TECHNICAL BULLETIN

FEEDING THE ENDURANCE HORSE

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A. INTRODUCTION

The competitive endurance horse is the epitome of equine athleticism. The completion rates, winning times and distances covered by endurance horses are testimony to the equine's athletic ability and a credit to their training and management by endurance riders. Proper nutrition is paramount to obtaining peak performance from endurance horses and over recent years there has been a great deal of research into this area. This has greatly improved our understanding as how to manage and feed these horses.

Most endurance horses are Arabian or Arabian derivatives as the natural physique of these horses is ideally suited to endurance. However many other breeds have competed successfully and should not be discounted as potential long distance mounts particularly if they are well conformed with a good attitude.

The fit endurance horse has a lean and wiry appearance. They should be maintained in condition score 2.5 to 3.0 for optimum performance and this would typically mean bodyweights about 380 to 480 kg.

In terms of equine sports, endurance riding offers great potential for nutrition to influence competitive performance. The reasons for this are (1) that the endurance horse spends a great deal of time working (from four to eight hours for an 80 km ride), (2) the endurance horse has an opportunity to be rested and fed both on track and at veterinary checks during the ride, and (3) the speeds at which endurance horses compete mean that the horse primarily uses aerobic pathways for energy metabolism. This reliance on aerobic metabolism means that more storage fuels are available to the animal as energy sources and these can partially be replenished while the horse is working.

This technical bulletin is intended to improve your understanding of horse nutrition and allow you to design feeding programmes for endurance horses to achieve peak performance. It deals specifically with endurance horses that are mature horses performing work. For information on nutrition in other classes of horses there are technical bulletins for stud horses and recreational horses. To better understand horse nutrition it is first necessary to review the digestive system of the horse and its capability to digest feed.

B. THE DIGESTIVE SYSTEM OF THE HORSE

The digestive system of the horse is quite unique when compared to other types of livestock. **Figure 1** is a diagrammatic representation of the equine digestive system.

The digestive system can be broken down into two functional parts: the **foregut** and the **hindgut**. The **foregut** is comprised of a small, simple stomach followed by a long, narrow small intestine. The foregut functions in a manner similar to that of monogastric species such as pigs and it is here that enzymatic breakdown of ingested feed occurs. The stomach and small intestine are where most of the protein, fat, vitamins, minerals and about half of the soluble carbohydrates are digested and absorbed. The **hindgut** is comprised of the caecum and the colon. The hindgut functions in a manner similar to the rumen of cattle in that it is a large, voluminous organ which contains billions of bacteria and protozoa which ferment fibre and the remaining soluble carbohydrates into volatile fatty acids which are then absorbed into the bloodstream and utilised as a source of energy by the horse.

The horse is therefore classified as a **hindgut fermenter** or **non-ruminant herbivore** and is somewhere between a ruminant and a monogastric in its utilisation of feedstuffs.

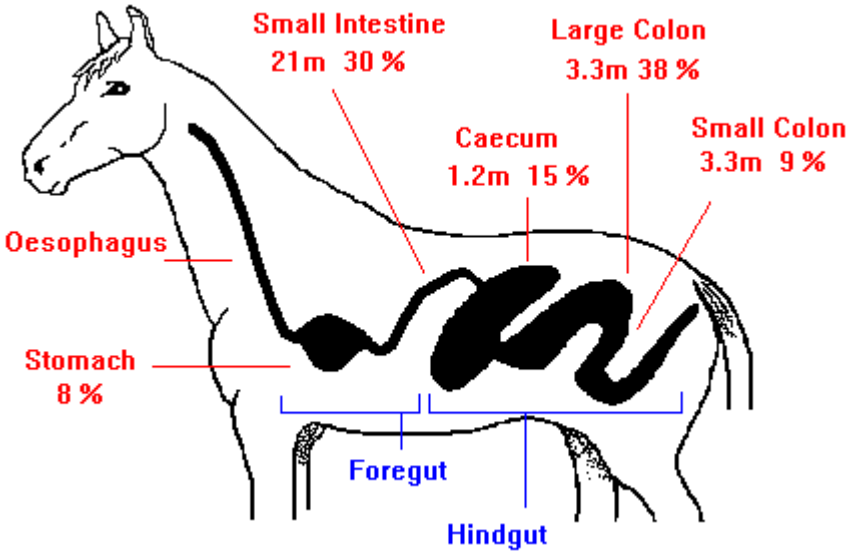

Figure 1. ***The Digestive System of the Horse***

The Practical Implications of the Equine Digestive System

As we have seen the horse has a small stomach and cannot tolerate too much feed at one time. Horses also have a fast rate of food passage through the stomach and the small intestine due to the relatively small size of these two organs. **Table 1** shows the relative rates that feeds pass through various areas of the digestive tract.

Area of Digestive Tract	Retention Time
Stomach	30 minutes
Small Intestine	1 to 6 hours
Hindgut	48 to 60 hours

Table 1. ***The Rates of Feed Passage through the Equine Digestive Tract***

Ingested feed in horses is firstly exposed to enzymatic breakdown in the stomach and small intestine fermentation in the hindgut. This means that soluble sugars and digestible proteins are well utilised and there is good absorption of glucose and amino acids in the foregut.

From this brief review of the equine digestive system, it can be seen that horses have evolved over millions of years for the continual intake of high fibre as occurs in the situation where horses are grazing pasture. The horse is not ideally suited to large meals of concentrated feed.

However with endurance horses performing considerable work and expending large amounts of energy, it becomes necessary to supplement pasture with energy in the form of either concentrated high starch feeds or fat in the form of vegetable oil. When feeding starch in the formof grain or pellets, it is important to remember that feed management should be carefully managed to ensure good performance and prevent problems.

Why is feed management crucial when feeding concentrated feed?

