In: Equine Clinical Nutrition - Feeding & Care. LD Lewis (1995)

TABLE 4–4
Market Hay Grades and Relative Feed Value of Hays[143]

Grade	Description	Chemical Composition—% in DM			Relative Feed Value—%[a]
		CP	ADF	NDF	
Prime	Legume (prebloom)	> 19	< 30	< 39	> 132
1	Legume (early bloom) and 20% grass (vegetative)	17–19	31–35	40–46	118–132
2	Legume (midbloom) and 30% grass (early head)	14–16	36–40	47–53	101–117
3	Legume (full bloom) and 40% grass (headed)	11–13	40–42	53–60	88–100
4	Legume (full bloom) and 50% grass (headed)	8–10	43–45	61–65	75–87
5	Mostly grass (headed)	< 8	> 45	> 65	< 75

DM = dry matter; CP = crude protein; ADF = acid detergent fiber; NDF = neutral detergent fiber; > = greater than; and < = less than.
[a] Indicates the relationship between the feeding and economic values of different forages. For example: grade prime hay would be worth at least 1.76 times the cost of grade 5 hay (132 ÷ 75), and grade 1 hay 1.18 to 1.5 times the cost of grade 3 hay (118 ÷ 100 to 132 ÷ 88).

shown below is also used to compare the relative quality, feeding, and economic value of different forages.

Quality Factor (QF)

$$= 0.9199 + [(0.0136 \times \% \text{ CP}) - (0.0054 \times \% \text{ ADF})]$$

Reference Factor (RF) = QF corrected for moisture

$$\text{RF} = \text{QF} \times \% \text{ DM} \times 0.0114$$

Although feeding good-quality hay is certainly preferred and recommended, if the only feed available is weathered, stemmy, weedy, or nutritionally deficient hay, lots of it should be fed. This allows the horse to sort through it and eat only the better portions. If lesser amounts are fed, the horse is forced to eat the poorer-quality portions of the feed, or consume inadequate feed to meet its needs. However, moldy or dusty hay should not be fed.

CEREAL GRAINS FOR HORSES

Grains are seeds from cereal plants that are members of the grass family Gramineae. In addition to the seeds, the entire plant can be grazed or harvested as a cereal grain hay or haylage, as discussed previously in this chapter. The primary use of cereal grain plants, however, is the utilization of their seeds for feed and the rest of the plant as chaff, stover, or straw for high-fiber, low-energy, and low-protein feeds for ruminants or idle mature horses, or the straw for bedding as discussed in Chapter 9. The seed is the nutrient store for the embryo or germ from which a new plant develops. It consists of a coat, starchy endosperm, and germ. In milling, the coat is removed as bran. Rice, oats, barley, husked sorghum and husked millet have a fused husk or hull; corn (maize), wheat, rye, and grain sorghum (milo) and millet do not. Hulls are high in fiber; grains with hulls are therefore much higher in fiber than those without hulls.

The density, nutrient content, and characteristics of the cereal grains most commonly available are given in Table 4–5. In contrast to forages, the nutrient contents of cereal grains vary little from the values given. These values, therefore, may be used in formulating diets for the horse. A laboratory analysis usually is not necessary. An exception to this is triticale, whose nutrient content is quite variable.

All cereal crops are annuals. Depending on the type and variety of grain, they may be either winter annuals (planted in the fall, grazed in the spring or harvested in the spring) or summer annuals (planted in the spring and harvested in late summer or early fall).

Wheat, corn, and rice each constitute about 25% of world grain production, barley 10%, and grain sorghum (milo), oats, millet, and rye 1 to 4%.[51] How different grains are used varies from country to country. Corn, oats, grain sorghum, and barley constitute about 75%, 10%, 10%, and 4%, respectively, of the grains fed to livestock and poultry in the United States.[34] However, production and feeding of corn is steadily increasing while that of oats is decreasing.[51,114] Most wheat produced in the United States is consumed by people; in Europe, large amounts are considered the primary feed grain for livestock and poultry. In Mexico, many consider corn primarily a food for people, while grain sorghum is considered the primary feed grain for livestock and poultry. In most of the world much of the rice is consumed by people, and barley and rye are used in the brewing and distilling industries. All of the cereal grains, however, and their by products, are sometimes fed to horses and other animals.

