NUTRITIONAL VALUE OF EASTERN GAMAGRASS HAY COMPARED WITH ALFALFA HAY

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NUTRITIONAL VALUE OF EASTERN
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Scope and Method of Study: Two experiments were conducted to determine the nutritional value of Eastern gamagrass hay in comparison with alfalfa hay. In Experiment I, first and second cutting alfalfa and Eastern gamagrass hays were fed to 16 lactating dairy cows in a switchback design to compare the energy value of the hays. Response criteria included feed intake, body weight change, and yield and composition of milk. In Experiment II, 12 mature wethers were utilized in a replicated 4x4 Latin square to evaluate the digestibility of the various nutrient components of first and second cuttings of alfalfa and Eastern gamagrass hay. Intake and chemical composition of the hays were determined. The various plant fractions analyzed were: dry matter (DM), crude protein (CP), acid detergent fiber (ADF), and neutral detergent fiber (NDF). Digestibility values were obtained for each cutting of the two hays by the total collection method.

Findings and Conclusions: In Experiment I, total dry matter and protein intake were higher when alfalfa hay was fed. Also, cows fed alfalfa hay produced more milk, whereas milk fat percentage and average body weight change apparently were unaffected by treatment. Fiber and protein content of the hays were consistent with an overall higher feeding value for alfalfa hay. In Experiment II, intake by the lambs was at a level of 2.25% of body weight. Digestibility of DM ranged from 51.8 to 56.8% with first cutting gamagrass having the highest dry matter digestibility (DMD) and second cutting gamagrass having the lowest DMD. Both cuttings of Eastern gamagrass had a higher digestibility of ADF and NDF than did alfalfa hay. The two cuttings of alfalfa hay were substantially higher in CP digestibility.

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CHAPTER I

INTRODUCTION

Eastern gamagrass (*Tripsacum dactyloides*) is a warm-season, perennial, tall grass found in the eastern half of the United States and in most regions of Oklahoma and Texas. It has been studied quite extensively by plant taxonomists and geneticists for morphological and cytogenetic clues to the evolution of maize (Mangelsdorf, 1974) and for its relationship to other Tripsacum species (Newell and DeWet, 1974b). This native grass is widely adapted, but grows best on moist, well-drained, fertile soils. Bates et al. (1981) reported that since the seed shatter naturally as a seed-dispersal mechanism, yields of seed from Eastern gamagrass are extremely low, thus accounting for its primary use as fodder or hay.

According to Polk and Adcock (1964), Eastern gamagrass can yield over 10,000 kg of hay/ha when managed properly. It appears that this grass may possess considerable potential as a forage source in dairy rations since it does have agronomic characteristics that make it suitable for hay or silage production. However, a very limited amount of information is available regarding its relative nutritional value.

Alfalfa or lucerne hay (*Medicago sativa*) is widely utilized as a primary forage source in the feeding programs of numerous dairymen and its feeding value has been investigated by many workers (Turnbull et al., 1982; Parker and Moss, 1981; Wilson et al., 1978; Sherrod, 1973). Since the nutritional value of alfalfa hay has been well documented and so little is known about Eastern gamagrass, the objectives of this study were to: (1) compare the value of the hays as energy sources in dairy rations and (2) determine the *in vivo* digestibility of the various nutrient components of the hays.

CHAPTER II

REVIEW OF LITERATURE

Several factors should be considered when attempting to determine the nutritive value of forages and its effect on animal performance. Some of these factors will be investigated in this review including: (a) role of management and environment in production of quality forage; (b) factors affecting digestibility of forages; and (c) animal response derived from forages. The agronomical characteristics of Eastern gamagrass and their effect on its potential utilization and value as a forage source will also be discussed.

The Role of Management and Environment in the Production of Quality Forage

Environmental and managerial factors have a profound effect upon forage quality, which in turn greatly affects animal performance. The high energy and protein cost associated with the use of feed grains has resulted in more emphasis being directed toward increased forage utilization. Although high quality and quantity are both of utmost importance in maximizing forage utilization, they do not occur simultaneously. Consequently, if quantity of forage is not a limiting factor and optimal animal performance is desired, then management plays a major role in the production of quality forage and subsequent animal response obtained.