When horses are fed large meals of high starch feed, much of the starch is digested in the foregut. Any remaining starch that is not digested passes quickly down to the hindgut. The consequences of large amounts of starch in the hindgut are that it is fermented to lactic acid that lowers pH (increases acidity) in the hindgut. This pH drop in the hindgut can cause the death of certain bacteria that then release endotoxins that can result in colic, colitis and various degrees of laminitis.

Practical methods of minimising problems

- **Feed adequate levels of fibre** – all horses should be fed an absolute minimum of 1% of body weight per day of good quality hay. This is usually not a problem in endurance horses that have access to grazing.
- **Introduce grain rations gradually** over a two week period.
- **Feed frequent small amounts** - ideally horses should not be fed more than 2kg of grain per meal. Most endurance horses are commonly fed only relatively small amounts of grain (up to 3 kilograms). When horses are fed in excess of 2 kilograms of hard feed per day it should ideally be divided into two feeds.
- **Feed by weight and not volume** - feedstuffs vary greatly in both energy and density. If you feed by volume you run the risk of either over feeding or under feeding your horse.
- **Use feeds that are processed** in order to increase starch digestion in the foregut – the digestibility of starch in the foregut can be greatly increased by the use of processing methods such as pelleting, steam-flaking, expanding and extrusion.

C. NUTRIENT REQUIREMENTS OF HORSES

To remain healthy and perform to their optimum potential, it is essential that endurance horses be provided with the required amounts of **energy, protein, minerals, vitamins** and **water**.

A good balance of nutrients is also critical as the appetite of the horse is principally controlled by its requirements for energy. When a horse has consumed sufficient energy, it stops eating, regardless of whether other nutrient requirements have been met.

The nutrient requirements of each individual horse depend on the physiological condition at the time. The horse requires nutrients for **maintenance**, i.e. to maintain weight and fuel body processes such as grazing and breathing. In addition to these the endurance horse will require additional nutrients to meet the additional requirements of **work.**

The following is a summary of the important nutrients for endurance horses:

1. Energy

Given that endurance horses cannot compete until five years of age they are mature and have no additional requirements for growth. The endurance horse therefore has energy requirements for both maintenance and work. This energy can be derived from feed in three main types (**fibre, starch** and **fat**). These fractions are digested in the gastrointestinal tract and stored in the body as fuel in various forms. This fuel can be stored as muscle and liver glycogen, intramuscular and adipose fat, all of which can be used to augment the feed taken in during the ride to provide energy for muscle contraction. When required these different fuels are mobilised and used by contracting muscles to lever the horse's mass to cover the ground.

Fibre from pasture and roughage sources is a very important energy source to the horse. Horses are hindgut fermenters which means they are able to utilise plant fibre. Bacteria in the hindgut ferment fibre into volatile fatty acids (VFA's) that are absorbed and taken to the liver where

they are converted to glucose and stored as liver glycogen or fat. The digestion of fibre is a slow process so fibre can contribute energy to the horse during the ride long after a meal has been eaten.

All fibre sources are not equal and fibre consists of many different fractions. Lignin is indigestible and is unable to be utilized by horses, cellulose can be utilized by fermentation in the hindgut but does not yield a lot of energy. Hemicellulose and pectin are two fibre sources that are well digested by the horse and yield more energy than other fibre fractions. Sugar Beet Pulp and soybean hulls are two ingredients that are commonly termed "**super fibre**" due to the fact that they are low in lignin and high in digestible fibres such as hemicellulose and pectin.

It is absolutely vital to the endurance horse that it has a healthy gut. Under normal circumstances the gastrointestinal tract is continually moving food through. During exercise much of the blood supply to the gut is diverted away to the muscles and the skin. Dehydration due to heavy sweating also causes a decrease in blood volume and electrolyte imbalances. All of these can result in slowing of the gut, which can lead to colic and even death.

Research has shown there are two advantages in having a high fibre diet. Firstly the high water holding capacity of fibre results in an increase in water intake. The water and electrolytes held in the hindgut can then be drawn upon by the horse to help prevent dehydration and electrolyte imbalances, which are the key cause of metabolic problems in endurance horses. Secondly the presence of fibre in the gut will ensure that some blood flow to the gut remains during exercise.

Starch from cereal grains is commonly fed to endurance horses to increase the energy level in the diet since horses can rarely maintain condition on energy from fibre alone. Starch is digested in the small intestine to glucose, which is absorbed and can then be used directly or stored as glycogen or fat. The digestion of starch stimulates the storage of glycogen by raising insulin levels. The rate of increase and the level of blood glucose after a meal is often termed "glycemic response" and has important applications in the feeding of endurance horses.

Fat from vegetable oil is a rich energy source for the endurance horse and oil contains 2.25 times as much energy per weight as cereal grain. Fat is extremely well digested in the small intestine and has no risk of the problems that can occur with cereal grains if they are not fed properly. Fat is digested in the small intestine to fatty acids, which can be metabolised directly or stored as body fat.

The feeding of fat to the long distance horse is particularly attractive, as research has shown that fat supplemented horses were better able to mobilise body fat reserves as an energy source therefore spared muscle and liver glycogen thus delaying the onset of fatigue. Fat is extremely energy dense and reduces the amount of total feed required to maintain condition in horses that exhibit depressed appetite.

Dietary energy is expressed in Megajoules of Digestible Energy per kilogram of feed (DEMJ/kg). There are equations that can estimate the Maintenance DE requirement and the additional requirements for work. An example of these values is presented in **Tables 2** and **4**. **Table 2** shows that the nutrient content of the diet does not change dramatically if extra feed is consumed to meet the demands of work. In many cases horses will not increase their intake to compensate and the diet must be further concentrated in order to meet the demands of training. It is impossible in horses that have access to grazing to determine total intake. The only way of determining the nutritional status is to monitor body condition score.