Cereal grains have the following general characteristics. Compared to other horse feeds, cereal grains are:

1. Quite palatable for horses. Most horses prefer most cereal grains to other types and forms of forage and, therefore, will eat all the grain available before they will eat forage.
2. Dense, with a high weight per unit of volume, which is 4 to 8 times that of baled hay and 10 to 15 times that of loose hay (Appendix Table 9).
3. Low in fiber and high in dietary energy. Cereal grains contain one-half to one-third the crude fiber and 50% more energy than average to good quality hay (Appendix Table 7).
4. Very low in calcium (below 0.1%) and most vitamins, including the vitamin A precursor beta-carotene (below 1000 IU/kg) and vitamins D, E, K, B_2, and B_{12} (Appendix Tables 2 and 3).
5. High in starch, which makes up 55 to 60% of grain dry matter, whereas starch is low in forages.

Some of the starch in grain is digested and absorbed as glucose, whereas most other carbohydrates in horse feeds are converted by microorganisms to and absorbed as volatile fatty acids.[127] As a result, the horse's plasma glucose (but not insulin) concentration increases more following consumption of grain than of hay; in one study, the peak was 128 and 108 mg/dl, respectively, from 93 mg/dl prior

TABLE 4–5

Cereal Grains: Density, Nutrient Content,[a] Relative Feeding Values, and Characteristics for Horses

Grains	Unground Density Lbs/qt (kg/L)	Digestible Energy[b] Mcal/qt (Mcal/L)	Digestible Energy[b] Mcal/lb (Mcal/kg)	Relative Feeding Value[b,34] (%) By wt.	Relative Feeding Value[b,34] (%) By vol.	Decrease in Density if Ground (%)[c]	Crude Protein (%)	Crude Fiber (%)	Comments
Other Feeds for Comparison:									
Soybean meal	1.8 (0.85)	2.5 (2.7)	1.4 (3.1)				44	6	Most common protein supplement fed
Alfalfa, hay			0.9 (2.0)				17	26	Average to good quality
pellets	0.6 (0.3)	0.6 (0.6)	1.0 (2.2)				17	24	
Grass hay, good			0.9 (2.0)				9	27	
poor			0.7 (1.5)				5	33	
Cereal Grains:									
Oats (regular)	0.85 (0.4)	1.1 (1.1)	1.3 (2.8)	85	45	28	11–12	11	Most palatable and safest grain. Often most expensive & variable.
Oats (heavy)	1.0 (0.5)	1.4 (1.5)	1.4 (3.1)	90	50	28	12.5	11	Also referred to as "race horse" or "jockey" oats
Oats (hull-less)	1.4 (0.7)	2.4 (2.5)	1.7 (3.8)	110	95		18	2.4	e.g., Pennula, Rhiannon, and Kynon varieties
Corn (maize)	1.7 (0.8)	2.6 (2.7)	1.5 (3.4)	100	100	14	8–10	2.2	Grain most prone to mold and most commonly overfed
Barley	1.5 (0.7)	2.3 (2.4)	1.5 (3.3)	95	85	25	12	5	Between oats and corn in safety but less palatable. Malting barley is higher in energy & lower in protein than regular.
Grain Sorghum (Milo)	1.7 (0.8)	2.5 (2.6)	1.45 (3.2)	95	95		11.5	2.6	Should be processed. Brown variety is high-tannin, less digestible & less palatable.
Wheat	1.9 (0.9)	2.9 (3.0)	1.55 (3.4)	100	110	14	11–14	1.5–3	Less palatable than oats and corn. Should be processed.
Rye	1.7 (0.8)	2.6 (2.7)	1.53 (3.4)	100	100	14	12	2.2	Feed processed with 1/3 maximum in grain mix. Ensure no ergot.
Rice, ground (rough)	1.2 (0.6)	1.85 (2.0)	1.55 (3.34)	100	75		7–9	7–9	
Millet	1.5 (0.7)	2.0 (2.1)	1.35 (3.0)				10–12	6–9	Should be processed. Used primarily as birdseed.
Emmer	1.1 (0.5)	1.2 (1.3)	1.1 (2.5)				11–12	9–10	Look like barley. Feeding values similar to oats.
Spelt	1.1 (0.5)	1.4 (1.5)	1.3 (3.0)				12	9–10	
Triticale	1.25 (0.6)	2.0 (2.1)	1.55 (3.45)				15	4	A hybrid of wheat and rye. Protein is high quality.

