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FORAGES FOR HORSES: MORE THAN JUST FILLER

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Horses have evolved over millions of years as grazers, with specialized digestive tracts adapted to digest and utilize diets containing high levels of plant fiber. They are capable of processing large quantities of forage to meet their nutrient demands. In an attempt to maximize growth or productivity, horses are often fed diets which also contain high levels of grains and supplements. Unfortunately, this type of grain supplementation often overshadows the significant contribution that forages make in satisfying the horse's nutrient demands.

Digestive function

Horses are classified anatomically as nonruminant herbivores or hindgut fermenters. The large intestine of the horse holds about 21 to 24 gallons of liquid and houses billions of bacteria and protozoa that produce enzymes which break down (ferment) plant fiber. These microbes are absolutely essential to the horse, since the horse itself cannot produce these enzymes. The by-products of this microbial fermentation provide the horse with a source of energy and micro-nutrients.

The equine digestive tract is designed in this fashion to allow the horse to ingest large quantities of forage in a continuous fashion. The small capacity of the upper part of the tract is not well suited for large single meals, a fact which is often ignored by horsemen. Large single meals of grain overwhelm the digestive capacity of the stomach and small intestine resulting in rapid fermentation of the grain carbohydrates by the microflora in the hindgut. These fermentations may result in a wide range of problems including colic and laminitis.

The fact that horses are hindgut fermenters has several implications for the person feeding the horse. First, since horses are designed to live on forages, any feeding program that neglects fiber will result in undesirable physical and mental consequences. Horses have a psychological need for the full feeling that fiber provides. Horses fed fiber deficient diets will in extreme cases become chronic woodchewers, 1000 pound termites that can destroy a good deal of fencing or stall front. It is also important to maintain a constant food source for the beneficial bacteria in the hindgut. Not only does their fermentation of the fiber provide a great deal of energy for the horse, but their presence prevents the proliferation of other, potentially pathogenic bacteria. Horses, like man, need a certain amount of bulk to sustain normal digestive function. Horses have an immense digestive system designed to process a large volume of feed at all times. Deprived of that bulk, the many loops of the bowel are more likely to kink or twist, and serious colic can result.

Forage should remain the foundation of a horse's feeding program, regardless of where it is raised or how it is used. Additional grains or protein and mineral supplements should only be used to supply essential nutrients not contained in the forage. This is the most logical and economical way to approach feeding horses, because it eliminates the needless duplication or dangerous excess of fortification. The problem with this method of ration balancing is that the quantity and quality of forage eaten by most horses is not precisely known. Horsemen pay close attention to a difference of a few percentage points of protein in a grain mix, but rarely assay hay or pasture for nutrient content. To compound the problem, intakes of hay and pasture are difficult to measure. This does not mean, however, that reasonable estimates of forage intake cannot be made. The following guidelines should help horsemen evaluate their forage programs and assist them in the selection of proper fortification for each class of horse that they are feeding.

Forage composition

Forages are composed of two components, cell contents and cell walls. Cell contents contain most of the protein, and all of the starch, sugars, lipids, organic acids and soluble ash found in the plant. These components are degraded by enzymes produced by the horse and are highly digestible. The cell wall contains the fibrous portion of the plant which is resistant to digestive enzymes produced by the horse. The primary components of the cell wall are cellulose, hemicellulose and lignin. The nutritive value of forages is determined by two factors:

1) Fiber content (The proportion of the plant that is composed of cell wall)
2) Fiber quality (The degree of lignification)

These factors are important because the horse can digest practically all of the cell contents contained in forages, but bacterial fermentation can only digest 50% or less of the plant cell wall. The degree to which plant cell wall is digestible is largely dependent on the amount of lignin that it contains. Therefore, it's important to understand how much of these components various forages contain and what factors affect their nutrient content.

Forage analysis

A great deal can be learned about the nutritive value of a forage by having it chemically analyzed. A number of commercial labs do a good job analyzing forage, but we regularly use the Northeast DHIA Forage Testing Laboratory in Ithaca, New York. This lab is fast and economical and they can conduct the majority of assays necessary to fully evaluate the nutritional value of a forage. Contact them at: Northeast DHIA, Forage Analysis Laboratory, 730 Warren Rd., Ithaca, NY 14850-9877 for postage paid mailers.

