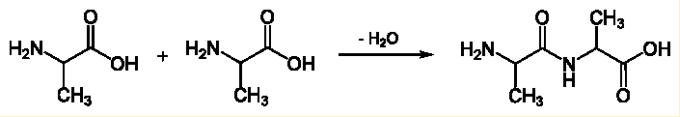
Protein

By The Nude Horse
(Equine Epidemiologist)

Amino acids are the building blocks of proteins. Protein is made of chains of amino acids. Therefore, the horse's requirement is for amino acids. Protein begins digestion in the stomach and moves to the foregut (small intestine) for most of the processing. Here the proteins are broken down in to free amino acids. From the foregut these individual amino acids are transported via the blood stream to the cells for use. The cells take these singular amino acids to recreate peptides or proteins needed by the body. Peptides combine to form a new chain of amino acids a polypeptide or protein. Shorter peptides are chains of 50 amino acids or less. Longer proteins have upwards of 27,000 amino acids. Amino acids can be arranged in many different combinations, it's possible for your horse to make thousands of different kinds of proteins from just the same 21 amino acids.



Peptide Formation from 2 amino acids

The horse can synthesize some of the amino acids itself. These are not specifically required in the diet and are thus termed "non-essential" amino acids. Those amino acids that the body cannot synthesize (or at least not in sufficient amounts) must be provided for in the diet and are considered "essential amino acids." There are 10 amino acids that are considered essential for the horse: arginine, histidine, isoleucine, leucine, **lysine**, **methionine**, phenylalanine, **threonine**, tryptophan and valine. A "limiting" amino acid is an essential amino acid that is often found in less than adequate amounts in feeds. Three such of these limiting amino acids are highlighted and will be expanded on in in this article.

Feed bags usually only list Crude Protein (CP) content. This can make it a challenge to know the quality of the protein content. Ideally you need to know the amino acid profile rather than the crude protein content. We will discuss some common base feed profiles, so you can understand if the CP you are feeding is of the desired 'quality' rather than pure quantity. You will have to read the 'Ingredients' list to see what amino acids are present on your hose feed bag rather than just the CP figure.

Likely signs of protein deficiencies

Unexplained weigh loss in adult horses
Fetal loss in pregnancy
Slow return to ovulating after the anovulatory period
Decreased milk production
Low growth rates in foals
Loss of top-line
Loss of muscle in working horses
Reduced feed intake
Poor hair growth
Reduced hoof growth – poor quality hooves

Protein Excesses

Not much evidence exists concerning the negative effect of excess protein feeding. Although concern has been raised from studies of other species that excess protein causes an increase in calcium loss. If so, the longevity of the horse and skeletal development in young horses may be of concern. It has been shown excess protein results in excess urea (smelly) and nitrogen excreted in the urine, this results in an increased demand for water. Another study discovered higher protein intake in exercising horses resulted in lower blood pH at rest and during sprint exercises.

Requirements for Protein

A young growing horse has a high requirement for the amino acids needed to build muscle and bone. Protein delivery via mare's milk delivers at the vital 4g CP x body weight (foal weight) per day in early lactation, regressing as the foal begins to graze and reduce milk intake.

Pregnant & lactating mares and horses in work require additional amino acid supply. A mare can produce up to 16 litres of milk a day (3.1 -3.23 percent of this is protein in early lactation, plateauing at 1.96 percent after 22 days) a high demand from the mare's reserves and/or diet. A mare not receiving adequate protein in her diet may begin to lose weight, milk supply likely reduce and the foal growth rates slow down. Insufficient protein in the mare's diet simply put means the milk protein content will also reduce.

Example: According to a study by Doreau (et al 1992) a 500kg lactating mare requires 2400g of Crude Protein per day in early lactation and 1920g CP in later lactation. This is higher than NRC recommendations, however the target 3% of BW in milk production was successfully reached.

A warning, pregnant mares for example, with a protein intake of less than 2g X Body Weight (BW) I.e. 2g x 500kg body weight = 1000g of Crude Protein a day are reported to have a higher incidence of fetal loss and tend to lose weight during gestation. Low protein intake can also slow down ovulating after the anovulatory period. Low protein intake is associated with low progesterone concentrations, critical to the maintenance of early pregnancy. Mares lactating on low protein diets (2g x BW or less) are likely to produce less milk and the foals are likely to have slower growth rates.

Working horses require an addition to maintenance levels of CP to compensate for muscle mass building and repairing after exercise. CP is also converted into energy and nitrogen lost in sweat. A study by Wicken et al (2003) recommended feeding 1.9-2.1g x BW for moderately exercised horses.