Category	Energy MJ DE/kg	Protein %	Calcium %	Phosphorus %	Intake kg
Maintenance	9.25	9.4	0.40	0.27	6.75
Training	9.25	7.5	0.32	0.21	10.125

Table 2 ***The Nutrient Requirements of Adult Horses***

Source: Kentucky Equine Research. Values are for a 450kg horse and expressed on a 100% Dry Matter Basis

Category	Forage	Concentrate	Total
Maintenance	1.5 to 2.0	0.0 to 0.5	1.5 to 2.0
Light Work	1.0 to 2.0	0.5 to 1.0	1.5 to 2.5
Medium Work	1.0 to 2.0	0.75 to 1.5	1.75 to 2.5
Heavy Work	0.75 to 1.5	1.0 to 2.0	2.0 to 3.0

Table 3 ***Expected Feed Consumption by Horses***
Source : NRC 1989. Percentage of bodyweight of air dry feed

Level of Activity	Digestible Energy[1] (MJ/day)
Maintenance	**62**
Slow trotting 1 hour	**74**
Fast Trotting 1 hour	**83**
Cantering 1 hour	**95**
Usual Intake Limit[2]	**100**
Daily Appetite Limit[3]	**140**
Endurance Ride 80km 6hr	**150-165**
Endurance Ride 160km 14hr	**220-240**

Table 4 ***Energy expenditure in horses***

Note: 1. The energy figures are all for a 450kg horse. They are approximations and are intended as a guide only. Energy expenditure will depend on many factors.
2. The Usual Intake Limit refers to the energy provided by a typical endurance ration assuming 2kg of high energy hard feed, 500mls vegetable oil, 2kg lucerne hay/chaff and access to pasture.
3. The Daily Appetite limit refers to the energy provided by a ration assuming 5kg of high energy hard feed, 750mls vegetable oil and 6kg lucerne hay/chaff.

When energy is fed in excess of requirements it results in weight gain. In situations where a horse's energy requirements are not met, poor performance and weight loss will result. The astute endurance rider will carefully monitor bodyweight or body condition score and adjust feed allocations accordingly. Recent research has shown the importance of maintaining body condition score in the appropriate range (2.5 to 3.0) for endurance horses to ensure better completion rates. (For more information consult the technical bulletin: ***The Importance of Body Condition Score in Endurance Horses***)

2. Protein

Protein is made up of individual amino acids linked together and it is for these amino acids that the animal has a specific requirement. As can be seen in Table 2 the protein requirements for endurance horses are quite low and are easily met by the feeds that are commonly fed to endurance horses. If protein intake exceeds the requirement then the excess can be used as a source of energy. In this process the amino acids are broken down by the liver, generating metabolic heat and the resulting nitrogen is excreted in the urine as ammonia.

Excessive protein intake should be avoided in endurance horses for several reasons:

- Water requirements increase with higher protein as the horse tries to excrete the ammonia and hydration is vital to performance
- Levels of ammonia and urea in the blood can lead to disturbances in gut function.

• High protein leads to an increase in metabolic heat and reduce the efficiency that a horse can cool itself

3. Minerals

Minerals can be classified into:

Major Minerals are those required in large amounts (grams per day) by the animals. Minerals are found in all feedstuffs but are commonly not present in adequate quantities or the correct ratio and supplementation is necessary. **Table 6** highlights the importance of the major minerals and the recommended levels that they are required.

Electrolytes are minerals that disassociate in solution into charged ions. They are all major minerals in that they are required in large amounts. Horses have evolved a highly efficient sweating mechanism to cool their body when exercising. The sweat output of horses depends on temperature and humidity and the duration and intensity of work

Sweat loss is in the range of 4 to 10 litres per hour:

- 10 litres per day Light Training
- 20 litres per day Medium Training
- 40+ litres per day 80km Endurance Ride

The electrolytes that are lost in sweat and must be replaced are **Sodium, Chloride, Potassium,** and small amounts of Calcium and Magnesium.

Electrolyte	Conc. In Sweat (grams/litre)	Total loss in 15 litres of sweat
Sodium Na^+	2.8	42.0
Chloride Cl^-	5.3	79.5
Potassium K^+	1.4	21.0
Calcium Ca^{2+}	0.12	1.80
Magnesium Mg^{2+}	0.05	0.75

Table 5 ***Electrolyte losses in the sweat of horses***

For horses on a mainly hay or pasture diet, the potassium requirement is usually met but sodium and chloride intake is often inadequate. Most hard feeds contain added salt and will contribute sodium and chloride. A simple strategy is to include 30 to 60 grams (1 to 2 tablespoons) of table salt mixed in with the daily feed depending on the workload. Feed intake will be affected at higher levels so it may need to be divided into several feeds. The use of a high quality electrolyte supplement designed for endurance a horse, according to the directions is recommended for several days prior, during and several days after competition events. Avoid electrolytes that contain bicarbonate or citrate as they can predispose to alkalosis.

Trace Minerals are required in very small amounts but play vitally important roles in many body functions. Deficiencies and excesses of trace minerals can be harmful to horses and trace mineral supplements should be used with care. **Table 7** highlights the importance of the trace minerals and the recommended levels that they are required.

4. Vitamins

Vitamins are complex substances that play important roles in growth, reproduction and health.

Essential vitamins are those that cannot be synthesised by the horse and must be provided in the diet. The essential vitamins are A, D_3 and E are found in quite high levels in forages that are commonly fed to horses so additional supplementation is rarely necessary. Vitamin E however is

becoming increasingly more important and supplementation is recommended particularly in hard working horses.

Non-essential vitamins (B group, K and C) are derived from common feedstuffs and synthesised by micro flora in the large intestine in amounts that are generally satisfactory. There may be circumstances however in hard working or stressed horses where supplementation can be beneficial.

Tables 8 and 9 highlight the importance of vitamins and the recommended levels that are required.