Of course, forage analysis is fairly useless if you don't know how to interpret the results. Below are listed many of the components often measured in forages with an explanation of why they are or aren't important for horses.

DRY MATTER

Dry matter, or % moisture, measures how much of the forage is water. Hays are typically 85-95% dry matter, but pastures contain much more water and can contain as little as 15- 20% dry matter. This water dilutes the other components of the forage, so for more of an "apples to apples" comparison, the composition of forages should be compared on a 100% dry matter basis. For example, a hay that is 90% dry matter may be 14.4% protein on an as fed basis. This is equivalent to 16% protein on a 100% dry matter basis. The difference between as fed and dry matter for this hay is not great. Compare this to a pasture sample that is 25% dry matter. If it contained 4% protein on an as fed basis, then this would equal 16% protein on a 100% dry matter basis. The hay and pasture actually have identical protein contents when the water is removed. Of course, be sure and express forage intake in the same terms as forage composition.

CRUDE PROTEIN

Crude protein is called "crude" because the assay used in its determination doesn't actually measure protein at all. Instead, the Kjeldahl analysis used by most labs measures nitrogen. Protein is calculated by multiplying nitrogen by 6.25. There are other substances in forages that contain nitrogen, so this analysis is subject to some error.

Most of the protein in forages is in the cell contents. This protein is readily digested by the horse's proteolytic enzymes. The digestibility of protein found in the cell contents is 80% or higher (table 1). Some protein in forages, however, is incorporated into the cell wall. This protein is called unavailable protein because it is completely indigestible. Unavailable protein is measured by running a Kjeldahl nitrogen analysis on the acid detergent fiber (ADF) of the forage. It can be expressed as ADIN (acid detergent insoluble nitrogen) and figure 2 shows how it affects protein digestibility in horses. In this study (Pagan and Jackson, 1991), the ADIN was primarily from distillers dried grains. ADIN is usually produced from heat damage in a chemical reaction between carbohydrate and protein called a Maillard reaction.

CRUDE FAT

Crude fat measures the lipids in forages that are soluble in ether. These lipids are contained in the cell contents of forages and have a true digestibility in horses of about 75% (table 1).

Table 1. ESTIMATED TRUE DIGESTIBILITY OF DIFFERENT CHEMICAL FRACTIONS OF FORAGE (ADAPTED FROM FONNESBECK, 1969)

Chemical Fraction	*Estimated True Digestibility (%)*
CELL WALL	
Cellulose	43.4 %
Hemicellulose	49.5 %
Lignin	0 %
CELL CONTENTS	
Protein	81.7 %
Soluble carbohydrate	100 %
Ether extract	75.1 %
Ash	90.5 %

ACID DETERGENT FIBER (ADF)

Acid detergent fiber (ADF) contains cellulose, lignin, and any of the insoluble nitrogen produced by a Maillard reaction. These are cell wall components and are therefore indigestible by the horse's digestive enzymes. Lignin and ADIN are also indigestible by the bacteria in the horse's hindgut, and lignin will decrease the digestibility of other cell wall components as well. ADF digestibility by horses averages 35-45% and is largely dependent on the level of lignification. We will discuss what affects lignin content later.

LIGNIN

Lignin is not usually assayed individually in a standard forage analysis, but the DHIA laboratory will perform lignin assays for an additional charge. If both ADF and lignin are determined, then cellulose can be calculated by subtraction. [ADF (%) - lignin (%) = cellulose (%)].