Application of fertilizer and schedule for harvesting or defoliation are two important management tools that can be used to obtain maximum forage quality. Crude protein content, as influenced by application of nitrogen fertilizer, is probably the most important effect of fertilization. Taliaferro et al. (1975) reported that the crude protein percentage of Midland bermudagrass, weeping lovegrass, Plains bluestem, and a native range grass increased with increasing levels of nitrogen application. Burton et al. (1969) found that application of nitrogen fertilizer signigicantly increased the crude protein content of Coastal bermudagrass and that the exclusion of phosphorus and potassium decreased forage quantity, but had little effect on the crude protein content.

Digestibility of forage is affected relatively little by nitrogen fertilizer (Van Soest, 1973) and digestibility of grass forage generally is considered to be regulated more by stage of maturity than by soil fertility (Meredith, 1963). Addition of nitrogen did tend to increase *in vitro* DMD in three introduced grasses but not in native range grass as reported by Taliaferro et al. (1975). Webster et al. (1965) observed no increase in *in vitro* DMD of Midland bermudagrass fertilized at nitrogen levels up to 1,568 kg/ha.

However, Fribourg et al. (1971) applied several rates of nitrogen to Midland bermudagrass and observed an increase in *in vitro* DMD from about 37 to 46% over the range of applied nitrogen levels.

The harvesting or defoliation schedule followed can greatly affect the quality of most forages. Delayed harvesting generally increases forage yields per unit area with reductions in forage quality. In the study by Taliaferro et al. (1975), grasses were harvested at relatively advanced stages of development with this late harvesting accounting for a depression in both crude protein and *in vitro* DMD. Jung and Baker (1973) and Ademosum et al. (1968) observed that a decrease in percent digestible DM and percent digestible protein occured during advanced stages of maturity along with an increase in percent cell wall components. Delayed harvesting appears to have similar effects with legumes. Blaser et al. (1969) showed that a negative relationship exists between increasing growth stages and DM digestibility in alfalfa hay. In general the nutritive value declines as the growing season advances and although frequent defoliation increases the quality of forage, it generally reduces the quantity.

Temperature, light, and moisture are three environmental factors that are relatively important in influencing forage quality. Burns (1978) stated that in general, when temperatures increase above the optimum for a particular species, the nutritive value is depressed. This depression can most likely be attributed to an accumulation of lignin and cell wall components occuring in the plant. It has been demonstrated by Deinum et al. (1968) that increasing temperature promotes a lowering of nutritive value at the same physiological age in grasses. This temperature-related phenomenon seems to occur particularly for cool season forages, such as bromegrass, as indicated by Smith (1970). A study conducted by Marten (1970) indicated that warm season forages such as alfalfa are less affected by increases in temperature.

Light may be the most important environmental factor affecting quality of forages. Black (1957) observed that the quantity of light energy available rather than the intensity appears to be the important factor. It has been suggested by Van Soest (1973) that independent of temperature, light becomes a vector toward increasing digestibility of forages. This is probably due to the fact light supports photosynthesis, which in turn initiates the synthesis of soluble sugars and organic acids, thus accounting for an increase in digestibility.

The major influences of moisture on forages appears to be on enhancing dry matter production with less striking influences on quality. Gonske and Keeney (1969) reported a 2.5 ton/acre increase in dry matter production of corn silage when irrigation was used. Although the effect of moisture on forages is somewhat variable, when under stressed conditions plants may be prevented from developing toward maturity. Water stress had a detrimental effect on the growth of annual ryegrass as reported by Corleto and Laude (1974). Perry and Larson (1974) obtained similar results with alfalfa when grown under stressed conditions.

Factors Affecting Digestibility of Forages

Although it has been suggested (Crampton et al., 1960) that intake appears to be more important than digestibility in limiting animal productivity, digestibility does have a tremendous effect on the nutritive value of forages and its subsequent effect on animal productivity. Stage of maturity, chemical composition, voluntary intake, and forage species are factors which determine the digestibility of forages.

