Feeding the endurance horse

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Endurance enthusiasts as a group are renowned for going the extra length to get the best fitting and comfortable saddle and tack, the best training regime for conditioning their horse, the best float or gooseneck the budget can provide to give their horses a comfortable ride but what about ensuring your horse is fed an optimised balanced diet using best possible feed ingredients?

What's the big deal about fibre?

Horses, along with koalas, wombats, elephants, guinea pigs, rabbits, and herbivorous reptiles are classified as hindgut fermenters, meaning their high requirement for grass and other complex plant material requires extensive fermentation. Horses evolved over a very long time with their digestive system adapted to benefit from the microbial fermentation of plant vegetation; grass, shrubs, leaves.

In the horse, fermentation of food begins in the non-glandular, neutral pH portion of the stomach but the majority of fermentation occurs in the hindgut. The caecum and large intestine that makes up the hindgut has a capacity of over 100 litres. The caecum alone can be 1.2 metres long and around 30 litres. Billions of organisms, both bacteria and protozoa make up several hundred different species in the hindgut. On high fibre diets, cellulolytic (fibre fermenting) species dominate. On high grain/starch diets, more simple carbohydrate fermenters will be present in generous numbers. The gut microbiome reflects what the horse eats though research at this stage has found that each horse's microbiome is unique. The proportions of the different types of microbes are highly dynamic and interact with each other. Microbes with similar food preferences, or those that feed on their by-products, will tend to thrive together under similar pH and moisture conditions. Intestinal gut microbes are very responsive to pH changes. Changing the diet should be gradual and phased to allow the gut microbes time to adjust and to avoid gut disturbances like colic.

In people, fibre has been long recognised for its need to be part of the diet for regulating bowel function and preventing a range of conditions like bowel cancer and diverticulitis. In horses, fibre is a vital source of energy and nutrients and has a role in fertility, behaviour and the immune system.

For an endurance horse, the benefits of feeding a high fibre diet are huge but one that should stand out as a key feature for endurance is the microbial production of volatile fatty acids (VFA), also known as short chain fatty acids. The three major VFAs are acetate, butyrate and propionate which can be used by cells, especially muscle cells to produce ENERGY.

- ✓ Acetate is used directly as an energy source by muscle and aerobic exercise.
- ✓ Butyrate is used by the intestinal lining cells as an energy source.
- ✓ Propionate is either converted in the liver to glucose and used by muscle cells immediately, or the glucose is stored in the form of glycogen for later. Or it is converted by the liver to amino acids and/or fat. Estimates suggest as much as 50% of blood glucose comes from the microbial production of propionate.

Any excess in acetate and butyrate can be converted to fat in the liver.

The key VFA's produce energy, can be converted to fat and even glucose

The main energy source that fuels horses to cover long distances but also to run body processes to stay alive are sugars. Glucose dominates energy production in cells. Glucose is essential for the brain.

The horse must never run out of glucose, as it is life threatening. There is only so much that can be stored in the form of glycogen (chains of glucose), therefore muscles will use fat whenever it can as an energy source.

Work intensity and energy source:
Sleeping, walking – fat is the dominant fuel source.
Racing, leaping from a starting gate, dragging extreme weight – anaerobic metabolism of glucose/glycogen.

In between (as in endurance work intensity), it's a mixture of the two; glucose/glycogen and fat. Endurance horses are performing at around 30 to 40% VO2max.

Training increases blood supply (oxygen and nutrients) and mitochondrial density. As that happens, the muscle is able to use more fat than an untrained muscle can. For low level work, fat oxidation may increase up to 30%. However, as intensity increases, the requirement for carbohydrate (glucose) burning also increases.

What is the answer? Do we feed our horses fat, say a cup of canola oil or rice bran oil or a high fat feed to fuel the work? **NO**

First, it's useful to understand that the horse's requirement for fat is satisfied by the amount in grass and other plant vegetation in the form of omega fatty acids. A 100% grass/plant vegetation diet would contain less than 6% fat. Horses are very efficient at absorbing and metabolising this fat, and don't require a gall bladder.

For 30 years or more, fat feeding has been pushed as the answer for performance horses. It may make sense at first that if horses need fat to fuel work, then feed fat but this is far from ideal and ignores the fact that horses already have fat sources to metabolise into energy.

In the body of the horse, fat is stored as:

- ✓ Adipose fat – the triglycerides just below our skin, what we can gather up in our fingers, includes the 'love handles'.