Sweat contains between 1 - 1.5 g of nitrogen per kg (sweat lost), and a horse can lose between 1 - 2.6% of pre-exercise body weight just through sweat. This equates to losses of approximately 38g Nitrogen or 238g CP for a 500kg horse.

Three formulas are therefore needed to calculate required CP for working horses:

Crude Protein Requirements – Maintenance + Work

1 - Maintenance feed rate	1.26 CP/kg BW/d
2 - Nitrogen Loss in sweat	0.14g CP/kg BW/d
3 - Muscle gain/repair	
Light exercise	BW x 0.089g CP/kg BW/d
Mod exercise	BW x 0.177g CP/kg BW/d
Heavy exercise	BW x 0.266g CP/kg BW/d
Extreme work	BW x 0.354g CP/kg BW/d

What does CP/kg BW/d mean?

It's so simple –

Multiple your horse's weight by the mg or g given in each example.

Example 1:

For a 500kg horse in light work

1) 1.26g X 500kg (Body Weight) gives you 630g.
2) For nitrogen loss 0.14g x 500kg = 70g.
3) For muscle gain/repair (light exercise) 0.089g x 500kg is 44.5g.

Now add all three outcomes, in this example it would be 630g + 70g + 44.5g = 744.5g of Crude Protein needs to be provided daily.

For a horse NOT in work the formula is simply 1.26g X BW.

Example 2:

1.26g x 500kg = 630g of Crude Protein per day.

Handy reference guide

CP (Crude Protein) Needs

Calculation	Age – Condition
4g x BW	4-10 months
3 – 3.3g x BW	11-17 months
1.26g x BW	First trimester mares
1.26g x BW PLUS (fetal gain kg/0.5)/0.79	5th month to parturition
3 – 4g x BW	Lactating, 1-2 months
2.5g x BW	Lactating, 2-6 months
1.26g x BW	Average horse 500kg no work
1.489 x BW	Light Work
1.577g x BW	Moderate Work
1.666 x BW	Heavy Work
1.754 x BW	Extreme Work

Limiting Amino Acid - Lysine

In trial, when protein feed sources are supplemented with the amino acid lysine, growth rates improved (NRC, 1989). Ott and Kivipelto (2002) concluded *Lysine was the most important factor affecting growth*, and that ***CP could be reduced in the diet if lysine intake was adequate***. Numerous studies agree Lysine is one of the most important amino acids necessary for pregnant horses and growing horses.

The amino acid profile varies among different protein sources. Reading a label that simply states the total CP will not help you know if the critical amino acid profiles for optimal growth, pregnant and lactating mares and horses in work are offered in the correct balances, for example of Lysine and Threonine.

An older horse in a study by Ralston et al (1989) reported digestibility of CP lowers with age. Digestibility went from a normal 73 % to 67%. Supplements with additional Lysine and Threonine have been recommended to maintain muscle mass in the older years.

Lysine requirement:

Calculation	Age – Condition
151-179 mg x BW (4.3% of the total CP requirement)	4-10 months
154-175 mg x BW	11-17 month
23 g daily	500kg no work
31 g daily	500kg hard work
31 g daily	Breeding stallion 500kg
34-38g daily	Late gestation 500kg
84-70g daily (reducing monthly)	Lactating 1-6 months

Example 1:

A foal (under 10 months) weighing 110kg:

4g x 110kg = 440g CP. Applying the recommendation of 4.3% of this CP to be Lysine, 4.3% of 440g = 18.9g Lysine.

Example 2:

A lactating mare 1-2 months post-partum weighing 500kg:

3g x 500kg = 1500g CP. Note a lactating mare also requires 4.3% of CP to be Lysine. So 4.3% of 1500g CP = 64g Lysine.

Limiting Amino Acid - Threonine

Improved growth rates were document when tested by Graham et al. (1994) with the addition of Lysine AND Threonine when compared to yearlings fed either no amino supplementation or just Lysine (without Threonine).

A similar study on exercising horses concluded that ***supplementation of Lysine AND Threonine enabled less CP to be fed***. This study by Graham-Thiers et al (1999,2001) also reported improved acid-based balance (higher blood pH and bicarbonate) during repeated sprints when fed a diet with less CP and fortified with Lysine and Threonine. Knowing that excess CP increases water loss through urination and urea formation, supplying additional Lysine and Threonine is especially of interest to owners with working horses. Specific quantities of Threonine requirements are not readily available; however, we can quote this one after significant clinical trial outcomes show its effectiveness.

Calculation	Age - Condition
110 mg x BW	yearlings 11-17 months

Limiting Amino Acid - Methionine

Methionine is a high sulphur containing amino acid. Sulphur accounts for 0.15 percent of the horse's body weight (i.e. 500 kg horse = 750g sulphur). A horse will excrete around 22g/d of sulphur via urine each day.