Stage of Maturity

Maturity is probably the most important single factor affecting forage digestibility. Several workers have reported a reduction in dry matter digestibility (DMD) due to an increase in plant maturity (Johnson et al., 1971; Colovos et al., 1970; Patten, 1943). It has also been documented that protein content decreases (Rowheder et al., 1978; Taliaferro et al., 1975; Kamstra, 1973) and fibrous components increase (Laredo and Minson, 1973; Smith et al., 1972). As a result of advancing maturity, Ademosum et al. (1968) observed a rather marked decline in digestibility of energy, crude protein, cell wall, and cell contents for 12 cuttings of sorghum-sudangrass hay.

The decrease in digestibility of forages as a result of advanced stage of maturity is primarily due to an increase in percent lignin (Van Soest, 1973; Laredo and Minson, 1973). In studies involving Pangola and Rhodes grass, Goto and Minson (1977) observed a decrease in DMD resulting from advanced maturity. Overall, the nutritive value of forages declines as the growing season is lengthened.

Chemical Composition

The nutritional availability of cell contents is almost complete, averaging 98% (Rowheder et al., 1978). In contrast, the cell wall or fibrous portion of a forage is inversely related to nutrient digestibility (Van Soest, 1967). Rowheder et al. (1978) stated that forages such as tropical grasses and very mature forages are high in nondigestible cell wall components which in turn affect digestibility of other components to the point that animals have difficulty obtaining adequate nourishment from the amount they are physically able to consume. It has been established by Ademosum et al. (1968) and Van Soest (1965) that the relationship between intake and cell-wall constituents is curvilinear, and intake is not limited by cell-wall consistuents when this fraction comprises less than 60% of the forage dry matter.

Histological studies of forage following digestion have confirmed that nearly all of the indigestible material is associated with lignin (Wilkins, 1969). Lignin is considered to be the least digestible portion of the forage, while also lowering the digestibility of cellulose and hemicellulose with which it is associated (Van Soest, 1973). However, Kamstra et al. (1955) suggested that the most highly lignified material is not always the least digestible. Based on estimations by Goto and Minson (1977) and Gaillard and Richards (1975), approximately 43% of the lignin consumed may be present as a soluble complex in the rumen of cattle.

In studies with both grass and legume forage, Smith et al. (1972) reported that up to 75% of the variation of cell wall indigestibility _in vitro_ could be attributed to lignification and about 50% of the variation in cell wall rates of digestion could be attributed to soluble dry matter content. In general, although various factors affect digestibility, the presence of indigestible components play a key role in depressing digestibility.

Voluntary Intake

Total nutrient intake and digestibility are highly related for ruminants consuming all forage diets (Smith et al., 1972). When intake and digestibility are considered to be positively related, intake is limited by rumen fill and is predicted from cell wall factors or others related to caloric density (Van Soest, 1973). Kilmer et al. (1979)

demonstrated that total intake of cell wall (NDF) is related to gut fill capacity of animals fed forage rations and thus to voluntary intake. In fact, McCroskey (1968) reported that intake is reduced when cell wall constituents comprise more than 50 to 60% of the forage dry matter.

It has been suggested by Jones et al. (1972) and Conrad et al. (1964) that the physical nature of the diet apparently regulates intake when dry matter digestibility is less than 70%. Differences in digestibility of grass and legume diets were apparently due to differences in mass and volume intakes of the two diets as reported by Kilmer et al. (1979). They pointed out the greater volume intake of a grass diet compared to an alfalfa diet was consistent with the greater digestibility of the grass diet and with a resultant smaller amount of undigested residue remaining in the gut. Graham (1964) observed no significant change in digestibility of chopped hay when level of intake was increased. On the other hand, Blaxter et al. (1961) indicated that the digestibility of long and chopped hays decreased when level of intake was increased.

Ademosum et al. (1968) concluded that the factor most limiting the nutritive value of sorghum-sudangrass forage was intake. It was noted in their study that low intake values resulted in low nutritive value indices (NVI) and low digestible energy consumption. Although sainfoin hay is coarse and stemmy, Parker and Moss (1981) found it highly palatable when fed to heifer calves. The sainfoin was preferred over alfalfa hay as evidenced by voluntary consumption of 2.26 vs. .47 kg/day, respectively. In a study with four improved selections of mature Old World bluestem hays by Londono et al. (1981), voluntary intake of all varieties was similar and relatively low, although digestibility of the hays was considered relatively high. The high values obtained were attributed to the associative effect of supplemental protein fed with the hay.