5. Water

Water is often the forgotten nutrient but is essential to maintain body functions and replace losses in urine, dung and from the lungs and skin. A supply of clean, fresh, cool water should be available to horses at all times. The requirements depend on duration and intensity of work. Up to 60 litres of fluid can be present in the hindgut, and this reservoir of fluid can be drawn upon during rides. Fibre has a high water holding capacity; therefore diets that are high in fibre increase the size of the fluid reservoir within the gut and are therefore highly beneficial to endurance horses

Maintenance, cool weather	4 to 5 litres per 100kg of bodyweight daily
	18 to 23 litres per day for a 450kg horse
Hard exercise, hot weather	10 to 15 litres per 100kg of bodyweight daily
	45 to 68 litres per day for a 450kg horse

Mineral	Importance	Requirement (% diet as fed)	Requirement (grams per day)
Calcium	Bone and tooth development Regulation of heart beat **Results of Deficiency** Bone weakness, joint troubles Developmental Orthopaedic Disease (DOD) Big Head, Osteomalacia **Sources** Lucerne and legumes Limestone and Dicalcium Phosphate	0.32	32
Phosphorus	Bone and tooth development Energy utilisation **Results of Deficiency** Bone weakness, DOD, rickets, infertility **Sources** Grain, bran, Dicalcium Phosphate	0.21	22
Magnesium	Bone and tooth development Nervous System **Results of Deficiency** Bone weakness, poor growth, Nervousness **Sources** Pasture and hay	0.20	20
Sulphur	Hooves, hair and cartilage Sulphur Amino Acids and Biotin **Results of Deficiency** Not well studied **Sources** Protein meals	0.15	15
Sodium	Acid-Base balance of body fluids Nerve transmission, kidney function **Results of Deficiency** Chronic: Depraved appetite, Rough Coat Acute: Unsteady gait, incoordination **Sources** Salt: Moderate sweat 30 to 40 grams per day High sweat 60 to 70 grams per day Electrolyte Mixtures	0.46	46
Potassium	Muscular contraction Acid-Base balance of body fluids **Results of Deficiency** Reduced appetite, muscle stiffness, Tying up **Sources** Pasture, hay, molasses	1.0	100
Chloride	Acid-Base balance of body fluids **Results of Deficiency** Electrolyte Imbalances **Sources** Salt - Sodium Chloride	0.53	53

Table 6. ***The importance of major minerals and their requirements***
Based on a 450 kilogram horse performing moderate work

Mineral	Importance	Requirement (mg/kg diet as fed)	Requirement (mg per day)
Copper	Oxygen utilisation, red blood cells Formation of bone, cartilage and tendons Coat condition **Results of Deficiency** Weakened bones, Anaemia, rough coat Developmental Orthopaedic Disease (DOD) **Sources** Pastures commonly deficient	15	150
Cobalt	Component of Vitamin B_{12} synthesised by bacteria in the hindgut **Results of Deficiency** No deficiency reported **Sources** Most feedstuffs adequate	0.1	1
Iodine	Constituent of thyroid hormones which regulate basal metabolism Oxygen Utilisation, growth and reproduction **Results of Deficiency** Goitre, abnormal cycling, weak foals Deformed joints in foals **Sources** Most feedstuffs adequate	0.2	2
Iron	Constituent of Haemoglobin which carries oxygen in the blood **Results of Deficiency** Anaemia, lack of stamina Deficiency not common - parasite burden **Sources** Legumes, molasses, bran Most feeds adequate	50	500
Manganese	Utilisation of carbohydrates, enzymes Cartilage and bone development **Results of Deficiency** Deficiency not reported **Sources** Most feeds adequate	45	455
Selenium	Component of Antioxidant Enzyme Constituent of Methionine and Cystine Linked with Vitamin E **Results of Deficiency** White Muscle Disease, prone to tying up **Sources** Yeast, bran, lucerne	0.25	2.5 (feed cautiously to avoid toxicity)
Zinc	Metabolism of protein, fat and carbohydrates Immune System, skin, hair and hoof, bone **Results of Deficiency** Deficiency not reported **Sources** Protein meals, most feeds adequate	45	455

Table 7. ***The importance of trace mineral and their requirements***
Based on a 450 kilogram horse performing moderate work

Vitamin	Importance	Requirement (per kg diet as fed)	Requirement (per day)
Vitamin A	Skin and mucous membranes, vision, growth, bone development, hoof quality **Results of Deficiency** Weakened bones, rough dry coat infertility, poor night vision, poor appetite **Sources** Green leafy forages contain Carotene Liver can store up to 3 months supply	5,000 IU	50, 625 IU
Vitamin D_3	Regulates Calcium and Phosphorus Metabolism **Results of Deficiency** Bone and joint trouble, Rickets **Sources** Sun cured hay Sunlight on skin causes Vitamin D synthesis	500 IU	5063 IU
Vitamin E	De-toxifying, resistance to disease Especially important in hard working horses Linked to Selenium - spares Vitamin E **Results of Deficiency** More prone to tying up, muscle soreness, reduced endurance **Sources** Young leafy plants, wheat germ Most feedstuffs reasonably low	80 IU	800 IU (Research indicates that up to 2,000 IU per day benefits working horses)
Vitamin K	Blood clotting **Results of Deficiency** Susceptible to internal haemorrhage **Sources** Synthesised by bacteria in hindgut	Not Determined	Not Determined

Table 8. ***The importance of fat-soluble vitamins and their requirements***
Based on a 450 kilogram horse performing moderate work