[a] All values given are for whole, unprocessed grain and are the amount of, or in, the grain as fed. All are 88 to 90% dry matter and contain the following: 1.5–4% fat (ether extract) except 5–6% in oats; 19–25% neutral detergent fiber (NDF) and 8–14% acid detergent fiber (ADF), except 10 to 16% NDF and 3.6% ADF in corn, wheat, and rye; 0.04–0.08% calcium, 0.27–0.37% phosphorus, 0.10–0.15% magnesium, 0.32–0.48% potassium, 0.01–0.06% sodium, 0.1–0.2% sulfur; in mg/kg (ppm), 4–8 copper, 0.04–0.11 iodine, 30–80 iron, 5–36 manganese, 0.1–0.4 selenium, 15–35 zinc, 0.06–0.14 cobalt, 4–7 thiamin, 1–3 riboflavin, 15–60 niacin, 5–30 pantothenate, 3–8 pyridoxine, 0.1–0.4 biotin, and 0.2–0.6 folacin; and in IU/kg, less than 1000 vitamin A and 5–15 vitamin E, except 30 in oats.

[b] For horses, these values for oats, corn, barley, and probably spelt and emmer are not affected by processing (rolling, cracking, crimping, flaking, pelleting, etc.), whereas for sorghum, wheat, rye, and probably millet and triticale they are increased 10 to 15% by processing.

[c] The weight or Mcal/qt or liter of ground (or rolled, flaked, or crimped) grain is the percentage lower than the weight or Mcal/qt or liter as given for whole grain. For example, as given above ground regular oats' density in 28% less than its unground density of 0.85 lbs/qt, which would be [0.85 × (1 − 0.28)], or 0.6 lbs/qt. Ground oats' energy content would also be 28% less than its unground density of 1.1 Mcal/qt, which would be [1.1 × (1 − 0.28)] or 0.8 Mcal/qt.

to feeding.[6] There was no difference in the plasma concentration of either glucose or insulin in horses fed barley, corn, oats, or a sweet feed. However, with exercise, the horses' plasma glucose concentration decreased when corn, but not when alfalfa, had been fed 2 hours previously.[11]

Starch digestibility by the horse is high (87 to nearly 100%) and similar in different feeds,[9] but differs in where it is digested. Starch not digested in the small intestine is converted by microbial organisms in the cecum to volatile fatty acids and lactic acid. A sufficiently rapid production of a sufficient quantity of these acids causes cecal acidosis.

If cecal acidosis is sufficiently severe diarrhea, colic and founder can occur. This risk can be lowered by decreasing the amount of starch reaching the cecum, using the following procedures.[79,104]

1. By feeding less grain.
2. By feeding oats, followed by grain sorghum (milo), corn and last barley. The amount of starch digested in the small intestine is highest from oats and lowest from barley.[104]
3. By grinding and heat treatment (popping, micronizing, etc.) of grain which increases the disintegration of the grains and its starch granule structure, but not by rolling or cracking which do not do so sufficiently to have any effect on small intestinal starch digestion.
4. By not feeding forage for an hour or more before and for 3 or more hours after feeding grain. Forage, unprocessed or chopped, consumed with grain decreases the amount of the grain's starch digested in the small intestine.[104]

Regardless of whether these procedures are used, the consumption of a sufficient amount of any cereal grain at one time will result in diarrhea, colic, founder or death. Even if excessive amounts are not consumed at one time the consumption of excess amounts of grain results in excess dietary energy intake which will, over time, result in obesity, frequently increased hyperactivity or nervousness, and may increase the risk of developmental orthopedic diseases in young horses (see Chapter 18). Because of these factors, grain or grain mixers should not make up over 50 to 70% of the total weight of the feed consumed by any horse, and need not be fed at all unless energy or nutrients in excess of that in the forages available are needed. A need for energy or other nutrients in excess of that in the forages available is the major reason nutritionally for feeding grains or grain-supplement (concentrate) mixes.