Forage Species

Grasses and legumes differ in quality with legumes or grass-legume mixtures generally producing superior animal performance. Several workers have observed that at the same relative digestibility grasses contain less lignin and more hemicellulose than do legumes (Rowheder et al., 1978; Thornton and Minson, 1973; Van Soest, 1973). The lower lignin content of grasses is offset by the greater hemicellulose and consequently higher cell wall content, so that digestibility is the same (Van Soest, 1973).

For a given level of digestibility, Thornton and Minson (1973) illustrated that legume diets resulted in a higher intake of organic matter, a higher intake of digestible organic matter, and a lower apparent retention time of organic matter in the rumen. Also, the voluntary intake of legumes was 28% higher than that of grasses when the digestibility of both was 60%. On the other hand, Kilmer et al.

(1979) obtained a higher voluntary intake with orchardgrass hay. The orchardgrass hay also had a higher digestibility of all nutrient components when compared to alfalfa hay.

Rowheder et al. (1978) and Thornton and Minson (1973) indicated that the nutritive value of most legumes decreased less with age than that of most grasses. The decrease in digestibility of grasses was attributed primarily to changes in the stem and leaf sheath which decline in digestibility at a much more rapid rate than the leaf, with similar changes occuring in legumes but at a less rapid rate due to less lignification of the stems and fewer changes occuring in the leaves (Church, 1977).

Digestibility is also affected by differences among forage species. When harvested at immature stages of growth, a cool season grass (orchardgrass) was superior in digestibility when compared with a warm season annual (sorghum-sudangrass) and a warm season perennial (coastal bermudagrass) as reported by Burns (1978). He further illustrated that the warm season annual was superior to the warm season perennial and that a legume such as sericea lespedeza was lower in nutritive value than most other legumes. It has also been suggested that tropical forages are less digestible than temperate forages (McDonald et al., 1981).

Animal Response Derived From the Feeding of Forages

The basic potential of an animal is determined by genetics and maturity, but nutritional factors have an impact on whether that potential can be reached. Quantity and quality of forage and supplemental feeding are nutritional factors affecting animal performance in a forage-based system (Moore, 1978).

The relationship between gain per animal (forage quality) and gain per acre (forage quantity) for yearling beef cattle has been described by Mott (1973). He concluded that at low grazing pressure animals can selectively graze and daily gains should be relatively high, whereas at high grazing pressure animals must compete for available forage which results not only in low performance but also high maintenance cost and undesirable carcass characteristics. Stobbs (1973) proposed that under range conditions, forage intake and animal performance may be limited by the small size of each bite of forage and limitations on the number of bites per animal per day.

The animal response obtained from the feeding of forages whether expressed as daily gain, daily milk production, etc. is primarily a function of forage quality (Burns, 1978). Animal daily gain has been recommended by Mott (1973) as being one of the better criteria to use in determining the nutritive value or quality of a particular forage. Based on the assumption that available forage is not a limiting factor, Burns (1976) has associated high yearling performance with high forage quality and consequently high energy intake.

High producing dairy cows cannot consume enough forage to produce the amount of milk of which they are capable, therefore more concentrated energy sources are needed as supplemental feed. Kilmer et al. (1979) reported a decline in milk production coupled with the absence of any significant body weight gain when alfalfa or orchardgrass hay was fed to cows in the second third of lactation. They attributed this to insufficient energy intake as the energy requirements of the cows were not met. Parker and Moss (1981) indicated a lower feeding value for sainfoin than for alfalfa hay, resulting in a lower production of milk, protein, and solids-not-fat for cows receiving sainfoin hay than for those fed alfalfa hay. The previous two studies demonstrate certain situations in which additional amounts of energy or protein supplements would be needed to meet the animals' requirement for these nutrients.

