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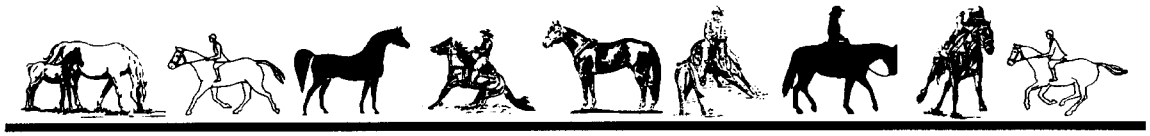

SELECTION AND USE OF FEEDSTUFFS IN HORSE FEEDING

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(edited by Michael Benefield)

INTRODUCTION

Diets for horses may comprise a variety of feedstuffs. Various ingredients or combinations can be used with success, provided the diet promotes normal digestive tract function, meets nutrient requirements, and represents a reasonable amount of feed that can be safely consumed by the horse. All diets need to contain sufficient roughage, with additional nutrients provided in a concentration that is balanced and offered in a fashion that will contribute to the horse's needs and continued well being.

Moreover, high quality roughage sources in the form of hay or improved pasture are normally suitable for meeting the majority of requirements for mature, nonworking horses. Additional nutrients required for young growing, late gestating, lactating, and working horses can then be balanced using concentrate sources.

ENERGY SOURCES

Energy requirements are normally met by feeding one or more cereal grains, which are high in energy density, in a balanced ration. This concentrate should be designed to provide the remainder of nutrients not supplied by roughage. Grains vary in energy density, are moderate sources of protein and phosphorus, and tend to be poor sources of calcium (Table 1). Thus, careful management is required when feeding grains to horses.

Oats - Oats are among the most popular grains fed to horses today. Oats are moderate in energy, and protein, and the high fiber content of oats (over 10%) makes them reasonably safe for horses, particularly where management is limited. This bulkiness also helps when mixing other grains with oats, because some fiber can be maintained in the concentrate.

The nutrient value of oats varies with weight, and as a result, oat grades range from US No. 1 oats weighing 36 lb./bu. to US No. 4 oats weighing 27 lb./bu. Also, high quality oats can be made to weigh as much as 42-50 lb./bu. by clipping the ends, which lowers the fiber and increases the nutrient concentration. Oat groats, oats from which the hulls have been removed, are excellent for use in foal rations, but are expensive. High quality oats are plump, heavy, clean (free of dust, broken seeds, dirt, weed seeds, etc.), bright in color, smell good, and have a low husk:kernel ratio. Whole oats are easily digested by most horses.

Corn - Corn is grown in almost all states in the U.S. and is readily available to horsemen. Corn is high in energy density (1.54 Mcal DE/lb.) and has a high volume weight (56 lb./bu.). Thus, feeding a volume of corn provides from two to three times more energy than when feeding that same volume of oats to a horse.

Only the highest quality corn should be purchased and fed, as corn can contain the mycotoxin Fusarium moniliforme,[12] which causes leucoencephalomalacia or "moldy corn poisoning" in horses. Mycotoxin related deaths

have been reported in the Gulf Coast area of Texas, as well as in some other states. Horseowners should avoid feeds that contain corn by-products, and should not feed corn screenings.[19]

Corn for horse rations should be plump, firm, dry (less than 14% moisture), clean, and insect/mold free. Corn can be fed on the cob, shelled, coarsely cracked, or rolled.

Barley - Barley is a popular energy concentrate for horses in the western United States and in several foreign countries. Barley is intermediate in fiber content between oats and corn, and has a harder kernel than oats. Therefore, it should be processed when being fed to horses.

Wheat - Wheat is traditionally utilized for human consumption and tends to be expensive. However, wheat can be an excellent energy concentrate for horse rations.

Wheat contains gluten, a sticky substance important in the baking industry. Large quantities of this dough gluten can cause digestive disturbances in horses, therefore, when utilizing wheat, don't include over 20% wheat in a ration,[4] and always feed it with a bulkier grain. Horseowners often get the opportunity to purchase oats which contain 10-20% volunteer wheat, and this can be good feed for horses.