Methionine is known to helps against hair loss. It also improves hair and hoof texture, quality and growth. Methionine is a powerful anti-oxidant a necessary nutrient that helps prevent hair disorders. Methionine increases blood flow to the skin surface thereby increasing nutrient supply to hair follicles and aiding hair production.

Methionine can also be converted to cysteine and from there to cystine – the other two structurally important sulphur amino acids. Taurine is another sulphur amino acid ultimately derived from methionine that plays many important roles in the nervous system, detoxification, liver function and metabolism.

Supplement feeding of 2 g a day of Methionine is recommended, while up to 10 g a day has shown improved hair and hoof growth rates.

Base Feed Amino Acid profiles

The base feed profiles below demonstrate for example of *excellent amino acid profiles of Lupins and Copra* that would make meeting dietary needs quite easy.

Expressed as % of Dry Matter

	Copra	Barley	Lupins	Oat grain	Wheat Bran	Corn Grain	Soya Meal	Beetpulp
Crude Protein	21.9	14.9	34.9	11.5	15.7	8.3	48	8.6
Arginine	2.4	0.61	3.71	0.96	1.18	0.41	2.24	0.35
Histidine	0.43	0.25	0.85	0.34	0.48	0.25	0.65	0.25
Isoleucine	0.83	0.45	1.54	0.53	0.54	0.31	0.73	0.4
Leucine	1.54	0.88	2.64	0.99	1.1	1.1	1.65	0.55
Lysine	0.66	0.44	1.65	0.44	0.66	0.33	0.77	0.55
Methionine	0.38	0.18	0.3	0.24	0.27	0.19	0.37	0.08
Cystine	0.33	0.22	0.55	0.44	0.33	0.22	0.44	0.11
Phenylalanine	0.92	0.67	1.34	0.72	0.68	0.43	1.17	0.33
Tryptophan	0.63	0.44	1.48	0.45	0.47	0.27	0.84	0.44
Threonine	0.72	0.44	1.32	0.48	0.57	0.38	0.71	0.41

%Chart: Common feeds - amino acid profiles

Common Feed type	Crude Protein g/kg
Wheat	114
Wheat Bran	157
Triticale	140
Maize (Corn)	83
Barley	149
Lupins	349
Oats	115
Copra	219
Soybean Meal	480

Soybean meal/biproducts

Soybean meal sports a high protein profile, accompanied with high ratios of Lysine and Threonine, so why not recommend it as the BEST protein base feed?
There has been a tremendous debate over soybean (and biproducts) and its associated risks on human and animal health. However, there is equal research showing its nutritional benefits. *The Nude Horse* found the following data from reputable sources worthy of consideration. We recommend caution be exercised depending on your horse individual age, sex and circumstances before deciding if it is a good option or not.

In 2014 data showed over 80% of all Soybeans are GMO (Genetically modified). Soybean meal is the biproduct of soybean oil. Virtually all soybeans (99%) are solvent extracted (usually hexane) undergo extreme repeat heating during the oil extraction process. Hexane poses health risks and is regulated as a hazardous air pollutant.

Soybean has known allergenic properties and may affect humans and animals who consume.

Soybean is relatively high in phytate. The behaviour of phytate is to bind to calcium-magnesium and/or to proteins. It is thought Soybean meal may contain around 1.4% phytate. Phytic acid has also been implicated in decreased availability of other minerals such as iron, zinc, magnesium, calcium and copper. Reddy et al. (Reddy, N. R., S. K. Sathe and D. K. Salunkhe. 1982. Phytates in legumes and cereals. Pages 1-92 in C.O. Chichester ed. Advances in Food Research. Vol 28. Academic Press, New York, New York 1982 and Forbes et al 1983. (Forbes, R. M., J. W. Erdman, Jr., H. A. Parker, H. Kondo and S. M. Ketelsen. 1983. Bioavailability of zinc in coagulated soy protein (tofu) to rats and effect of dietary calcium at a constant phytate:zinc ratio. J. Nutr. 113:205-210 1983)

The phytic acid/protein interaction has also been shown to be dependent upon pH. An acidity or alkaline internal environment can further determine the protein solubility and/or inhibited absorption rates of calcium and magnesium. https://lib.dr.iastate.edu/cgi/viewcontent.cgi?article=9299&context=rtd and Phylate-Protein Interactions in Soybean Extracts by O. de Rham & T. Jost. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1365-2621.1979.tb03844.x

More reading: Journal of Food Science, Volume 44, Issue 2
PHYTATE-PROTEIN INTERACTIONS IN SOYBEAN EXTRACTS AND LOW-PHYTATE SOY PROTEIN PRODUCTS

Soybean contain isoflavones, there are 12 isomers of isoflavones in soybean. These compounds have been implicated in reproduction issues in animals fed diets containing large amounts of soybean meal (Schutt, 1976) Other studies attest to the estrogenic effect attributed to the consumption of soybean biproducts.