In general, if forage quantity is not limiting and forage is the only source of energy and protein, differences in forage quality may be expressed as differences in voluntary intake of digestible energy (DE) or total digestible nutrients (TDN), since there is a close relationship between DE and TDN as proposed by Garrett et al. (1959). Golding et al. (1976) suggested that data on voluntary DE intake of forages fed alone to a given class of animal can be used to formulate hay-grain rations for animals of the same class. However, in order to apply forage quality data across classes of animals, forage quality standards should be based upon expected performance of animals on forage diets (Moore, 1978). For example, when feeding forages only, steer gains of 0.6 kg/day obtained by Burton et al. (1967) and milk production of 10 kg/day reported by Stobbs (1971) would be examples of forage with "good" quality, although higher rates of performance would be expected with excellent quality forage.

Agronomic Characteristics of Eastern Gamagrass Relative to Potential Use and Value as a Forage Source

Eastern gamagrass (Tripsacum dactyloides) is a widely adapted, warm-season, perennial, tall grass that grows in large clumps from approximately one to four feet in diameter. According to Leithead et al. (1971) Eastern gamagrass makes the majority of its growth in early spring and produces seed from July to September on stems three to nine feet tall.

Eastern gamagrass has been referred to as the "granddad" of native grasses and is found throughout the eastern half of the U.S. extending west on favorable sites to Colorado (Leithead et al., 1971). Newell and DeWet (1974a) noted that although Eastern gamagrass is widely distributed east of Kansas-Oklahoma-Texas, it occurs in isolated colonies. Leithead et al. (1971) reported that this grass grows best on moist, well-drained fertile soils and does not tolerate standing water for long periods.

The genus and species of Tripsacum dactyloides has been studied fairly extensively by plant taxonomists and geneticists. Morphological and cytogenetic aspects have been investigated by Mangelsdorf (1974) to obtain clues to the evolution of maize. According to Janick et al. (1974), there is evidence that cultivated maize arose through natural crossing, perhaps first with Tripsacum dactyloides. By crossing maize and Tripsacum dactyloides, Mangelsdorf and Reeves (1931) were the first to successfully produce hybrids in the laboratory. The purpose of further evaluation of crosses by Newell and DeWet (1974b) was to potentially improve maize by exploiting the genetic variability transferable from Tripsacum dactyloides. Paulis and Wall (1977) compared the protein compositions of three maize cultivars, Eastern gamagrass and two collections of teosinte (Zea mexicana) to substantiate evolutionary and biochemical genetic relationships. The seed structure and protein quality of Eastern gamagrass has been examined by Bates et al. (1981). They reported higher protein and fat content in Eastern gamagrass seed when compared to maize, with Eastern gamagrass being lower in fiber and nitrogen free extract (NFE) and also lower in the basic amino acids lysine, histidine, and arginine.

Eastern gamagrass is used primarily as fodder or hay. According to Leithead et al. (1974) and Polk and Adcock (1964), this tall, leafy grass produces a substantial volume of forage when managed properly. They also reported that Eastern gamagrass is very palatable and is readily consumed by all classes of livestock.

It has been suggested by Polk and Adcock (1964) that the primary factor limiting use and establishment of Eastern gamagrass is the lack of a satisfactory method for harvesting seed or a need for development of a plant from which seed can be harvested. Bates et al. (1981) reported low yields of seed due to the fact that the seed ripens unevenly and then shatters naturally as a seed-dispersal mechanism. Bates et al. (1981) also reported the discovery of a nonshattering variant, which they suggested could be a first step toward domesticating or managing a new perennial crop.

In summary, Eastern gamagrass appears to possess agronomical characteristics that would indicate potential for use as a forage source. However, based on available literature, intensive management may be required to obtain maximum utilization of Eastern gamagrass, which in turn would limit its use as a primary forage source in livestock rations.

