the fiber, digestible energy (DE), protein and calcium content of the hay. First, to prevent digestive upset, it is absolutely essential to provide the horse’s hindgut with an adequate source of digestible fiber. This would mean maximizing the use of good quality hay/pasture with a high NDF value and a low ADF value. Second, the digestibility and thus the DE content of any given plant decreases with maturity. Therefore, horse owners should avoid feeding extremely mature forages. Since endurance horses 1) do not have high protein requirements, and 2) have to expend energy and use extra water to get rid of excess protein, select a hay with a lower protein content (8% to 14% as-fed). Finally, since chronic over-supplementation with calcium can cause problems with endurance horses, avoid high calcium hays. With these selection criteria, the endurance horse would be well suited with free-choice access to a good quality grass hay. A mixed alfalfa/grass hay is also acceptable provided it is predominantly grass.

GRAIN CONCENTRATES

Most competitive endurance horses are unable to maintain body weight on all forage diets. These horses need additional sources of energy that come in the form of starch, fat, fiber and protein. These energy sources are found in most commercial grain concentrates. With the information presented in this paper outlining the benefits of starch for energy production, it may sound like "the more starch the better." This is not the case. There is a limit to the amount of starch which an endurance horse's diet should contain. If a large amount of starch is fed in a single meal (ie. greater than 5 lbs of grain/meal), the small intestine's ability to digest and absorb the starch may be overwhelmed, and a substantial amount of the starch may pass into the large intestine. Once in the large intestine (cecum, colon), a cascade of reactions occur which can result in laminitis (founder) or colic.

There also is a limit to the amount of fat which can be added to the diet. First, from a palatability standpoint, horses will indicate when they have reached their peak level of fat intake by refusing to eat the feed. The threshold level of fat necessary to reach this stage varies with the horse and the type of fat; however, grain concentrates with over 20% added fat (top-dressed) are prone to feed refusal. The other limitation on the amount of fat that can be added to the diet occurs in situations where calories from fat are replacing calories from starch. These high fat, low starch diets can limit the amount of starch available for glycogen synthesis and actually decrease liver and muscle glycogen stores (Pagan *et al*., 1987). Grain concentrates which have between 7 and 10% added fat appear optimum for endurance horses. To obtain the best results with the addition of fat to the diet, begin adding the fat during the conditioning phase of training and continue throughout the season. This will expose the muscles to high levels of fat and condition the body to use fat as an energy source. The combination of dietary fat and fitness will allow endurance horses a greater mobilization and utilization of fat during long distance exercise. The addition of fat only on "race days" will be of limited value.

Just as there were limitations in the amount of starch and fat appropriate for endurance horses, so are there limits on the amount of protein. The actual protein requirement for the endurance horse is only about 8 to 10% of the total diet. This is much lower than is actually fed to endurance horses because there are few ingredients that are this low in protein. For example, corn is around 9% protein, oats 11.5%, timothy hay 10% and alfalfa hay 15 - 20% protein. Therefore, it is not practical to restrict protein intake to the horse's actual requirement. Instead, protein content of the ration should be monitored and not allowed to become extremely high.

TIME OF FEEDING

Specific information relating time of feeding prior to exercise with endurance horse performance is not available. Research efforts have mainly concentrated on time of feeding prior to a relatively short bout of exercise. In these studies, a diet is typically fed at a given time prior to exercise and blood indicators of metabolism and stress are monitored throughout the exercise protocol. Pagan *et al*. (1995) have demonstrated changes in plasma glucose and plasma insulin prior to and during exercise as a result of feeding time. These differences in plasma metabolites did not result in any marked differences in exercise performance. Further, Stull and Rodiek (1995) reported the composition of the diet and the timing of the meal prior to exercise can be manipulated to influence glucose availability in the blood before and during exercise. However, stress measurements (lactate and cortisol) did not respond to feeding time. Both of these studies are interesting since they were able to change plasma glucose levels as a result of pre-exercise feeding. However, it is possible the duration of the exercise protocol was not long enough to see a difference in stress. With endurance horses, the exercise protocol would definitely be long enough to determine the affect of feeding. In addition, endurance horses are fed at rest points during the ride so time of feeding and the composition of the meal may have a dramatic influence on exercise performance. Kentucky Equine Research is currently working on the design of an experiment which could evaluate feeding time prior to exercise in endurance horses.