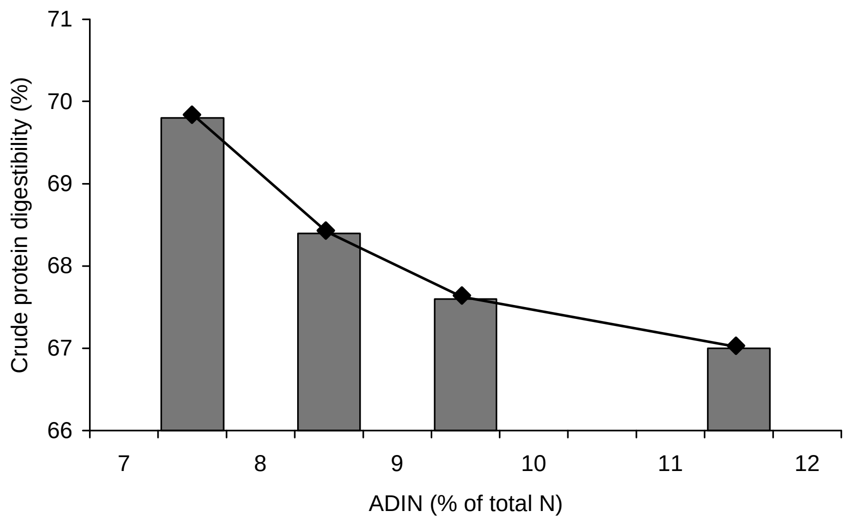

Figure 2. The relationship between ADIN and protein digestibility in horses

NEUTRAL DETERGENT FIBER (NDF)

Neutral detergent fiber (NDF) measures the entire cell wall content of a forage. It consists of lignin and cellulose like ADF as well as hemicellulose. NDF (%) -ADF (%) = hemicellulose (%). The overall digestibility of NDF in forages by horses varies from 40-50%. Hemicellulose is usually more digestible than cellulose, but its digestibility is also more depressed by lignin.

CRUDE FIBER (%)

Crude fiber is a very old and imprecise assay that is unfortunately part of our labelling requirements for animal feeds. This is a particularly bad assay because it doesn't really measure anything in particular. Table 2 shows what cell wall components crude fiber does not measure in different types of forages. For example, mature alfalfa hay contains 45% cell wall, but only 27% crude fiber. Even worse, beet pulp contains 47% cell wall but only 17% crude fiber. Crude fiber always underestimates the actual fiber content of a forage and its use for anything but to satisfy a government regulation should be avoided.

Table 2. THE PERCENTAGE OF ORIGINAL FEED LIGNIN, HEMICELLULOSE AND CELLULOSE DISSOLVED IN CRUDE FIBER DETERMINATION. (ADAPTED FROM VAN SOEST, 1982)

Class		*Lignin %*	*Hemicellulose %*	*Cellulose %*
Legumes	Range	8-62	21-86	12-30
	Average	30	63	28
Grasses	Range	53-90	64-89	5-29
	Average	82	76	21

ASH

Ash is what is left after the forage is burned at a high temperature in a furnace. Ash contains all of the inorganic components of the forage. Included in the ash portion are all of the minerals normally considered important for horses (calcium, phosphorus, potassium, magnesium, copper, zinc, manganese, iron, etc.) and minerals that are not usually considered as nutrients (mostly silica, but also traces of aluminum, fluoride, boron, etc.). Ash is not usually performed on forage samples, but it can provide valuable information in certain circumstances.

INDIVIDUAL MINERALS

The DHIA forage report includes calcium (%), phosphorus (%), magnesium (%), potassium (%), sodium (%), iron (ppm), zinc (ppm), copper (ppm), manganese (ppm), and molybdenum (ppm). Other labs also perform additional assays for selenium, cobalt, iodine, and sulfur.

CALCULATED VALUES

There are two values that can be calculated from a forage analysis that are very useful in evaluating its quality. First, the amount of soluble carbohydrate or sugar can be calculated. The original way to calculate this was as nitrogen free extract (NFE) = 100 - crude protein - crude fat - crude fiber - ash. This is not a good way to estimate soluble sugar because a lot of the cell wall components end up in the NFE estimate since they aren't recovered in the crude fiber fraction. True cell soluble sugars are completely digestible by horses, so any of the cell wall that escapes crude fiber detection is falsely estimated to be completely digestible. A much better way to estimate this fraction is to substitute neutral detergent fiber (NDF) for crude fiber. By doing this, what is left by subtraction is likely to be readily digestible by the horse.

The second value that is often calculated for forages is energy content. This is expressed as either digestible energy (DE) in calories or joules per kilogram or pound or as percent total digestible nutrients (TDN %). For all practical purposes, these various expressions of dietary energy are interchangeable. TDN% X 4.4 = DE (Mcal/kg) or TDN% X 2 = DE (Mcal/lb). What is important to realize is that both DE and TDN are only estimates of the actual digestible energy content of forages. They are calculated based on the relationship between some of the assays mentioned above to the digestible energy content of feeds determined in actual digestion trials with animals. Be sure you know which equations are used to calculate DE or TDN by a laboratory. DHIA uses equations developed with horses, but some labs still use equations developed with cattle or hogs.