Sorghum Grain (Milo) - Sorghum grain is a plentiful grain in the southwestern United States where it is fed to all species of farm animals. As with corn, many misunderstandings are associated with the feeding of sorghum grain. Sorghum grain is much like corn in its nutrient content, except it varies considerably more in protein content than corn. From a safety standpoint, the same feeding precautions for corn also apply to feeding sorghum grain. Due to availability and price of sorghum grain in the southwest, studies have been conducted comparing sorghum grain to oats and corn in rations for horses. In one study, researchers feeding yearling horses compared rations containing oats and corn to rations with 0, 23, 45 and 67% rolled sorghum grain.[1] There were no differences in feed intakes, weight or height gains, or efficiency of feed utilization. Also, there were no incidences of digestive disorders in the horses fed sorghum grain. Another study compared rations containing oats or sorghum grain for growing horses, and reported no significant differences in feed consumption, weight or height gains.[9]

High energy feeds such as corn, barley, or sorghum grain are sometimes rejected by horse owners because of concern over digestive disorders associated with energy dense grains. Colic and/or laminitis can result from high caloric density - low fiber diets, that are victims of poor feeding management.[2] However, with good management, such feedstuffs can supply needed energy without contributing to digestive disorders. It is important to realize that grains of differing energy content also weigh differently. For example, a 3 lb. coffee can of oats weighs about 3 lbs., while the same can full of corn weighs about 5 lbs. On a pound per pound basis, corn contains about 15% more energy than oats. But, when a coffee can of corn is substituted for a can of oats, the horse is receiving over 2 times as much energy. Thus, it is fairly easy to overwhelm the ability of the horse's digestive tract. The small intestine of the horse normally serves as the major sight for digestion and absorption of non-structural carbohydrates (starches) in cereal grains.[13] This digestion is not affected by frequency of feeding, provided the horse does not consume more feed than can be digested in this area of the digestive tract where rate of feed passage is rapid. When energy dense grains are overfed, readily fermentable carbohydrate enters the large intestine and can ultimately precipitate colic and/or founder.

In short, feed intake must be regulated for a given horse according to the energy density of the grain mix. The advantage of high-energy concentrates is that they meet energy requirements in a lesser amount of daily feed compared to higher fiber, lower energy feeds.

PROCESSING

Processing is an important consideration for some cereal grains. Crimped or flaked oats are popular, but research has shown that processing increases the digestibility by no more than 5%.[3] This added utilization is generally not enough to offset the cost of

processing. Commercial companies, however, often process oats to help support a concentrate that contains other ingredients. One study compared micronization to crimping processes in oats and sorghum grains in rations for horses.[9] Micronization improved pre-cecal starch digestibility 14% and 20% for oats and sorghum, respectively, over traditional crimping.

Relatively large, high energy grains such as corn and barley should be cracked, rolled, or steam-flaked prior to feeding. This can increase the digestibility of corn by 7-9%.[10,11]

Processing can increase the digestibility of sorghum, rye, and wheat by 15% and is highly recommended for these smaller, harder grains. Although processed milo is less digestible than processed oats[9] research on intake of milo suggests that palatability is not a problem. Fine grinding of cereal grains should always be avoided, except in cases where grinding is a preliminary step in producing an extruded or pelleted feed.

Pelleting serves well in preventing horses from sorting the feed. However, pellet quality is extremely important and horseowners should pay particularly close attention to the crude fiber content of the pelleted concentrate. Soft, crumbly pellets fall apart easily and can promote more rapid intake by horses. Although pellet size apparently has little effect on rate of intake,[6] the harder, denser pellets are consumed more slowly. Pelleting can also serve to increase particle size,[21] especially where grains such as sorghum or wheat are being fed.

Rate of feed intake has also been compared among pelleted, mixed, and extruded feeds.[8] Research has demonstrated that a corn, oat, soybean meal, and molasses mixture will be consumed more slowly if extruded. However, intake between a typical grain mix and pelleted form is not different. Horseowners might want to consider extruded feeds for special situations, such as in the case of a horse that habitually "bolts"the feed.