Manufacturing an endurance feed

To manufacture a grain concentrate for endurance horses, several points need to be addressed. First, the energy content of the feed is probably the most important factor. Energy should be available from a combination of sources. Fortification with processed starch in the form of cracked corn, rolled barley or crimped oats will be the basis of the feed. Addition of energy in the form of vegetable oil or a quality animal fat product is the next step. Finished grain concentrates for endurance horses should contain between 7 and 10% fat. With the many benefits that fiber has both for energy production and for maintenance of proper digestive function, inclusion of additional fiber is justified. Adding any one, or a combination of, the “Super Fibers” (beet pulp, soybean hulls, almond hulls or oat hulls) at a rate of 10 to 40% would be beneficial. The next criterion the finished grain concentrate will be judged on is protein content. For endurance horses, high protein and high performance do not go together. Finished grain concentrates, therefore, should contain 12% protein or less. Electrolytes would seem like an obvious group of minerals to add to an endurance horse feed. Unfortunately, most endurance riders have worked out their own schemes for dosing horses with electrolytes. This eliminates the need to put a lot of time into figuring out proper electrolyte inclusion in grain concentrates. The addition of plain salt at a rate of 0.5% is adequate. Other nutrients which warrant consideration include: vitamin E, selenium, and B-vitamins. Vitamin E and selenium are both involved in antioxidant reactions within the body. Vitamin E should be added at a rate of 100 IU/lb of finished feed, with selenium adjusted to provide 0.3 ppm of total diet. A B-vitamin package should be added to the grain concentrate to account for any potential deficiencies which may occur due to stress. These products are water soluble and safe to add. Finally, the total grain concentrate must be balanced for other essential nutrients including vitamins and minerals.

If manufacturing a complete (forage + grain) pellet for endurance horses is your intention, the energy and protein content of the product is critical. It is essential that enough grain (starch) be included in these products to raise the energy content. A product with approximately 30% grain with added fat should be appropriate. The protein content of this product should not exceed 14%, so use alfalfa sparingly. Finally, most endurance riders do not like to feed pelleted products. The conception that only "trash" goes into pellets is alive and well in endurance riding circles. Therefore, pelleted products will take a bit more marketing skill. The United States Forest Service is doing their part to help you market these products by requiring that feed used in the "back country" be certified as weed seed free. The pelleting process is recognized by the Forest Service as a method to control weed seeds. Therefore, any pelleted horse feed is currently acceptable in the National Forest.

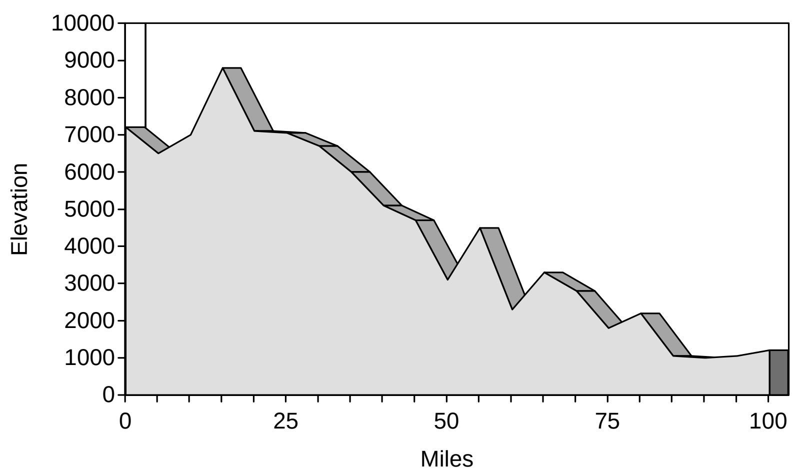

Figure 2. Tevis Cup profile map

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