Grain Types

Any of the cereal grains given in Table 4-5 are nutritious, good feeds that may be fed to horses. Providing they are good quality and that excess amounts are not fed, none are harmful in any way. The major criteria that should be considered in determining which grain to feed are: (1) the quality of the grain, determined as described in the sections "Grain Quality" and "Grain Storage" later in this chapter, and (2) the characteristics of each grain most important for the feeding program and horses. When the amount of grain fed is not more than a few pounds (up to 6 or 7 lbs or 3 kg) daily, doesn't vary greatly from day to day, and the chances of feeding too much are minimal, the major criterion in determining which of similar-quality grains to feed is the relative feeding value of the grains with respect to their cost. Other than as a carrier to ensure that the desired amount of a supplement is consumed, the major reason nutritionally to feed grain is to provide dietary energy. Therefore, barring differences in quality, cost with respect to energy provided is the most rational factor to consider in determining which type of grain to feed.

The relative feeding values of equal-quality cereal grains for horses are given in Table 4-5. The usefulness of these values is as an indication of the relative amount that each grain is worth. For example:

1. If corn costs $8/100 lbs, heavy oats would be worth $8 times their relative feeding value with respect to corn, which as given in Table 4-5 is 90%. Heavy oats would therefore be worth $8 times 90%, or $7.20/100 lbs. If oats cost more than this, they aren't worth it nutritionally. Whether their other attributes, such as less chance of being overfed or harmful, is worth their additional cost must be considered for that feeding program.
2. If sorghum is $10/cwt, regular oats would be worth $10 times their feeding value with respect to sorghum, which is regular oats' relative feeding value divided by sorghum's relative feeding value. As given in Table 4-5, this would be 0.85 ÷ 0.95, or 0.895. So, regular oats would be worth $10/cwt times 0.895, or $8.95/cwt.

The feed preference of most horses from the most to the least preferred is a mixed-grain sweetfeed, oats, cracked corn, whole corn, good-quality alfalfa hay, wheat, barley, rye, and soybean meal.[64,74] However, there are large individual variations in feed preferences by horses, just as there are in people. Although some horses may, for example, prefer rye to oats, just as some people may prefer liver to steak, for the majority the reverse is true. In addition, most horses prefer the type of feed to which they are accustomed.[64,74] Thus, when the type of grain fed is changed, regardless of which type of grain is involved, initially most horses will show a preference for the one to which they are accustomed. This initial lack of preference for the newly introduced grain doesn't, therefore, indicate that it is unpalatable, even for that horse, but only that the horse is unaccustomed to it.

Oats

Oats (Avena sativa) are in many areas the most popular cereal grain fed to horses (Fig. 4-10). They are reported to make up 31% of all commercially prepared horse feed.[51] Although they are fed to other livestock, they are less popular because of their lower energy density (Table 4-5), higher fiber content, greater variability in quality, and frequently higher cost. Oats are not as widely grown as many cereal grains and their production is decreasing because their yield per unit of ground is lower than it is for other cereal grains. Because oats require a low amount of water and a short season, and grow well in cool weather, their major production is in areas where other grains do less well, such as the northern plains states (Dakotas, Minnesota, Iowa, Wisconsin, Ohio, and Michigan). Their popularity as a food for horses is often due to habit, a lack of familiarity with feeding other cereal grains, and the fact that they are the safest and most palatable cereal grain for horses (in contrast to pigs).[64,74] Oats also have a relatively soft kernel that is easy for the horse to chew. Cooking and processing oats to crack the kernel aren't necessary or of much benefit, except possibly for very young horses or horses with poor teeth. This is a benefit not only because