Vitamin	Importance	Requirement (per kg diet as fed)	Requirement (per day)
Vitamin C	Formation of Collagen Powerful antioxidant **Results of Deficiency** No deficiency reported **Sources** Synthesised in the liver	Not Determined	Not Determined (Research indicates that up to 2,000 mg per day benefits working horses)
Thiamine - B_1	Metabolism of carbohydrates, nerve function Commonly used in tonics to stimulate appetite and calm horses **Results of Deficiency** Nervousness, poor appetite **Sources** Bacterial hindgut synthesis and diet - forages	5mg	50mg
Riboflavin - B_2	Metabolism of carbohydrates, nerve function **Results of Deficiency** No deficiency reported **Sources** Bacterial hindgut synthesis and diet	2mg	20mg
Niacin - B_3 **Pantothenate - B_5** **Pyridoxine - B_6**	Metabolism of carbohydrates, nerve function **Results of Deficiency** Deficiency not reported **Sources** Bacterial hindgut synthesis and diet	Not Determined	Not Determined
Vitamin B_{12}	Production of red blood cells, metabolism **Results of Deficiency** Deficiency not reported **Sources** Cobalt synthesized into vitamin in hindgut	Not Determined	Not Determined
Folic Acid	Red blood cell formation, general metabolism **Results of Deficiency** Deficiency not reported **Sources** Bacterial hindgut synthesis and diet	Not Determined	Not Determined
Biotin	Metabolism of fats, carbohydrate and protein Hoof quality and strength **Results of Deficiency** Poor hoof quality - not all defects Supplement 15 to 25 mg per day for 9 months **Sources** Bacterial hindgut synthesis and diet	Not Determined	Not Determined
Choline	Transport and metabolism of fat from liver Nerve impulse transmission **Results of Deficiency** Deficiency not reported **Sources** Bacterial hindgut synthesis and diet (fats)	Not Determined	Not Determined

Table 9. ***The importance of water-soluble vitamins and their requirements***
Based on a 450 kilogram horse performing moderate work

D. NUTRITIONAL VALUE OF FEEDSTUFFS

Table 10 shows the nutritional value of feedstuffs that are commonly fed to horses.

Feedstuff	Energy MJ DE/kg	Protein %	Calcium %	Phosphorus %
Cereal Grains				
Corn	14.2	9	0.05	0.27
Barley	13.8	10	0.05	0.34
Oats	12.5	9	0.08	0.34
Rice	14.1	8	0.07	0.32
Protein Meals				
Soybean Meal	13.1	45	0.35	0.63
Sunflower Meal	11.7	30	0.42	0.94
Tick Beans	13.1	25	0.04	0.24
Sunflower Seeds	18.7	20	0.04	0.3
Forages				
Lucerne Hay / Chaff	9.2	17	1.1	0.25
Cereal Hay / Chaff	7.5	7	0.21	0.25
Improved Pasture (Green)	10	14	0.25	0.18
Improved Pasture (Dry)	7.5	6	0.22	0.14
Native Pasture (Green)	8	12	0.22	0.15
Native Pasture (Dry)	5	5	0.2	0.12
Miscellaneous				
Bran	11.5	15	0.07	1.13
Molasses	11.4	5	0.75	0.1
Vegetable Oil	33	0	0	0

Table 10 ***The Nutritional Value of Feedstuffs Commonly Fed to Horses.***
Figures are on an air dry basis and are intended as a guide only

The principal feed for horses in Australia is grazing from either native or improved pasture. The highly seasonal climate in Australia means that the nutritional value of pasture varies markedly throughout the year. **(See Figure 2)**

During certain times of the year or when work is performed the grazed pasture contains insufficient energy. The answer to this is to supplement with energy in the form of cereal grains of fat. When increasing energy in this way it is important to retain the correct ratio of all other nutrients to energy in order to minimise nutritional problems.

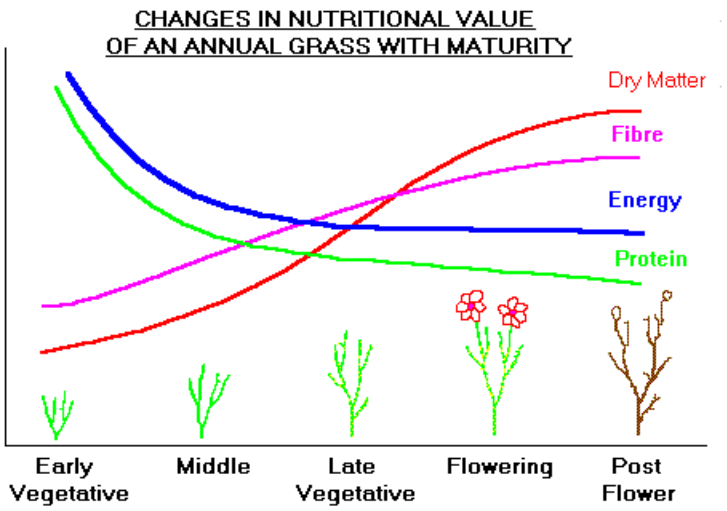

Figure 2. ***Changes in the Nutritional Value of an Annual Grass with Maturity***

Suitability of Feeds

Cereal Grains – cereal grains are all relatively high in energy due to the high starch content. They only contain moderate levels of protein and are low in calcium and high in phosphorus. **Oats** are the safest grain for horses because they are higher in fibre. They are highly palatable and can be fed whole or crimped. **Barley** is higher in energy than oats and is quite palatable. Barley is a hard grain and should be processed before feeding either by rolling, pelleting or steam flaking in order to increase the digestibility. **Corn** is a very high energy grain and is used to increase energy levels in the diet. Corn also benefits from being processed.

Protein Meal – protein meals are used to increase the protein in horse rations. As we have seen they have little role to play in the diet of endurance horses. **Black Sunflower Seeds** are a palatable high fat energy source but are also high in protein.

Forages – hay, chaff and grazing forms a most important part of the endurance horses ration. **Lucerne Hay/Chaff** is highly palatable roughage that is readily accepted with little wastage. It is however not ideal as the sole source of forage as it is high in protein and calcium. The theory is that diets too high in calcium can depress the ability of the horse to mobilise calcium body reserves during a ride an increase the risk of thumps (synchronous diaphragmatic flutter) Cereal **Hay/Chaff** may be less palatable and is lower in energy but has a better protein and calcium level for endurance horses. A blend of white and green chaff is an ideal mix. **Pasture** is extremely variable depending upon the composition of the pasture and the conditions under which it is grown.