- ✓ Intramuscular triglycerides (IMTGs) are fats stored in-between muscle fibres

With endurance work, glucose is required but as the muscle starts to run out of glycogen, fatty acids liberated from adipose fat and stored intramuscular triglycerides increases. Where this fat comes from is the VFAs from **fermentation of fibre**; acetate, butyrate and propionate. A less fit horse will run out of glucose quicker than a fit horse. As horses increase in fitness, the mitochondria in the muscle cells increase in number. Mitochondria are called 'power factories' where cell respiration and **energy production** occurs. A higher density of mitochondria in muscle cells means a higher capacity to utilise glucose aerobically.

If your aim is to have a horse able to complete endurance rides well, whether that be at the front or elsewhere, your aim should be to train your horse to be as fit as possible so that he is able to do the job as easily as possible. To do this, anything that compromises mitochondria function and number should be avoided.

What's wrong with feeding fat?
There is a mountain of research that has looked at fat feeding for athletic performance. It is theorised that the push for high fat feeding in horses originally came from the idea that feeding human athletes high levels of fat would improve performance. This has not been the

case, and there isn't one study that shows that fat feeding improves performance for people or horses.

In people, a 43% increase in fat intake had striking effects on mitochondrial function, reducing mitochondrial number. The authors concluded that the metabolic changes seen with high fat feeding are identical to those induced by **fasting or starvation**. The release of fatty acids from body fat depots occurs when blood glucose levels drop, as during fasting or starvation. This sends a red flag message to curb the burning of glucose and preserve stored glycogen. So instead of 'glucose sparing' as pushed by those who recommend high fat intakes, it may instead convince the body it is starving.
A high-fat diet coordinately downregulates genes required for mitochondrial oxidative phosphorylation in skeletal muscle
https://diabetes.diabetesjournals.org/content/diabetes/54/7/1926.full.pdf

The body interprets high levels of circulating fat as a sign of inadequate calories (fat is released with fasting) and moves to conserve glucose for vital organs. Exercise can override this to some extent but constant exposure to high fat slows glucose uptake and interferes with aerobic energy generation in muscle. High fat diets impair high speed performance and are of no benefit for submaximal exercise.

Brief human review:
"Fat Adaptation" For Athletic Performance: The nail In the Coffin?
https://www.physiology.org/doi/full/10.1152/japplphysiol.01238.2005

The fat burned during exercise comes from fat depots and stored intramuscular fat. The body can and does manufacture all the fat it needs from other energy sources. If you have a horse with good body condition score, as expected for an endurance horse, then the horse has an excellent reserve of adipose triglycerides and intramuscular triglycerides.

Other than lower number of mitochondria in muscle cells, what else can go wrong?

- High fat feeding has been shown to compromise gut microbial populations. Feeding a higher fat diet for horses means that there is less fibre in the intake. Lower fibre decreases the fibre fermenting microbial species in the gut = reduced fibre utilisation.
  The effect of replacing nonstructural carbohydrates with soybean oil on the digestibility of fibre in trotting horses
  https://www.ncbi.nlm.nih.gov/pubmed/10661381
- High intakes of vegetable oil can suppress magnesium absorption by forming insoluble salts. If the oil is totally digested, it's not a problem. If it escapes to the large bowel, it will carry bound magnesium with it. Dr Eleanor Kellon VMD can see a potential with as little as 100 ml in a meal.
  Bioavailability of Minerals in the Horse
  http://www.ivis.org/proceedings/eenhc/2006/kienzle.pdf?LA=1
- Fat is directly contraindicated for growing horses, decreasing bone mineralisation:
  Dietary carbohydrates and fat influence radiographic bone mineral content of growing foals
  https://www.ncbi.nlm.nih.gov/pubmed/10641881

If a horse is on a high fat diet, then it's impossible for the horse to be at the same time, on a high fibre diet. Fat is a concentrated energy source, empty of nutrients. The high energy means that less grass or hay or fibre feed is needed to maintain a good body condition score.

More research has been done recently to look at the effects of low fibre intakes vs high fibre intakes in horses. Low fibre diets show poor immune system responses, lowered fertility in mares and poorer behaviour outcomes. Before reaching for a 'calmer' product, consider the quality of diet being fed to the horse. Is the diet as high in fibre as possible? Is the horse being fed more than sufficient salt? Are you calm?