CHAPTER III

COMPARATIVE NUTRITIONAL VALUE OF EASTERN GAMAGRASS AND ALFALFA HAYS FOR LACTATING DAIRY COWS

Summary

A study consisting of two trials was conducted to determine the nutritional value of Eastern gamagrass (Tripsacum dactyloides) hay in comparison with alfalfa hay. In Trial I, 16 lactating dairy cows (11 Holsteins, 5 Ayrshires) were fed the two hays in sequences according to a switchback design with three 4-week periods. All cows were assigned randomly to one of two blocks representing cutting of hay to be fed and then to feeding sequences within the blocks. The hays were compared as energy sources with protein intake equalized by feeding grain mixtures containing 12, 15, or 18% crude protein on a dry basis with alfalfa, first cutting gamagrass, and second cutting gamagrass hay, respectively. Intake of protein and dry matter of hay averaged 2.09 and 9.86 kg/day for alfalfa hay and 1.27 and 9.00 kg/day for gamagrass hay. Milk yield of cows fed alfalfa was significantly higher ($P<.01$) than that of cows fed gamagrass hay, i.e., 24.1 vs. 22.9 kg/day. Milk fat tests and weight changes for cows fed the two hays were similar.

In Trial II 12 mature wethers were utilized in a replicated 4x4 Latin square design to compare the digestibility of first and second cutting alfalfa and Eastern gamagrass hays. The sheep were housed in individual digestion cages and fed chopped hay supplemented with 10 grams of mineral mix per day. Acid detergent fiber (ADF) and neutral detergent fiber (NDF) content of the hays was: 35.3, 55.6; 36.3, 51.2; 37.6, 70.1; 39.7 and 73.3% for first cutting alfalfa, second cutting alfalfa, first cutting gamagrass, and second cutting gamagrass, respectively. Apparent digestibility of dry matter, crude protein, ADF, and NDF was: 53.8, 54.2, 56.8, 51.8; 68.7, 70.4, 57.7, 50.2; 42.1, 38.3, 59.9, 54.1; 49.4, 41.1, 65.2 and 59.1% for first cutting alfalfa, second cutting alfalfa, first cutting gamagrass, and second cutting gamagrass hays, respectively. Overall, the Eastern gamagrass was comparable to alfalfa hay in digestibility, with the first cutting gamagrass being higher in digestibility of all nutrient components except crude protein.

Introduction

Animal productivity is the ultimate measure of the nutritional value of a feed. Productivity reflects the consumption, digestibility, and efficiency with which nutrients are used for productive purposes.

Some researchers (Crampton et al., 1960; Osbourn et al., 1970) reported that intake of a forage was a more accurate indicator of its quality than was its digestibility, although both should be taken into consideration in evaluating forage quality. Palatability of a forage, influenced by stage of maturity and physical or structural nature of the plant, affects voluntary intake (Ademosum et al., 1978; Conrad et al., 1964).

Digestibility of forages is related to plant maturity (Church, 1977). As plant maturity increases, lignin content also increases and digestibility of the forage is lowered, usually accounting for subsequent reduction in animal productivity. Van Soest (1965) reported a negative correlation between digestibility and increasing lignin and ADF levels.

Leithead et al. (1974) and Polk and Adcock (1964) reported that Eastern gamagrass is very palatable when harvesting occurs at the initial emergence of seedheads. They noted that Eastern gamagrass is used primarily as hay and that a substantial volume of forage can result from proper management. Polk and Adcock (1964) suggested that the primary factor limiting use and establishment of Eastern gamagrass is the lack of a satisfactory method for harvesting seed or a need for development of a plant from which seed can be harvested. Low yields of seed have been reported by Bates et al. (1981). They attributed the low yields to the fact that the seed of Eastern gamagrass ripens unevenly and then shatters naturally as a seed-dispersal mechanism. Bates et al. (1981) reported the discovery of a nonshattering variant, which could possibly result in increased utilization of Eastern gamagrass.

Eastern gamagrass has been studied quite extensively by agronomists and it appears to possess considerable potential as a forage source based on its agronomic characteristics. However, the relative nutritional value of Eastern gamagrass is somewhat unknown due to limited information available in regard to this subject.

The purposes of this study were to: (a) compare the nutritional value of Eastern gamagrass and alfalfa hays as energy sources in rations for lactating dairy cows, and (b) compare the apparent digestibilities of different nutrient components of Eastern gamagrass and alfalfa hay by wethers.