Factors affecting forage quality

There are a number of factors which can affect the quality of a forage. Most important of these are the species of plant, stage of maturity, location where the plant was grown and content of inhibitory substances. All of these factors should be considered when assessing the suitability of a particular forage for horses.

SPECIES

Most plants that serve as forage for horses can be divided into two different categories, grasses and legumes. Grasses contain much structural matter in their leaves and leaf sheaths and these can be as important or more important than the stem in holding the plant erect. Examples of grass forages used for horses include temperate species such as timothy, orchard grass, brome grass and fescue and tropical species like pangola, guinea, bermuda and kikuyu. Legumes, on the other hand, tend to be tree-like on a miniature scale. Their leaves have very little structural function and tend to be on the ends of woody stems. The primary legumes used as horse forage are alfalfa and clover.

At a similar stage of maturity, legumes tend to be higher in protein, energy and calcium than grasses. Tables 3 and 4 describe the composition of legume and grass hays according to market grade. ADF (lignin plus cellulose) does not vary that much between grasses and legumes at the same stage of maturity. NDF (lignin + cellulose + hemicellulose), however, is much higher in grasses than legumes (figure 3). This is because grasses contain a great deal more hemicellulose than legumes. Therefore, evaluating the fiber content of forages based on ADF alone underestimates the total cell wall content and overestimates the total energy content of a grass.

Table 3. MARKET HAY GRADES FOR LEGUME HAYS (ADAPTED FROM HAY MARKETING TASK FORCE)

Grade	*Stage of Maturity*	*Physical Description*	*CP %*[a]	*ADF %*[a]	*NDF %*[a]
1	Pre bloom	40-50% leaves	>19 %	31 %	< 40 %
2	Early bloom	35-45% leaves	17-19 %	31-35 %	40-46 %
3	Mid bloom	25-40% leaves	13-16 %	36-41 %	47-51 %
4	Full bloom	< 30% leaves	<13 %	>41 %	>51 %

[a] 100 % DM basis

Table 4. MARKET GRADES FOR GRASS HAY (ADAPTED FROM HAY MARKETING TASK FORCE)

Grade	*Stage of Maturity*	*Physical Description*	*CP %*[a]	*ADF %*[a]	*NDF %*[a]
2	Pre Head	50% or more leaves	> 18	< 33	< 55
3	Early Head	40% or more leaves	13-18	33-38	55-60
4	Head	30% or more leaves	8-12	39-41	61-65
5	Post Head	20% or more leaves	< 8	> 41	> 65

[a] 100 % DM basis

Remember, hemicellulose is only 50% digested in the horse and cell solubles are almost completely digested. By only considering ADF, the assumption is that the rest of the forage (besides protein, fat and ash) is soluble sugar. This is truer in legumes which only contain around 10% hemicellulose than in grasses which can have hemicellulose contents of 30% or more. The fiber that is in legumes tends to be less digestible than the fiber in grasses, largely because legumes tend to have a higher lignin content per unit of total fiber. This means that the digestible fiber content of grasses is much higher than it is in legumes of similar maturity.

Because of the factors mentioned above, legumes contain 20-25% more digestible energy than grasses at the same maturity. In certain instances, the amount of legume hay fed may be limited so that the horse doesn't get too fat. This can result in intakes of digestible fiber that are below optimal levels, particularly in extremely high quality hays.

STAGE OF MATURITY

Generally, as plants mature they become less digestible. This is because a greater proportion of their mass becomes structural and less metabolic. Legumes tend to mature by decreasing leafiness and increasing the stem-to-leaf ratio. Alfalfa leaves maintain the same level of digestibility throughout their growth. Their stems, however, decrease dramatically in digestibility as they mature. This is because they become highly lignified to support the extra weight of the plant. The ultimate example of lignification for support is the oak tree. The wood of the oak tree is highly lignified and practically indigestible. When pulp wood is processed to make paper, the lignin is removed using harsh chemicals such as sulfuric acid (hence the sulfur smell around paper mills).