FATS AND OILS

Energy feeds can also be made more energy dense by adding up to 10% additional fat or oil. Research has shown that feed grade rendered animal fat can be used to increase the digestible energy content of a concentrate, but is less digestible than vegetable oil. Oils, on the other hand, are more expensive to use. Fats and oils contain over two times as much energy as carbohydrates (Table 1), and allow horseowners to provide the same amount of total energy with significantly less total daily intake. Fats and oils, if utilized correctly, can be beneficial in putting weight on thin horses, and they have also been shown to have certain extracaloric effects. Research has found that fat added diets increase fat percentage of mares' milk in early lactation and cause the fat content to stay higher as lactation advances.[5] Furthermore, performance horses are able to spare muscle glycogen for short duration, exhaustive exercise, by utilizing energy from fats while working aerobically.[16] Increased stamina and delayed onset of fatigue can result from the proper use of added fat.[22] It is important to recognize that additional fat should be incorporated into the diet slowly and that horses should be allowed ample time (around 3 weeks) to adapt to this energy supply. Careless topdressing of oil or fat can contribute to digestive disorders and can negatively affect feed intake by horses.

It is important to remember that fats/oils supply a significant amount of energy to the diet. Therefore, if the horse's body condition is to remain the same, intake of a concentrate containing added fat should be decreased. And, the grain mix should contain no more than 10% added fat or oil.

SOURCES OF SUPPLEMENTAL PROTEIN

Increased attention has been given to utilization of protein supplements (Table 2) for those classes of horses known to require additional dietary protein. The two major classes that fall into this category are lactating mares and growing horses.

Protein concentrates are primarily the oil seed meals, by-product feedstuffs from the brewing and distilling industry, and certain animal by-products such as milk and meat meals.

It is important to understand that all

protein concentrates do not have the same value when measured from a quality standpoint.

Proteins are composed of amino acids. There are over 20 amino acids; 10 of which are called essentials, while the others are referred to as nonessential amino acids. An essential amino acid is one which cannot be synthesized in the body and must be provided in the diet. If all essential amino acids are present in a protein concentrate, each in adequate quantity, the body can synthesize adequate nonessential amino acids for building protein. When one or several essential amino acids are not present or are low in a protein concentrate, growth or milk production is slowed. Certain protein concentrates (soybean meal) have an excellent balance of essential amino acids and are considered high-quality concentrates, while others (linseed meal) are deficient in one or more essential amino acids and are low-quality protein concentrates. When young, growing horses are synthesizing a great deal of protein tissue, amino acid balance in the ration is critically important.

Soybean Meal - Of the oil seed meals, soybean meal is the most widely used protein supplement. Soybean meal generally contains 44-50% crude protein, and has an excellent balance of essential amino acids. Soybean meal is a good source of phosphorus, is low in fiber, and is highly digestible. The fat content of soybean meal ranges from 1.5-5.0% which is beneficial to energy nutrition, but can cause rancidity when soybean meal is not fresh. Whole uncooked soybeans should not be fed to horses, as uncooked soybeans contain a trypsin inhibitor which prevents the enzyme trypsin from digesting protein. Soybean meal can be added to a grain ration as a top dress when extra protein is needed in the ration, but some horses may sort the soybean meal out of the ration. Therefore, it is best to mix it in the feed.

One study compared height, heartgirth, and weight gain in foals nursing mares fed a control diet supplemented with either soybean meal, soybean meal + urea, or urea.[15] The soybean meal supplemented diet resulted in foals having significantly greater weight and heartgirth gain. Little or no improved foal performance was observed when urea was supplemented and nitrogen balance data indicated a higher percentage nitrogen was utilized by mares fed pre-formed protein than those fed urea. In another study, milk production was measured in 14 Quarter horse mares fed soybean meal and soybean meal + urea.[7] Mares fed the all soybean meal supplemented diet produced over 2.5 pounds more milk daily than those supplemented with urea. These results indicate that the equine can tolerate urea in the diet without noticeable health problems, but that urea may only be used to help meet maintenance requirements.

Linseed Meal - Linseed meal is produced from flax, which is grown largely in the north central United States. Linseed meal contains 30-36% crude protein; however, because it is low in lysine, linseed meal is not a complete protein supplement for horses.