Miscellaneous – Bran is a byproduct from the flour milling industry and is commonly fed to horses as it is readily available. It can be a useful feed in endurance horse programs when it is dampened to make a "wet mash" which make a good feed for use at vet checks. The use of too much bran can cause an imbalance in the ration as it is low in calcium and high in phosphorus. **Molasses** is a byproduct from the sugar industry and is low in protein but is moderately high in energy as it contains approximately 40% sugar. The use of molasses mixed in water to help promote water intake and mask the taste and smell of different water will also provide potassium and some calcium and help with electrolyte balance. **Vegetable Oil** is a highly concentrated form of energy but provides no other nutrients except for energy.

E. EXERCISE PHYSIOLOGY

There are two pathways by which the horse can utilise stored fuels. The first is **aerobic metabolism** whereby fat and/or glucose and/or glycogen can be utilised in the presence of oxygen. The second is **anaerobic metabolism** that occurs in the absence of oxygen and only glucose and/or glycogen can be utilised. The type of metabolism that occurs depends primarily on the speed of work and the type of muscle fibres recruited.

At the walk fat stores are primarily used aerobically, when trotting fat stores and glycogen are used aerobically and at a canter fat cannot be mobilised rapidly enough and only glycogen is utilised aerobically. Eventually at a fast enough speed the respiratory and cardiovascular system cannot deliver enough oxygen to allow fuels to be utilised aerobically and glycogen is utilised anaerobic ally with a resultant lactic acid accumulation and rapid onset of fatigue. **Figure 3** shows the very low glycogen utilisation at low speeds where fat is the main source of energy. As the speed increases the glycogen utilisation increases until there is a dramatic shift to glycogen utilisation as the horse crosses the anaerobic threshold. Obviously the speed at which this occurs depends on factors such as terrain, environmental conditions etc.

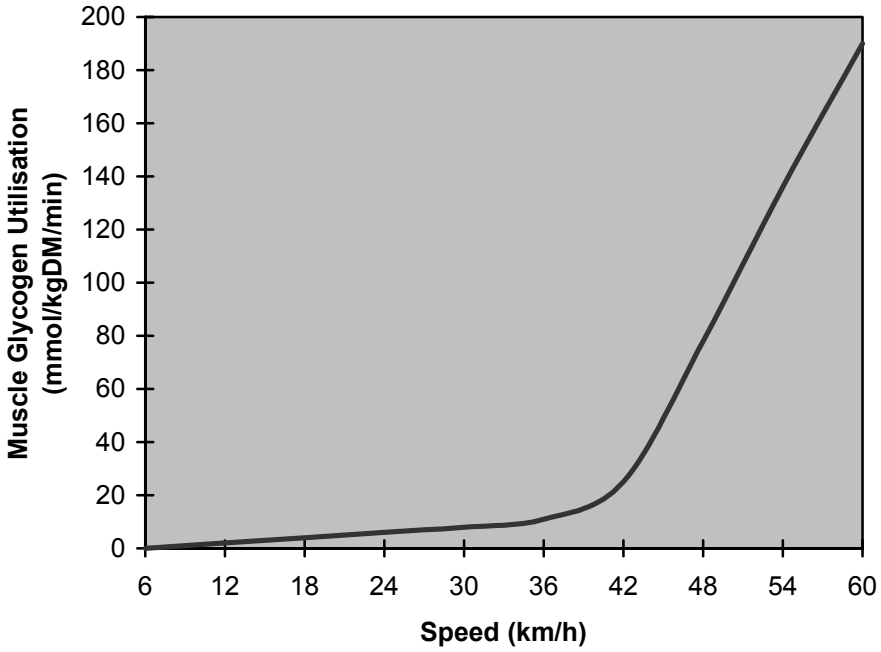

Figure 3. ***Muscle Glycogen Utilisation Vs Speed in the Horse***

The reason for the change in the usage of fuel is the recruitment of different muscle types. The horse has three types of muscle fibre: Type I, Type IIA and Type IIB. **See Table 11.** Type I and IIA fibres have a high aerobic capacity whereas Type IIB fibres rely very heavily anaerobic energy generation. Different breeds of horses have different percentages of muscle fibre types. The Arabian has a high proportion of Type I and Type IIA fibres and is ideally suited to endurance.

Muscle Type	Type I	Type IIA	Type IIB
Classification	Slow Twitch	Fast Twitch High Oxidative	Fast Twitch
Speed of Contraction	Slow	Fast	Fast
Tension Developed	Low	High	High
Oxidative Capacity	High	Intermed to High	Low
Capillary Density	High	Intermediate	Low
Fat Content	High	Intermediate	Low
Glycogen Content	Intermediate	High	Low
Fatiguability	Low	Medium	High

Table 11 ***Metabolic Characteristics of Different Muscle Types***

Endurance horses perform almost exclusively in the aerobic zone and only during very fast work and steep hill work would anaerobic metabolism be employed. Fatigue in endurance horses in most cases is therefore a result of the depletion of glycogen and fat stores rather than lactic acid accumulation. The stores in the body of a conditioned endurance horse are quite substantial and explain the remarkable feats of stamina we observe.

Fuel	Tissue	Grams
Fat	Muscle	1400 to 2800
Fat	Adipose	40 000
Glycogen	Muscle	3150 to 4095
Glycogen	Liver	90 to 220

Table 12 ***Fuel stored in Horse Tissue***
Assumes a 450 kg horse in moderate body condition

Table 12 shows that the fat reserves in a horse are by far the most extensive. It is highly beneficial to condition endurance horses to utilise fat reserves by feeding fat in the diet and conditioning appropriately, thereby sparing muscle and liver glycogen and delaying the onset of fatigue. It also highlights once again the importance of body condition score. Horses that are too lean will not have the fat reserves on which to depend during competition.

