Protein quality and requirements in exercising and growing horses

Dr C.E. Foote
Equine Consulting Services

Protein – what is it?

Protein is the major structural component of muscles, blood and many other tissues. Proteins primarily provide amino acids and nitrogen for tissue growth. Different types of proteins consist of different combinations and numbers of amino acids. As an analogy, if amino acids were letters in the alphabet, proteins would be words. Just as different words consist of different numbers and combinations of letters, different proteins consist of different numbers and combinations of amino acids.

Knowing which feeds are major protein sources

The table below describes the major protein meals commonly used in horse feeds.

Table 1. Common protein sources in horse feeds

Feed	Protein %	Best form to feed to horses	Comments
Soyabean meal	44.5	Meal extracted	Best source of balanced protein and amino acids available for growing and performance horses
Full fat soyabean	38%	Granules/meal extruded	Higher energy than extracted meal, suitable to boost energy – Very palatable, turns rancid on storage unless extruded
Linseed meal	34.6%	Low dust meal	Often expensive and not widely available, stepwise introduction to ensure acceptance
Cottonseed meal	41%	Clean meal	Reduced availability in drought seasons. Stepwise introduction to ensure acceptance
Sunflower seeds	23%	Plump whole seeds	Good "cool" energy boost to performance and show horses, lower in protein so more is required to replace high protein sources
Tick beans	25.5%	Clean cracked beans	Common protein source in racehorses, if not available replace with lupins
Lupins	33.8%	Clean cracked seeds	Good energy source, palatable and suitable replacement for other protein meals
Copra meal	22%	Clean, free of shells	Palatable, cool energy feed, low lysine content

(Kohnke et al., 1999)

Essential and non-essential amino acids

Proteins are composed of 22 different amino acids. Although all of them are needed for synthesis of body protein, some can be produced in body tissues and do not need to be supplied in the feed or absorbed from the intestine. These are referred to as "non-essential" amino acids, while those that must be provided in the diet are "essential" amino acids. The ten essential amino acids in horse rations are shown in Table 2.

Table 2. Essential Amino Acids in Horse Diets

Amino acid	**Action** **Role in Metabolism**
Arginine	- Promotes release of metabolic hormones insulin and growth hormone - Involved in the immune response
Histidine	- Essential for growth
Isoleucine	- Branched chain amino acid - Metabolised in muscle - Involved in protein metabolism and energy production
Leucine	- Branched chain amino acid - Metabolised in muscle - Regulation of protein synthesis, energy metabolism
Lysine	- Required for growth and optimum nitrogen balance in tissues - **The major amino acid that is used as a standard for dietary content in growing animals**
Methionine	- Essential for optimum growth
Phenylalnine	- Essential for nitrogen balance in tissues
Threonine	- Required for optimum growth, feed conversion and nitrogen balance in tissues
Tryptophan	- Essential for growth
Valine	- Branched chain amino acid. - Metabolised in muscle – energy metabolism and protein synthesis

(Kohnke et al., 1999)

Proteins composed of a high proportion of these essential amino acids are referred to as ***high-quality proteins***. Those containing a high proportion of nonessential amino acids are ***low- or poor-quality proteins***. Ensuring high quality protein is particularly important in growing foals and lactating mares, and of lesser importance in adult horses providing the feed contains sufficient protein to meet the horse's dietary protein needs. Table 3 describes the amino acid content of common protein feeds in horse diets.

Table 3. Amino acid composition of common protein sources. The feeds that contain the highest and second highest levels of each of the amino acids are shown in red/bold and blue/italics respectively.

	Lucerne	Soyabean meal	Copra (coconut)	Cottonseed meal	Lupins	Sunflower	Canola
Arginine	7.1	*32.3*	23.8	**42.6**	33.8	23.8	22.1
Histidine	3.7	**11.7**	3.9	*11.1*	7.7	6.6	9.6
Isoleucine	6.8	**19.9**	7.5	12.9	14.0	12.9	*14.3*
Leucine	12.1	**34.2**	13.6	24.5	24.3	18.6	*25.8*
Lysine	7.4	**28.3**	5.8	16.5	15.4	10.1	*20.8*
Methionine	2.5	6.1	3.5	*6.7*	2.7	5.9	**7.4**
Phenylalanine	8.4	**21.8**	8.4	*19.7*	12.2	12.3	14.3
Threonine	7.0	**17.3**	6.7	13.4	12.0	10.4	*15.9*
Tryptophan	2.4	**6.1**	1.9	*5.4*	2.6	3.8	4.5
Valine	8.6	**20.6**	10.7	17.6	12.9	14.9	*18.2*

As shown in Table 3, protein feeds that contain the highest levels of the essential amino acids are soyabean meal, cottonseed meal and canola meal. Copra and sunflower contain relatively low levels of essential amino acids, and are therefore unsuitable as the sole protein source in growing foal rations.