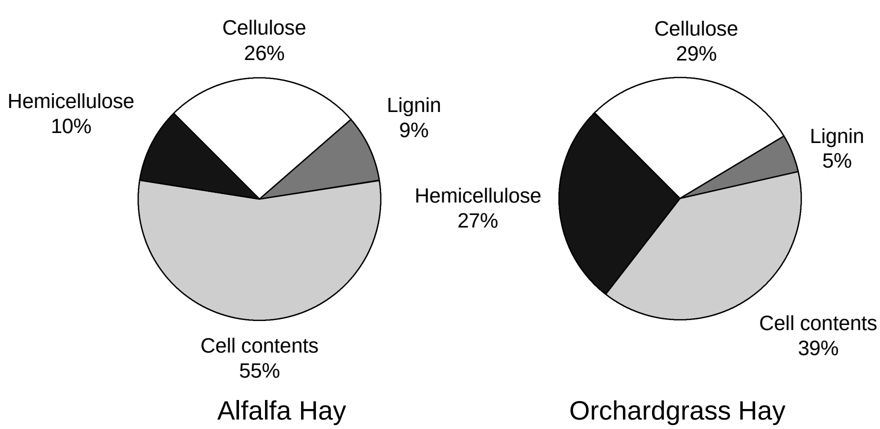

Figure 3. A comparison of the fiber content of early bloom alfalfa and orchard grass hay

The leaves of grasses serve more of a structural function than in legumes. As they mature, these leaves become more lignified and less digestible. Since the stems of certain grasses serve a reserve function, they may actually be more digestible than the leaves of these grasses at a later stage of maturity. Table 5 illustrates the effect that stage of maturity has on protein and fiber content of a temperate grass (timothy), temperate legume (alfalfa) and a tropical grass (pangola grass). When forage is grazed as pasture, its nutrient quality is almost always higher than when it is harvested as hay unless the pasture is the dead aftermath leftover from the previous growing season. New spring pasture can be quite low in fiber content and high in soluble carbohydrates. At this time of year, it is often a good management practice to continue to offer horses on pasture additional hay even if the pasture appears thick and lush. If the horses are getting adequate fiber from the pasture, then they will ignore the hay.

Table 5. THE EFFECT OF STAGE OF MATURITY ON PROTEIN AND FIBER CONTENT OF LEGUMES AND GRASSES

Forage/Stage of Maturity	*Crude Protein %*[a]	*ADF%*[a]	*NDF%*[a]
Timothy Hay early bloom	12.0	35.2	61.4
Timothy Hay mid bloom	9.7	36.4	63.7
Timothy Hay late bloom	8.1	37.5	64.2
Alfalfa Hay early bloom	19.9	31.9	39.3
Alfalfa Hay mid bloom	18.7	36.7	47.1
Alfalfa Hay late bloom	17.0	38.7	48.8
Pangola Hay 15-28 days growth	10.1	40.8	70.0
Pangola Hay 29-42 days growth	7.4	41.8	72.7
Pangola Hay 43-56 days growth	6.3	46.0	77.0

[a] 100 % dry matter basis

Table 6 compares digestibility of an early cut alfalfa hay with a more mature alfalfa hay. The less mature hay contained 37% cell wall while the mature hay was almost 52% cell wall. These differences were reflected in a 15% higher energy content in the early cut hay. This illustrates how stage of maturity and fiber content can impact the quality of alfalfa hay.

Table 6. NUTRIENT COMPOSITION AND DIGESTIBILITY OF EARLY AND LATE CUT ALFALFA HAY (KENTUCKY EQUINE RESEARCH DATA)

Nutrient	*Early cut composition*	*Early cut digestibility*	*Late cut composition*	*Late cut digestibility*
Digestible energy[a]	2.60 Mcal/kg	59.2 %	2.27 Mcal/kg	51.6 %
Dry matter[a]	90.4 %	65.9 %	92.4 %	56.0 %
Crude protein[a]	19.8 %	79.8 %	17.2 %	69.5 %
ADF[a]	32.3 %	41.6 %	40.7 %	39.2 %
NDF[a]	36.6 %	38.8 %	52.0 %	41.5 %
Soluble carbohydrate[A]	28.5 %	92.2 %	18.6 %	93.9 %

[a] 100% dry matter basis

LATITUDINAL EFFECTS

Dr. Peter Van Soest has reported that the digestibility of tropic forages averages on the order of 15 units of digestibility lower than temperate forages. Plants that grow in the tropics have been genetically selected for a larger proportion of protective structures such as lignin to avoid predation. At the other extreme are the perennial plants in the far northern regions of the world. These plants have very short growing seasons and need to store energy in reserves rather than in irretrievable substances such as lignin and cellulose.