Cottonseed Meal - Cottonseed meal, which is readily available in the southern United States, contains 35-41% crude protein, and is high in phosphorus. However, cottonseed meal has two limitations which must be accounted for when incorporating this protein concentrate into horse rations. First, cottonseed meal is only average in amino acid balance, being lower in lysine content than soybean meal. Second, some cottonseed meal contains gossypol, a compound known to be toxic to pigs and poultry if fed at high levels. However, several studies have been conducted utilizing cottonseed meal as a protein supplement for young horses.[18,23,14] These studies indicate that direct-solvent or prepressed-solvent extracted cottonseed meal, containing .2% or less free gossypol, can be used as a protein supplement for young horses if either synthetic lysine or lysine rich protein feeds (e.g. soybean meal, fish meal, etc.) are added to the ration. No gossypol toxicity symptoms were reported in any of the studies.

When utilizing cottonseed meal in horse rations follow these guidelines: 1) Use cottonseed meal with .2% or less free gossypol, 2) supplement cottonseed meal with synthetic lysine or lysine rich feeds, 3) if it is not possible to add synthetic lysine, use half cottonseed meal and half soybean meal in the ration, 4) when no other protein concentrate is available, include cottonseed meal in the ration at 15% over

required levels when balancing for crude protein. This will bring the lysine content of the ration to an adequate level.

Pelleted Supplements - When available, it is strongly recommended that horsemen use completely balanced, pelleted supplements when feeding grain based rations. Commercial protein supplements generally contain a combination of plant and animal protein concentrates. These supplements are usually well formulated, balanced, and ready to include in rations for horses not already consuming a balanced concentrate feed. Most are designed such that when mixed with grain to achieve the desired level of protein, all other nutrients are supplied in the correct relationship to protein.

Other Protein Concentrates - Other plant protein supplements are obtained as by-products from grain milling and starch extraction (e.g. corn gluten feed, corn gluten meal), as well as from brewing and distilling (e.g. brewers grains, distillers feeds). These protein concentrates vary both in protein quantity and quality. Protein concentrates from animal sources are derived from meat packing or rendering plants, and from surplus milk or milk products. Dried milk and milk products are costly but are excellent protein supplements due to their amino acid balance.

MINERALS & VITAMINS

The majority of horses which are fed high quality roughage and balanced concentrates with added calcium, phosphorus, trace minerals, salt and vitamins will need no additional vitamin or mineral supplementation. Likewise, most classes of horses receiving good quality roughage, grains, and free choice trace mineralized salt will need no additives. When diets for horses on pastures are suspected of being low in phosphorus (and possible calcium), various forms of concentrated calcium and phosphorus can be provided on a free choice basis (e.g. calcium carbonate, dicalcium phosphate, bone meal, etc.). However, it should be noted that horses don't have "nutritional wisdom" or the ability to regulate their own mineral intake.[20] For this reason, the proper quantity of mineral should be added to the grain mixture, or provided in a complete pelleted supplement. It is an acceptable practice to provide free choice mineral supplements to adult horses on pastures, but young horses or stalled horses should not be fed minerals on a free choice basis.

Horseowners who mix rations "on the farm" should take time to insure that diets contain sufficient amounts of minerals and vitamins. Commercial concentrates from reputable companies are already balanced and normally require absolutely no supplementation. However, it is unfortunate that almost 50% of commercially prepared feeds are mixed with some other cereal grain prior to being fed. This process, referred to as "cutting", drastically alters the nutrient balance. Survey information also indicates that over 50% of people who buy commercial feeds also purchase and use a topdress supplement of some kind, with every two horseowners using a different supplement.

Both fat-soluble and water-soluble vitamins are required by the horse. These vitamins are normally supplied through green growing forage, sun cured hays, and commercially prepared feeds. In addition the horse can synthesize certain water-soluble vitamins in the hindgut. However, very young horses, horses under stress (hard working horses), sick horses, or horses fed rations of questionable nutrient content may sometimes need supplemental vitamins. Vitamin concentrates are offered by many commercial companies and most of these products are good. However, vitamins should be fed according to directions, and in no case should indiscriminate over use of commercial vitamin/mineral supplements be practiced, due to potential toxicities and the upsetting of dietary nutrient balance. Over use of vitamins or mineral supplements can be just as harmful as feeding nutrient deficient rations. In particular, vitamin supplements should contain no more than 10% as much Vitamin D as Vitamin A. Higher levels of Vitamin D can be harmful to the horse.