Protein requirements

The amount of crude protein needed in the diet depends on:

(1) The amount of that diet consumed
(2) The digestibility of the protein in that diet
(3) The individual horse's need for protein
(4) For the growing horse, the amino acid content or quality of the protein consumed

The amount of a nutrient needed in a diet depends on the amount of that diet consumed as well as the digestibility of the nutrient. The amount of a diet consumed depends on the animal's dietary energy needs and the energy content of the diet. The higher the energy content of the diet, the less of that diet the animal needs and will consume to meet its energy needs, and therefore, the higher the concentration of all nutrients in that diet must be so that the animal will receive enough of them to meet its needs. Thus, the most accurate way to express the amount of nutrients needed in a diet is the amount per unit of energy provided by that diet.

Protein requirements: Maintenance and physical activity

A horse needs a daily intake of protein to maintain, grow and repair tissues. Unlike energy, protein is not stored in the body and must be provided in the diet on a daily basis. Breakdown on protein contained in muscle and other tissues occurs in horses on low protein diets and additional protein is required to replace tissue degradation and losses in sweat (1.4g/L) and in working horses and the protein secreted into the milk of lactating mares (17-25g/L).

Studies have shown that horses in work require approximately 9.5 – 10g crude protein per megajoule of digestible energy (MJDE) consumed each day. Several studies also indicate that the amount of protein needed increases with increasing physical activity. The estimated protein requirement, relative to energy intake for light, moderate and intense work is shown in Figure 1.

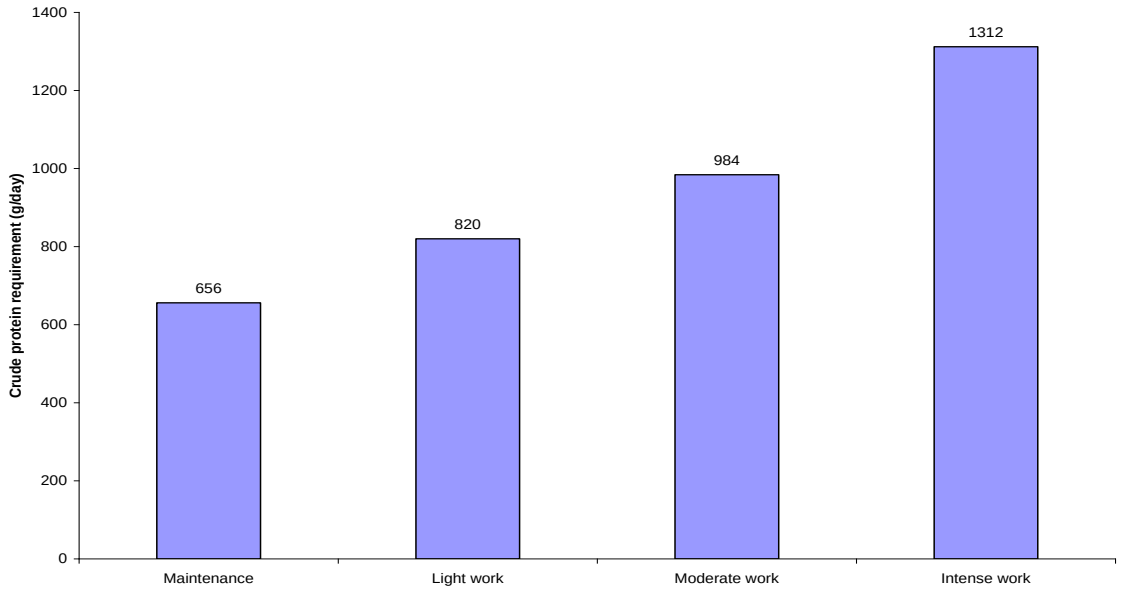


Fig 1. Crude protein requirement of a 500kg horse at varying levels of exercise.

This increased protein requirement is needed for

(1) increased muscle development and mass with increased physical condition
(2) perhaps increased muscle protein content and
(3) nitrogen lost in sweat

The horse can lose as much as 5kg of sweat/100kg body weight (Meyer, 1987) and this loss could increase crude protein needs as much as 0.5% in the diet dry matter. Nitrogen retention, for both idle and working horses, is higher in physically conditioned than unconditioned horses and, therefore, protein requirements may be higher for conditioned than unconditioned horses. This increased protein requirement may be due to increased muscle mass and, therefore, body protein content and turnover in the conditioned animal.

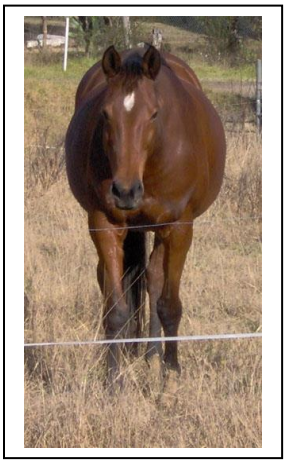
Protein and Amino Acids Required for Growth

Both the amount of protein and its quality, or amino acid content are important for growth. A greater amount of the essential amino acid lysine is needed by the young horse for growth than is available from microorganisms in its intestinal tract and than is present in many feeds. Two other essential amino acids, methionine and tryptophan are also present in low quantities in cereal grains. If the forage consumed is grass, intake of the amino acid threonine may be marginal. However, in one study, adding threonine to the ratio of primarily pasture fed horses only increased growth rate by 0.35kg in 4 months and feed efficiency from 77 to 79g gain/kg feed dry matter (Graham et al., 1993).