Other benefits of fibre:

- Source of nutrients
- Microbial fermentation produces all the B vitamins
- Acetate is particularly effective in encouraging glycogen repletion
- Relaxes the stomach and help control acidity
- Decreased probability of ulcers
- Constant flow of material along the GI tract stimulates normal motility
- 'Gut fill' weighing down the colon helps prevent displacements and twists

Feeding horses 101 (very brief)

The ideal intake for horses (fibre fermenting, trickle feeders) is to feed as much grass as possible, then the next choice is hay (or chaff), then the bagged feed should be one of the high soluble, fermenting fibre types, based on either beet pulp, soybean hulls or lupin hulls. The following feeds are ideal for all horses including insulin resistant (IR)/EMS horses: soybean hulls (Energreen Maxisoy), beet pulp (Speedi-beet, Hygain Micrbeet, CEN SuperBeet) or feeds based on lupin hulls: Hygain Zero or Prydes EasiFibre.

Also suitable but **not** safe for insulin resistant (IR)/EMS horses: Prydes EasiSport, copra in small amounts (poor quality protein). These feeds are too high in fat for IR horses. Hygain Fibressentials contains millrun.

Low fibre feeds are any that contain mainly high starch feeds like grain or bran, especially rice bran.

All feeds (high fibre or not) should be fed wet to help with digestion and to prevent dust/lung allergies, choke and impaction colic. All high fibre feeds are an excellent carrier for supplements and salt.

Grain

If your endurance horse is likely to experience fatigue, then combining the high, soluble fermentable fibre feed with a grain like oats is ideal for generating a steady release of energy throughout the endurance ride. Oats are recommended as they are the safest, most palatable grain. Best time to feed is straight after a workout when the muscles are glycogen deficient. Each individual horse can have the amount of oats fed tailored for that horse, which you can't do with a premix feed. Some horses may need less than others and always, oats are optional. Some horses may have plenty of energy, never fatigue don't need any. I don't recommend any more than 1 kg oats per day.

Protein and minerals

Dr. Eleanor Kellon VMD http://drkellon.com/, says "Healthy young to middle-aged adult horses will tolerate a wide range of minimal imbalances with no obvious outward signs, but many of the things we take for granted as 'usual' in horses, such as sun-bleaching, tendon/ligament/joint issues, immune system imbalances, poor fertility, muscle and nerve problems, bone problems can all have a nutritional component. All problems are a combination of genetics and outside influences. The list of outside influences is huge, but worth investigating since it's in our control. Horses on pasture, not under any stress, may show no outward signs at all of mineral deficiencies - until their immune system is stressed, they become ill or have an injury."

To know if a nutrient is deficient or being prevented from being absorbed or interfered with in the digestive tract by another nutrient and therefore out of balance, it is essential to know the amounts of nutrients in the whole diet; the main forage plus supplementary feeds and supplements.

Vitamin E and selenium

Vitamin E and selenium are antioxidants that protect the body against damage from reactive molecules. These are generated in the body as a result of metabolism and cause cell damage, known as oxygen free radicals. It's like the chemical reaction that creates rust on a bicycle or turns the surface of a cut apple brown. Stress from a workload can increase the production of these oxygen free radicals, most important for tissues with high aerobic

metabolism activity like the brain/nervous system, heart, skeletal muscles and rapidly growing tissues.

Vitamin E in the intestine has to ‘find’ dietary fat to be absorbed. Naturally occurring vitamin E in the diet in grass is already associated with fats when ingested. Ideal way to supplement vitamin E is with vitamin E capsules, best is natural with fat or oil in the capsule.

Vitamin E shouldn’t be stored with other nutrients. It acts as a preservative, most of it is used up, keeping the food 'fresh', before getting to your horse.

It’s vital to get supplementation of selenium right as too much can be toxic, if not deadly. On the other hand selenium should not be ignored as muscle soreness can be a sign of a selenium deficiency.
Metabolic and haematological profiles in mature horses supplemented with different selenium sources and doses
https://pdfs.semanticscholar.org/ba6f/0858a2ebc6b850f525bf6abf805649c5d8e8.pdf

Grass and hay grown on acidic to neutral soils are known to be deficient in selenium for horses. Soil conditions, especially pH influence plant uptake of selenium.
Selenium in soil
http://www.doiserbia.nb.rs/img/doi/0352-4906/2003/0352-49060304023C.pdf

Unfortunately it is impossible to know the selenium level on the basis of a pasture or hay test. The best way is to request a vet to do a whole blood test (plasma and red blood cells) or Glutathione peroxidase (GSH Px) test for selenium to find out if your forage is deficient. The whole blood test is the preferred test with results in either ug/L (micrograms per litre) or umol/L (micromole per litre). Wait 4 weeks before testing to allow levels to stabilise. If only serum is tested, the result can be up to 25% off in accuracy.