The National Toxicology Program (NTP) agree there are "numerous studies in laboratory animals exposed to the isoflavones… including genistein, show adverse effects on development." https://www.niehs.nih.gov/health/topics/agents/sya-soy-formula/index.cfm

"Studies using a variety of animal models report negative effects of soy isoflavones exposure during development." https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3257624/#B26-nutrients-02-01156

NRC prints that excessive protein from soybean sources has been linked to flexural limb deformities in growing horses (Fackelman 1980).

Soybean Oil has been implicated by its phytosterols content to be associated with the condition cholestasis in pigs at trial. Administration of phytosterols in neonatal piglets increases serum bile acids and reduces bile acid-dependent bile flow, resulting in the development of cholestasis. Phytosterols may contribute to the development of cholestasis by downregulating the suppression of bile acid synthesis. Cholestasis causes a stoppage or reduction of the flow of bile into the duodenum.
https://www.researchgate.net/publication/287746723_Cholestasis_and_biliary_calculi_in_horses

Generalized itchiness are characteristic symptoms of cholestasis. Most other symptoms are also common among other diseases, so diagnosis is often difficult and prolonged. Cholestasis is rarely detectable until greater than 80 percent of the liver mass is lost for more than three weeks.
https://academic.oup.com/ajcn/article-abstract/60/3/333/4731888

No data is available on the final Omega 3:6 ratio of Soybean Meal, however soybean seeds are known to contain up to 11% Omega 6 of dry matter (DM). See more information on Omega 6 below under *Sunflower Seeds*.
https://pubag.nal.usda.gov/pubag/downloadPDF.xhtml?id=3483&content=PDF

Almost every commercially prepared premade feed will contain some product of soy, whether it is soybean meal, soy hulls, or soybean oil. So, if your choice is to avoid soybeans altogether, you will have to read labels thoroughly and likely make your own simple base feeds from alternative high protein, lysine and threonine types. See *Keep It Simple Diet* at https://thenudehorse.com.au/nutrition/

Sunflower Seeds

At a glance sunflower seeds appear a good source of CP, Lysine and Threonine. It boasts a CP of 26.8%, Lysine 1.1% and Threonine 1.14%.

Studying the composition further reveals a severe inverse ratio of Omega 3 to 6. Diets containing grains and cereals are predominately high in Omega 6. Research shows high ratios of Omega 6 to Omega 3 fat in the diet shifts the physiological state in the tissues toward pathogenesis of many diseases such as sugar related illness, allergies, mood problems and inflammation.

Sunflower kernels have an alarming ratio of 1:311 (3 to 6 of Omegas). Pasture grass (an ideal Omega ratio) is 4:1 (Omega 3 to 6) Sunflower kernel's extremely high Omega 6 to 3 content deems it potentially detrimental to feed regularly to horses.

Protein in Hay and Grass

Forage	Crude Protein content
Fresh grass Winter	150 g/kg
Fresh grass Summer	70 g/kg
Lucerne hay	170 g/kg
Oaten hay	80 g/kg
Ryegrass grown in summer	100 g/kg
Ryegrass grown in Winter	220 g/kg
Meadow hay	90 g/kg
Clover hay	120 g/kg

How to calculate the amount of Crude Protein in my horses diet

Weigh the daily hay/grass and dry feed intake you give your horse. Or estimate its daily intake of pasture grass at 1-2% of body weight (i.e. 500kg x 1.5% = 7.5kg)

Example:
A 500kg horse needs 8.5kg Dry Matter (DM) daily

7.9 Kg lucerne hay x CP, (170g CP/Kg) = 1343g CP
PLUS
0.6 Kg oats x CP, (115g CP/kg) = 69g CP

Add 1326 + 69 = 1395g CP provided daily in this blend making up the necessary 8.5kg of DM.

In this example the horse is consuming 1395g of Crude Protein daily. If the horse is 500kg and at rest (500kg x 1.26 CP) the daily needs would be only 630 g CP, so adjustment to the type of feeds can be made to reduce the CP content.

Always ensure you meet the dry matter weight (DM) recommendations for your size horse. See the article '***How Much To Feed A Day***' by *The Nude Horse.* Find at https://thenudehorse.com.au/nutrition/

More research on cross animal species re Soy
https://www.westonaprice.org/health-topics/soy-alert/studies-showing-adverse-effects-of-isoflavones-1950-2010/

More research on Omega 3 & 6
see article "Fatty Acids - Omega 3 & 6 What is the difference"
https://thenudehorse.com.au/nutrition/