INHIBITORY SUBSTANCES

Besides lignin, a number of other substances in forages can reduce digestibility of fiber and minerals. Silica is used as a structural element complementing lignin to strengthen and add rigidity to cell walls. Alfalfa and other temperate legumes restrict absorption of silica and never contain more than a few hundred ppm in their tissue (Van Soest, 1982). Table 7 shows how the cumulative effect of silica and lignin can depress forage digestibility in ruminants. Cereal straws are quite high in silica. This gives the straw a clean, glassy appearance and it also depresses its digestibility. Rice hulls are extremely high in silica and indigestible by horses.

There are also substances contained in forages that can inhibit mineral digestibility. Two that are particularly important are phytate and oxalate. Phytates contain phosphorus in a bound form that is unavailable to the horse. Phytate may also inhibit the digestibility of other minerals such as calcium, zinc and iodine. Research from our laboratory (Pagan, 1989) suggests that the addition of yeast culture (Yea Sacc[1026]) may improve the utilization of phytate phosphorus by the horse. The digestibility of phosphorus was 23% from a control ration and 28% from the same ration containing Yea Sacc[1026]. Zinc digestibility was also improved.

Oxalates can reduce the digestibility of calcium in forages if the calcium-to-oxalate ratio in the forage is 0.5 or less on a weight-to-weight basis (Hintz, 1990). This is a common problem in tropical forages which tend to be high in oxalates and low in calcium (table 8). Hintz (1990) cited data from Blaney *et al* (1981) showing how oxalate affected calcium digestibility in horses (table 9). Calcium from forages with high Ca:oxalate ratios (>1) had very high calcium digestibility, while those with low ratios had very poor digestibility. Low calcium availability in tropical forages can lead to nutritional secondary hyperparathyroidism (NSH) or "big head" disease. Therefore, when tropical forages are fed to horses, supplemental sources of calcium should be available.

Table 7. CUMULATIVE EFFECTS OF SILICA AND LIGNIN ON FORAGE DIGESTIBILITY IN RUMINANTS (ADAPTED FROM VAN SOEST, 1982)

Forage	*Source*	*Silica % DM*	*Lignin % DM*	*Lignin + silica*	*Apparent digestibility*
Bermuda	Tex	2.2	4.7	6.9	56 %
Bermuda	Ark	2.3	6.0	8.3	50 %
Bermuda	S.C.	0.7	8.5	9.2	53 %
Bermuda	Ariz	4.1	4.9	9.0	55 %
Bermuda	Ariz	6.2	4.8	11.0	47 %
Bermuda	La	6.7	5.5	12.2	42 %
Rice straw	Ark	13.1	3.1	16.2 3	7 %
Rice hulls	Tex	22.9	15.6	38.5	8 %

There is a common misconception that oxalates reduce calcium digestibility in alfalfa hay. This is not true because the Ca:oxalate ratio is much higher than 0.5, even in alfalfas that contain high levels of oxalates. Hintz *et al* (1984) demonstrated this in an experiment in which no difference was found in the absorption of calcium from alfalfa containing 0.5% and 0.9% oxalic acid in which the calcium:oxalate ratios were 3 and 1.7, respectively. The true digestibility of the calcium from both hays was estimated to be >75 %.

Table 8. CALCIUM AND OXALATE CONTENTS OF FORAGES FROM COLOMBIA, SOUTH AMERICA (ADAPTED FROM HINTZ, 1990)

Name	*Calcium %*	*Oxalate %*	*Ca:oxalate*
Napiergrass	0.21	1.6	0.13
Napiergrass	0.41	1.5	0.24
Kikuyu	0.37	1.6	0.23
Kikuyu	0.32	1.2	0.27
Guineagrass	0.54	2.0	0.27

Table 9. EFFECT OF CALCIUM:OXALATE RATIO ON DIGESTIBILITY OF CALCIUM (ADAPTED FROM HINTZ, 1990)

Name	*Calcium %*	*Oxalate %*	*Ca: oxalate*	*True Digestibility*
Flinders	0.49	0.25	1.92	99 %
Spear-blue	0.33	0.18	1.81	78 %
Rhodes	0.80	0.45	1.79	76 %
Oaten Chaff	0.11	0.08	1.36	100 %
Buffel	0.40	1.06	0.38	17 %
Pangola	0.34	0.92	0.37	39 %
Green panic	0.26	0.81	0.32	42 %
Para	0.22	0.75	0.29	24 %
Kikuyu	0.28	1.30	0.23	20 %
Narok setaria	0.27	1.60	0.13	0 %
Kanzunguki setaria	0.21	3.37	0.10	0 %