Before topdressing, consult a feed company representative to determine if the supplement is needed along with the concentrate being fed. If mixing rations from several feedstuffs, secure help in bringing the calcium:phosphorus ratio into balance and in

selecting a trace mineralized salt premix that can be added at .5-1.0% of the grain mix. Many sources are available that will allow selection and incorporation of a vitamin/mineral package into the ration every time a new batch of feed is mixed. This can save both time and money and will provide a calculated approach to meeting the needs of horses.

COMMERCIALLY MANUFACTURED FEEDS

No individual grain by itself is nutritionally balanced for all classes of horses. The above mentioned cereal grains are all energy feeds that serve primarily to provide fuel for the horse. However, these grains are not very helpful in terms of balancing a total diet. On the basis of mineral content (Table 1), these cereal grains all contain inverted calcium:phosphorus ratios, and in some cases, the phosphorus levels may actually inhibit calcium absorption[20] thus, eventually leading to weakened or crooked bones and lameness. Consequently, feed companies utilize different grains and add proteins, vitamins , and minerals to make balanced horse feeds. Most feed companies manufacture a complete line of well balanced, ready to feed horse feeds.

Some information about the nutrient content of commercially prepared feeds is listed on the feed tag. In evaluating any feed, a horseman would like to know at least the energy, protein, calcium, phosphorus, and Vitamin A content. Feed companies will provide this information upon request, but are not required to list exact formulations on the feed tag. The law requires feed companies to list crude protein, crude fat, crude fiber, and ingredients on the guaranteed analysis tag, and from this information horsemen can at least partially evaluate a feed.

Feed tags on commercial concentrates usually do not provide minimum or maximum values for energy density. However, they do list crude fiber, which is a good indicator of energy content. There is an inverse relationship between crude fiber and the expected digestible energy content of grains and grain mixes (Table 3). Cereal grains that are high in energy are low in fiber, and vice versa. This relationship applies to almost all grains that are typical in horse feeding, except for sorghum grain (milo), which is quite low in crude fiber relative to energy density.

Examples of average feed intake using concentrates with varying levels of crude fiber are shown in Table 4. These examples allow for comparison with straight oats, which contains just over 10% crude fiber.

Today some commercial companies manufacture fat supplemented diets using a blend of fat and oil that is stabilized and less likely to become rancid. Feed tags that indicate approximately 3% fat usually contain no added fat, as this is merely an accounting for the fat that occurs naturally in cereal grains. So, if a feed contains 5% added fat, the feed tag will indicate approximately 8% total fat. Shown in Tables 3 and 4 are examples of changes in digestible energy and feed intake as 5% fat is added to concentrates of varying crude fiber levels.

The percentage of crude protein is listed on the feed tag and the quality of the protein can be estimated by looking at the specific protein concentrates shown in the ingredient listing. Specific quantities of calcium, phosphorus or Vitamin A may or may not be shown on the tag; however, calcium, phosphorus and vitamin A are generally added in adequate quantities.

Feeds labeled as "horse feeds" are generally more expensive than feeds labeled for cattle and other animals. Some feed companies produce 10, 13 and 16% crude protein cattle feeds at a price considerably cheaper than comparable horse feeds. These feeds usually have less than 12% crude fiber and are fortified with vitamins and minerals, and can often be utilized in horse feeding programs. However, the horseman should make sure the feeds contain no urea, rumensin, Bovatec™, drugs, or other additive medications.

SUMMARY

As previously mentioned, there are many different feedstuffs that can be utilized in safe and effective horse feeding. The foundation of a good feeding program is

roughage, either in the form of top quality hay or grazing. An average guideline for daily roughage intake is 1.0% of body weight. Nutrient needs not provided by the roughage can then be satisfied by using one or more cereal grains in a concentrate. Extra protein needed for broodmares and young growing horses should come from a pre-formed protein that contains sufficient lysine. And, several mineral sources are available that allow the commercial manufacturer or the individual horseowner to correct the inverted calcium:phosphorus ratios in cereal grains. A trace mineralized salt or mineral/vitamin package can easily be added when rations are being mixed. This balanced concentrate can then be fed to effectively meet the nutrient needs of horses, with intake usually ranging from .5 to 2.0% of horse body weight daily. Time and care given to selection and use of high quality feedstuffs will be worthwhile in feeding and managing horses with minimal interruptions due to digestive disturbances.