Energy Source	Starch	Fat	Protein	Fibre
Site of Absorption	Small Intestine Large Intestine	Small Intestine	Small Intestine	Large Intestine
Forms Absorbed	Glucose – SI Lactate – LI	Glycerol Free Fatty Acids	Amino Acids	Volatile Fatty Acids
Aerobic Energy	Yes	Yes	Yes	Yes
Anaerobic Energy	Glucose only	No	No	No
Energy Storage Form	Glycogen Fat	Fat	Protein Glycogen Fat	Glycogen Fat

Table 13 ***Dietary Energy Sources and their utilisation by the horse***

Table 13 shows the dietary energy sources available to horses and how they are utilised. From this information it is evident that because endurance horses perform largely aerobically they are able to utilise starch, fat and fibre as energy sources. The ideal hard feed for an endurance horse is one that:

- contains a blend of energy from fat, fibre and starch
- is low in protein (12% or less)
- contains a moderate but not excessive amount of starch to increase energy and help boost glycogen reserves
- contains between 6 and 10 % fat (rations with higher fat are often the cause of palatability problems)
- contains a high level of good quality fibre
- is designed to provide a balance of minerals and vitamins at a feeding rate that suits endurance horses. Most endurance horses are able to be maintained on hard feed levels of less than 3 kg per day.

E. FEEDING STRATEGY AND HINTS

General Recommendations

- For endurance horses the most important recommendation is to **feed a high fibre diet**. This fibre can provide large quantities of energy to the working horse and has several other advantages that have already been discussed. Ideally horses could be fed exclusively on good quality pasture and supplemented with minerals, vitamins and electrolytes where appropriate. However most horses require some sort of supplementation in order to maintain condition under the rigours of an endurance season. If selecting hay then a high quality grass hay or mixed grass/legume hay would be the ideal choice.
- **Feed a high fat diet.** This will ensure the utilisation of fat rather than glycogen. High fat feeds or top dressing with vegetable oil can be used. Fat feeding is most beneficial for horses with low feed intake as the volume of feed can be reduced but energy maintained. One cup (250 ml) of vegetable oil per day is equivalent to 600 grams or a 1 litre dipper of barley and should be readily

accepted by horses. Higher rates can be fed where additional energy is required but palatability can be a problem at high rates.

- **Supplement with electrolytes**
- **Maintain body condition in the desired range** and feed according to the work level
- **Supplement with trace minerals and vitamins.** Endurance horses have high requirements due to their heavy workload. Many trace minerals such as chromium and selenium have proven benefits. Similarly some of the vitamins such as Vitamin E and Vitamin C have a role to play in improving the performance of the endurance horse.
- **Ensure water is fresh, clean, cool and available.** Hydration is critical to endurance horses and horses need to be trained to drink at every opportunity.

Leading up to a ride

- **Reduce training intensity and frequency** to ensure glycogen reserves are full. For horses prone to tying up grain will also need to be reduced. On rest days all horses should be provided rations with grain reduced by at least one third.
- **Electrolyte loading** is commonly practiced by endurance riders with their horses. Doses of electrolytes in a non-working horse are rapidly excreted and can cause water loss due to high urine output. Standard doses of electrolytes should be used. A dose of electrolytes within one hour of ride start may help stimulate thirst on the first leg.
- **Maintain forage intake.** If the horse is not routinely fed hay and will be at the ride it is a good idea to introduce a small amount of hay for 1 to 2 days prior to the ride.
- **Make a Travel Plan.** Travelling can be quite stressful. Allow for rest stops on long trips and offer the horse water as well as hay or grazing during stops. Horses should not be fed hard feed for at least 6 hours prior to travel. Allow adequate recovery time from the trip.

At the ride before competition

- **Ensure the horse is completely hydrated and has an adequate reserve of electrolytes**. Making sure that a horse is drinking and supplementing with electrolytes will ensure this. For horses that do not drink well consider taking water from home or try "sweetening" the water with molasses, vanilla essence or apple juice.
- **If a horse is to be given a hard feed it should preferably be at least 6 hours before ride start.** This will ensure that high insulin levels do not impact negatively on performance.
- **Provide free choice access to water and grass or hay up until ride start** to ensure the horse has a hindgut full of fibre and reserves of water, electrolytes and energy.

During the Ride and at Vet Checks

- **Allow horses to drink at every opportunity on track**
- **Allowing horses to graze occasionally on track will help improve gut sounds**
- **At vet checks the first priority is to have the horse rehydrate itself.** Offer both plain water and water sweetened with molasses as the horses preference may change.
- **After the horse has begun to rehydrate itself then it can be offered some feed. Strategies to maximise water intake include the use of "wet feeds"**. These feeds are easily eaten by a tired horse and reduce the need for salivation. Examples are:

- dampened, sweetened chaff with added electrolytes. Small amounts of grain may be useful in tempting the horse but large feeds of grain should not be used. Treats such as carrots or apples can also be used.
- wet bran mash or soaked pellets are highly palatable
- hay dampened by wrapping in a wet hessian bag and left for up to 6 hours is highly palatable and helps to replenish lost fluids.

• **Electrolytes if being dosed should be given after a horse has drunk and eaten as they can discourage intake for a short period**

After the ride

• **At the completion of the ride the horse should be fed as at the vet check but can also be fed a usual hard feed**. An important point to remember is that the horse will often consume large quantities of water and feed and the rider should make sure that the horse does not run out.

• **Electrolytes are most important in the recovery period** and high doses should be given for 2 days after the ride.

• **Rest and recovery is important for the longevity of endurance horses.** It can take up to 72 hours to replenish the glycogen reserves that have been depleted. Over this time horses should be fed up to 50 % more than usual and then tapered off to normal levels.

Spelling horses between seasons

The aim with spelled horses is to maintain bodyweight and health during the rest period. Spelled horses will generally have access to pasture. The level of feeding necessary will depend upon the condition of the pasture. On good quality pasture no additional energy will be required but the use of a high quality mineral supplement will assist where deficiencies occur. Where pasture quality and quantity are reduced then feeding of hay and a balanced hard feed will ensure that spelled horses do not lose too much condition. As a general rule horses in this category should receive a maximum of 0.5% of their bodyweight in hard feed per day (0.5kg of feed per 100kg bodyweight)

Feed management hints

• **The feeder is as important as the feed** - the person who feeds the horse should closely observe the horse for change in appetite, monitor the condition of the horse and adjust the horse's feeding regime accordingly.