FORAGE SAMPLING

Knowing what your horses are actually eating is not always easy. Sampling forages presents a challenge, especially when sampling fresh forage or pasture. A hay core should be used to get a meaningful hay sample for analysis. Hay cores are available that may be attached to a hand-held (brace and bit) or electric drill. Square bales of hay should be sampled diagonally across the long axis of the bale rather than directly through the center. This direction is more critical for sampling legume or mixed grass-legume hays than for single-species grass hays. During the baling process leaves are shattered and may fall to the bottom of the baling chamber. Thus, the diagonal sampling technique should provide an artificial remixing of the stem and leaf, and a more representative sample of the material actually available to the horse. Many times, multiple cores must be taken to obtain an adequate sample for analysis. To get the most accurate mean analysis when sampling hay, one should sample four to six bales taken from different parts of the stack. Pasture analysis is even more perplexing than the sampling of other feedstuffs. The basic question that must first be addressed is whether the entire pasture should be systematically sampled or if only those areas heavily grazed should be sampled. As horses are spot grazers, tending to graze in the lawns and defecate in the roughs, it is probably more accurate to sample the forage actually eaten to get an assessment of the forage quality that contributes significantly to the nutrient intake of the horse. Additionally, unless the sward is a monoculture (one species of forage present) one must try to make sure that the species of forages sampled are those that the horse selects when grazing. This attempt is best done by examining the pasture, observing the grazing behavior, and then sampling the turf as a horse appears to graze. Because of the high moisture level in many fresh forages (50-85%), a sample of at least 1 lb of fresh forage must be taken to ensure that adequate dry matter is available for analysis.

SELECTING HAYS

When selecting hays, the appearance can tell a great deal about the quality of the forage. If it is a predominantly grass hay, remember that as these hays mature and go to seed, their relative energy value goes down. This means that more will have to be fed than a hay cut at a younger time. However, being less energy dense may be an advantage in some instances. For horses on a restricted diet, this type of hay would be ideal to keep the horse happy and its gut full without providing unneeded energy.

FORAGE INTAKE

To accurately calculate the contribution that forage makes to the horse's overall feeding program, forage intake as well as composition must be known. Hay intake can be determined by simply recording the total weight of hay offered minus any hay wasted or refused. This record does not take into account the differences in composition between hay that is offered and that consumed, but is accurate enough to do a good evaluation in the field.

Table 10 gives a range of forage and concentrate intakes for various classes of horses based on their body weight. High forage intakes will occur where there is an abundance of forage available, such as with Kentucky pasture or Washington state alfalfa hay. Low forage intakes will occur where forage is sparse and of poorer quality such as in the tropics. These estimates illustrate how much forage quality and level of intake can affect a horse's overall feeding program. Not taking into account the contribution that forage makes to a horse's overall nutrient intake can result in some serious errors in feeding. At the very least, underestimating a forage's nutrient contribution will result in unnecessary and expensive supplementation. In extreme cases, this may cause nutrient imbalances or toxicities to occur. At the other extreme, overestimating what a horse gets from its forage will result in nutrient deficiencies. Therefore, it is very important that forage's role in supplying nutrients to the horse be accurately assessed. Hopefully, the guidelines presented here will make that evaluation easier and more meaningful.

Table 10. EXPECTED FEED CONSUMPTION BY HORSES

	% of body weight		*% of diet*	
Horse	*Forage*	*Concentrate*	*Forage*	*Concentrate*
Maintenance	1.0-2.0	0-1.0	50-100	0-50
Pregnant mare	1.0-2.0	0.3-1.0	50-85	15-50
Lactating mare (early)	1.0-2.5	0.5-2.0	33-85	15-66
Lactating mare (late)	1.0-2.0	0.5-1.5	40-80	20-60
Weanling	0.5-1.8	1.0-3.0	30-65	35-70
Yearling	1.0-2.5	0.5-2.0	33-80	20-66
Performance horse	1.0-2.0	0.5-2.0	33-80	20-66

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