TABLE 1. NUTRIENT CONTENT OF ENERGY FEEDS, FATS AND OILS*

Energy Source	Digestible Energy (Mcal/lb)	Crude Fiber (%)	Crude Protein (%)	Calcium (%)	Phosphorus (%)
Barley	1.49	4.9	11.7	.05	.34
Corn	1.54	2.2	9.1	.05	.27
Oats	1.30	10.7	11.8	.08	.34
Rye	1.53	2.2	12.0	.06	.32
Sorghum	1.46	2.6	11.5	.04	.32
Wheat	1.55	2.4	11.4	.04	.38
Fats	3.61	-	-	-	-
Vegetable Oils	4.08	-	-	-	-

***** From NRC, 1989

TABLE 2. NUTRIENT CONTENT OF PLANT SUPPLEMENTS*

Protein Source	Digestible Energy (Mcal/lb)	Crude Protein (%)	Lysine (%)	Calcium (%)	Phosphorus (%)
Soybean Meal	1.45	44	2.9	.35	.63
Cottonseed Meal	1.25	41	1.7	.17	1.11
Linseed Meal	1.25	35	1.2	.39	.80
Peanut Meal	1.35	49	1.5	.29	.61

***** From NRC, 1989

TABLE 3. RELATIONSHIP OF CRUDE FIBER TO EXPECTED DIGESTIBLE ENERGY IN CONVENTIONAL AND FAT ADDED GRAIN MIXES

If the feed tag indicates Crude Fiber (%) of	Then, Digestible Energy (Mcal/lb) of the feed will be approximately	But if the feed also contains 5% Added Fat, the Digestible Energy (Mcal/lb) will be approximately
4	1.55	1.65
6	1.45	1.55
8	1.35	1.45
10	1.25	1.35
12	1.15	1.25
and only 3 % Crude Fat,		

TABLE 4. EXAMPLE GRAIN INTAKE COMPARISONS AT VARIOUS CRUDE FIBER LEVELS FOR A MATURE 1100 LB. HORSE @ LIGHT WORK LOAD*

If the feed tag contains **CRUDE FIBER** (%)	Then the horse typically needs **DAILY GRAIN** (lbs)	This is either less or more **COMPARED to OATS** (by weight)	But, if the feed contains **5% ADDED FAT** then the horse typically needs **DAILY GRAIN** (lbs)	This allows feed intake to decrease (by weight)	This amount of feed is either less or more **COMPARED to OATS** (by weight)
4	7.75	21% ↓	7.25	6-8% ↓	23% ↓
6	8.25	15% ↓	7.75	6-8% ↓	21% ↓
8	9.00	8% ↓	8.25	6-8% ↓	15% ↓
10	9.75	same	9.00	6-8% ↓	8% ↓
12	10.50	8% ↑	9.75	6-8% ↓	same

Intake ranges from .6% to 1% of body weight daily.
*Assume that horse is also receiving good quality hay at 1% of body weight daily.

HOW TO USE THIS CHART: If you know the crude fiber content, you can more accurately determine daily grain needs. Also, knowing the crude fiber content helps you make economic and feeding value decisions by comparing your feed to oats. (Example: If a feed tag indicates 6% as the crude fiber level, then that means a typical 1100 lb. horse performing at a light work load will require about 8.25 pounds of this grain daily. Compared to oats, this amount of feed is 15% less, by weight. If this 6% crude fiber feed also contains 5% added fat, then a typical 1100 lb. horse would only require 7.75 lbs. of feed daily. Compared to oats, this amount is 21% less daily feed, by weight). **Note: These are example intake levels and may need to vary for individual horses. Some horses may require significantly less feed, while others may need larger amounts. Change feeds or amounts of feed gradually. And feed horses at least twice daily when grain intake exceeds .5% of horse body weight daily.**

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