To provide the amount of lysine needed by the horse for growth, all of the additional protein above that provided by the grain and forage fed that is needed to meet these protein requirements should be provided by a good quality protein supplement containing feeds such as soyabean meal or canola meal, or supplements which have been fortified with lysine (such as commercial products based on cottonseed meal with lysine and methionine added). If feeds are offered which do not contain adequate lysine, growth rate and feed efficiency will be reduced.

Protein Required for Reproduction and Lactation

During the last three months of gestation, crude protein requirements increase. During the first three months of lactation, both milk protein content and the amount of milk produced are at a peak. As a result, the amount of protein needed is greatest during this period.



It may be beneficial to ensure that the lactating mare's diet not only contains adequate protein but is also high in the amino acids lysine and perhaps methionine since these are the most needed by the foal. In one study, mares fed high quality protein containing lysine and methionine prior to and following foaling produced milk with higher protein content during the first month of foaling compared to mares who were not on the supplemented feed. Foals born from these supplemented mares also had significantly higher growth rates during the first 7 weeks of life compared to foals born from unsupplemented mares (Glade and Luba, 1987).

Protein Deficiency

Manifestations of a protein deficiency are:

- reduced growth in young animals, and
- in mature horses,
    - weight loss
    - reduced performance ability, endurance, and production (such as reduced milk production during lactation).
    - Slowing of hair growth and shedding, resulting in a rough, coarse, unkempt appearance.
    - Slowly of hoof growth, which may result in increased hoof splitting and cracking

A protein deficiency may also cause appetite depravity and coprophagy (eating manure), which are alleviated within 5 to 7 days after correcting the deficiency. A protein deficiency may decrease feed intake, which not only worsens the protein deficiency but causes an energy deficiency which contributes to the clinical signs and further worsens the protein deficiency.

Protein defiencies are caused by the following factors:

(1) Inadequate protein in the diet (such as some mature grass forages)
(2) Poorly digestible dietary protein (such as heat damaged protein)
(3) Inadequate feed intake, in which case the major effect is due to an energy deficiency

If there is inadequate intake of energy in the ration, protein is used for energy and not for the animal's protein needs and the horse will lose body weight. An adequate energy intake should also be provided before trying to meet protein needs.

Protein excess

As a result of excess protein in a horse's diet, urea is excreted in the urine. This increases urine volume and water requirements. It also increases the ammonia smell in the urine which can be noticed in poorly ventilated stables when horses are fed higher-protein-containing feeds. In some stables, protein intake is elevated by the sometimes unnecessary addition of oil seed meals as a protein supplement. Protein intakes in excess of 50% above the horse's needs can lead to higher heat waste from fermentation, elevated heart and respiratory rates and may have an adverse affect on athletic performance. The utilization of protein for energy produces three to six times more heat than the utilization of carbohydrates or fats (Smith et al., 1978). This may be beneficial in a cold

environment, but may contribute to excessive sweating and heat exhaustion during physical activity, particularly in a warm environment. Excessive protein intake has also been implicated as a contributor to developmental orthopaedic disease. The most likely explanation for this is inadequate provision of minerals such as calcium and phosphorus to support a faster rate of bone growth in a higher energy (and consequently protein) diet. Although excessive protein intake increases urinary calcium excretion in people and rats (Linkswiler et al., 1974), it does not appear to have an adverse effect on calcium or phosphorus metabolism or musculoskeletal development of growing horses (Hintz, 1985; Schryver et al., 1987; Topliff et al., 1988).

Diet-Induced Allergy

Occasionally, allergies to specific protein may occur. This may result in the rapid development of round elevated areas on the skin surface over all or small portions of the body. These are referred to as urticaria, wheals, plaques, or protein bumps. They may or may not be pruritic (itchy), and they may persist for a few hours to several days, disappearing as rapidly as they developed. Numerous factors other than dietary protein may be responsible, including insect bites, inhalation of chemicals and pollens, internal parasites, vaccines and local anaphylactic reactions following administration of drugs such as penicillins, streptomycin and tetracyclines. When caused by the diet, the action is due to a specific protein in the diet and not the amount of protein and is frequently associated with pruritus. Severe tail rubbing may occur. Feeds reported to most frequently cause allergic reactions in horses include potatoes and their by-products, distillery wastes, beet pulp, buckwheat, clover, St John's wort, wheat, oats, barley, bran, tonic and chicory.

Less commonly, an allergy to an ingested protein such as clover pasture in bloom or fish meals, may result in the sudden occurrence of subcutaneous oedema, and the head is the most commonly affected site. Eyelids may be oedematous, the third eyelid may swell and protrude, and profuse lacrimation may occur. Although the condition may be caused by a feed allergy or snakebite, drugs are often implicated. Spontaneous recovery is common.

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