• **Horses have individual tastes** - horses have personal likes and dislikes and this should be taken into account when feeding but always remember to provide a balanced diet. The ration should be modified to suit individual horses requirements.

• **Use only quality feedstuffs** - feeds should be free of weeds, dust and mould.

• **Feed a horse according to its needs** - an adequate ration will ensure that a horse looks good, maintains bodyweight and is willing to work. An underfed horse will look poor, lose bodyweight and lack vitality. An overfed horse will gain bodyweight and may express excess energy as 'fizzy' behaviour.

• **Feed small meals often and at regular times** - horses are creatures of habit and appreciate a regular feeding routine.

• **Observe dung for changes** - check the amount, consistency, smell and colour of the dung as an indicator of digestive function and hydration status. Any deviation from normal may indicate digestive upsets.

• **Regularly review feed programme** - seek the help of experienced equine nutritionists.

• **Follow a health program** – keep up to date with worming, teeth and vaccination schedules.

G. COMMON PROBLEMS

Poor quality or shelly feet

Poor quality feet can be the downfall of an otherwise good endurance horse. The old saying "No Hoof – No Horse" is no truer than in the sport of endurance. There are many **"hoof foods"** on the market based on the vitamin Biotin with or without extra ingredients such as methionine, zinc etc. These products can improve the quality of some horses feet but do not work in all cases. The products that provide the correct dose of 15mg of biotin per day are expensive and need to be used for at least nine months in order to grow a new foot.

Fizzy or Overly Nervous Horses

These horses can be their own worst enemy in endurance. They often expend a lot of nervous energy and go a bit too hard early on and deplete their energy reserves. Quite often this is a temperament issue but nutritionally there are a couple of things that are worth a try such as :

- the use of a **"calming supplement"** containing Thiamine (Vitamin B1)
- eliminate oats from the ration and feed processed feeds
- divide the hard feed into two feeds per day
- the use of oil to replace energy from starch
- ensure adequate electrolytes are provided
- feed according to workload (do not overfeed)

Tying-Up or Equine Rhabdomyolysis

Tying-up is a complicated condition and recent research has expanded our knowledge, but there is still much more to be determined. Some horses have a genetic predisposition to tying-up and these horses need to be managed carefully. Other horses can tie-up as a result of poor feed management. If you have a horse that ties-up seek professional help from a veterinarian and nutritionist. They will consider many options such as :

- eliminate oats from the ration and feed processed feeds
- divide the hard feed into two feeds per day
- the use of oil to replace energy from starch
- ensure adequate electrolytes are provided
- reduce feed on rest days. Feed after work not in anticipation of work
- Vitamin E, Vitamin C, Selenium, Chromium

Depressed Appetite

Many endurance horses, especially those that run towards the front of the field will train off and exhibit signs of **depressed appetite**. This typically occurs after longer, hard training or competitions. For these horses, experiment and find a feed that they like. **Consider a pre-race and post-race booster** of B Vitamins to combat stress and help appetite and an antioxidant supplement of Vitamin E and Selenium.

Horses that are hard to put weight on

The consequences of horses that are **too lean and difficult to put on weight** are fully explained in the technical bulletin: ***The Importance of Body Condition Score in Endurance Horses***. In simple terms these horses need to consume more energy and expend less. Fat in the form of vegetable oil will increase the energy in the diet and it may also be necessary to feed horses more than the owner is used to. Remember that horse are all individuals and what works for one may not

necessarily work for another. A reduction in training intensity or complete spell is often the only way to regain lost condition on notorious poor-doers.

H. FEEDS AND SUPPLEMENTS

Ridley AgriProducts and **Kentucky Equine Research** manufacture and distribute a range of high quality horses feeds and supplements. These products are scientifically formulated by experienced equine nutritionists to ensure that they provide a complete nutritional solution for optimum performance. Commercially prepared horse feeds are an economical and simple feeding solution. However, it is important that horse owners take care to select the feed product most suited to their horses needs and also follow the manufacturers feeding recommendations.

The following table will guide you in selecting the appropriate product. For any other assistance with horse nutrition contact your nearest Ridley AgriProducts or Kentucky Equine Research office.

Horse Category	Requirements	Suitable Products
Endurance Horses-Spelling		
Usually over summer on reasonable quality pasture.	Low energy, low protein Balanced for major minerals, trace minerals and vitamins	
Horse that needs to simply maintain condition		Equivit All Phase Pellet
Horse that needs to put on condition		Equivit All Phase Pellet + Grain **or** Barastoc Calm Performer Pellet
Endurance Horses – Early Training		
Energy expenditure in early training is not high.	Mod energy , low protein Balanced for major minerals, trace minerals and vitamins	
Horse that needs to be trimmed down.		Equivit All Phase Pellet **and** Equivit Restore **or** Four Salts
Horse that needs to simply maintain condition		StableMaster Endurance **and** Equivit Restore **or** Four Salts
Endurance Horses – Heavy Training and Competition		
Energy expenditure is much higher. Pasture over winter lower quality.	High energy, low protein Balanced for major minerals, trace minerals and vitamins	StableMaster Endurance **and** Equivit EnduraMax **and** Enhance Oil **or** Equi-Jewel

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Horse Category	Requirements	Suitable Products
Specific Problems		
Poor quality, shelly feet	Biotin, Zinc complex	Equivit BioBloom
"Fizzy" horses	Min. starch - processed	StableMaster Cool Command **and** Equivit B Quiet
Stressed, underperforming, off-feed	B vitamins	Equivit Hemabuild
Tie-Up	Min Starch, Electrolytes, Vitamin E, Selenium	Enhance Oil **or** Equi-Jewel **and** Equivit Restore **and** Equivit Preserve
Low body condition	Increase energy, spell ?	Stablemaster Furlong **and** Enhance Oil **or** Equi-Jewel