The suggested maximum safe intake, above which toxicity many develop over weeks or months, is 20 mg/day or 2 mg/kg (2 ppm):
Selenium Paranoia
https://drkhorsesense.wordpress.com/2014/10/09/selenium-paranoia/

Electrolytes
Electrolytes are very important and are utilised in many different ways by the body, such as the production and secretion of sweat to cool down, saliva, intestinal tract fluid, urine and mucous, hydration, heart contraction, involuntary/smooth (intestinal tract amongst others) and voluntary (skeletal) muscle contractions including the heart, nerve function. The difference in sodium vs potassium concentrations outside and inside cells is the basis for excitability of muscle and nerve tissue.

All forages are a rich source of potassium so never needs supplementing for maintenance needs. To ensure that sodium and chloride is covered for maintenance requirements (standing around, grazing and some sweat) supplement at least 2 tablespoons of salt per day (45-50 g), more in hot weather, split among feeds if feeding more than once per day.

Access to a bucket of loose salt (preferred) or a salt block is sensible but can never be relied upon for supplying the daily requirement of salt. Horses do not self-medicate.
Electrolytes for Sport Horses - Are They Needed?
https://newcms.eventkaddy.net/event_data/60/session_files/EQ017_Conference_Note_jjacobs_cvma.net_EQ017_SCHOTT_Electrolytes_for_Sport_Horses_Are_They_Needed_20150511175547.pdf

Sodium is involved in many, many cellular processes including muscle contraction and the movement of glucose into the cell where it becomes metabolised in the mitochondria to produce energy. If sodium is deficient because it has been drawn into the bloodstream to maintain concentration then it causes impaired performance. As little as 2 to 3% dehydration can lead to a 10% drop in performance.

When a vet pinches the skin to form a tent they are getting an indication of sodium deficiency. Sodium is what the brain 'reads' in determining when to trigger thirst and when to regulate the amount of sodium, and therefore the amount of water excreted in urine. Electrolyte levels in the blood are tightly regulated by hormones. A horse's internal systems will do everything to avoid the concentrations of electrolytes changing in the blood. If sodium is low, the body will draw the sodium ions from the extracellular spaces (outside the cells) and you get that tented look on a sodium deficient horse.

After a workout, if the horse is sodium deficient (standard for a horse in heavy work from sweating) then sodium will be drawn out of the skeleton to maintain that all important concentration in the blood stream and this is likely to occur for 2 to 3 days depending on the electrolyte sources such as grass/hay/feed and salt added to a meal. To minimise having sodium pulled from the extracellular spaces and bones then it is very important to replenish electrolytes after a big workout.

Horses can't stockpile electrolytes, they easily and efficiently excrete any electrolyte excess via the kidneys in the urine, can be as quick as within 1 hour.

The best daily electrolyte product that has the highest sodium and chloride for the amount fed is salt. Doesn't need to have minerals or be pretty, just plain or iodised salt.

Omega fatty acids
The one exception to feeding fat is omega-3 fatty acids. Grass is rich in the anti-inflammatory omega-3 fatty acids, around 4:1 to the inflammatory associated omega-6 fatty acids, can be as high as 20:1. Both are essential to the horse; have to come from the diet. Omega-3 fatty acids don't survive well the process of turning grass into hay. Any bagged feed or product is unlikely to be high in omega-3 unless they have the proprietary process of stabilising the fatty acid but will be high in omega-6. Check the label of any product you buy that claims that it's balanced in fatty acids. The majority of products are not balanced for horses. If the diet is not 100% grass (and it's not likely for an endurance horse) then some feeding of omega-3 fatty acids will go towards making up the deficit. Best source are linseeds (flaxseeds) and chia seeds. The hard shelled seeds are best ground for optimal digestion. A blender can help.

To sum up, a mineral balanced diet including vitamin E, selenium and salt, with no nutrient deficiencies based on data is the gold standard. The type of feeds chosen should have as the number one priority; high, soluble fermentable fibre for the production of energy to fuel endurance so the horse can do the distance well. Avoid high fat feeds like rice bran.

Further reading:
Dr Eleanor Kellon VMD, online courses
NRCPlus
Nutrition and the Performance Horse
http://drkellon.com/

McLaughlin D (2010) Fats: The Good, the Bad and the Ugly
https://blog.easycareinc.com/fats-the-good-the-bad-and-the-ugly/

Waller AP, Geor RJ, Spriet LL, Heigenhauser GJ, Lindinger MI (2009) *Oral acetate supplementation after prolonged moderate intensity exercise enhances early muscle glycogen resynthesis in horses*
https://www.ncbi.nlm.nih.gov/pubmed/19429643