Materials and Methods

First and second cuttings of both alfalfa and Eastern gamagrass hay were harvested in May and June of 1981. The alfalfa was obtained from the Eastern Pasture Research Station at Haskell, Oklahoma and Eastern gamagrass was acquired from the South Central Research Station at Chickasha, Oklahoma. Each hay was harvested during relatively early stages of maturity with growth stage and approximate yield shown in Table I. The rather low yield for first cutting gamagrass was a result of very dry conditions during March and April which reduced the total yield by an estimated 75 to 100%. Fertilizer was applied to each of the hays, but weed infestation accounted for a somewhat less desirable chemical composition of the second cutting gamagrass as compared to that of the other hays (Table I).

Trial I

Sixteen lactating dairy cows (11 Holsteins, 5 Ayrshires) were utilized in a feeding trial to compare the energy value of Eastern gamagrass and alfalfa hays. Each cow was fed the two types of hay in sequences of a switchback design with three 4-week periods. The initial two weeks of each period was used for animal adaptation to the rations, whereas data collection was during the final two weeks. The cows were divided into two blocks of eight cows each, with each block representing the cutting of hay to be fed. All cows were assigned randomly to one of the two blocks and then to feeding sequences.

The forages were compared as energy sources in this trial with protein intake equalized by feeding grain mixtures containing 12, 15, or 18% crude protein with first and second cutting alfalfa hay, first cutting gamagrass hay, and second cutting gamagrass hay, respectively (Table II). Prior to initiation of the trial, cows were adjusted to diets having a 50:50 concentrate-to-forage ratio, with this ratio and amount fed being constant throughout the remainder of the trial. Response criteria included feed intake, body weight change, and yield and composition of milk. Cows were fed in individual stalls twice daily before morning and afternoon milkings with grain and hay refusals being collected and recorded daily. Hay and grain were sampled weekly during the

TABLE I

MATURITY, YIELD, AND CHEMICAL COMPOSITION[a] OF ALFALFA AND EASTERN GAMAGRASS HAYS

Hay	Growth stage	Approximate total yield (kg)	Crude protein	Acid detergent fiber	Neutral detergent fiber
			%		
Alfalfa, 1st Cut	10% Bloom	9,820	21.4	35.3	55.6
Alfalfa, 2nd Cut	15% Bloom	10,640	16.5	36.3	51.2
Gamagrass, 1st Cut	Early Boot	5,730	13.8	37.6	70.1
Gamagrass, 2nd Cut	Full Leaf	7,640	9.1	39.7	73.3

[a] Dry matter basis

trial and analyzed for crude protein (N x 6.25) by macro-Kjehldal (AOAC, 1975) and dry matter. Cows were weighed before milking on 3 consecutive days prior to the trial and at the end of each experimental period. Individual milk yields were recorded twice daily and samples of milk were collected at four successive milkings each week for analysis of milk fat content (Foss Milko-tester Mark III Industrial Model).

Analysis of variance was performed and statistical significance of treatment differences was determined by the procedure of Brandt (1938) for analyzing switchback trials.

Trial II

Twelve mature crossbred Dorset wethers weighing 40.0 to 48.2 kg each were used to determine digestibility of different components of the two hays. Each hay was coarsely chopped to not less than 2.5 cm and then fed to each of the 12 wethers in sequences of a replicated 4x4 Latin square design (Table VII). The hays were fed during respective periods of two weeks each and each lamb had received all the hays at the end of the four periods. All lambs were allocated randomly to individual digestion cages to avoid any bias resulting from location during the trial.

Hay was fed twice daily (0800 and 1700 hours) to permit 0 to 10% feed refusal in most instances. No protein supplement was added since each hay supplied adequate protein for maintenance. A complete mineral supplement consisting

TABLE II

COMPOSITION OF CONCENTRATE MIXTURES

Item	IFN[a]	Protein content		
		Low	Medium	High
Ingredients, % as fed				
Corn, ground	4-02-931	73	64	55
Soybean meal	5-04-604	9	18	27
Oats	4-03-388	10	10	10
Molasses, cane	4-04-696	5	5	5
Dicalcium phosphate	6-01-080	2	2	2
Salt	6-04-152	1	1	1
Calculated protein content, % air dry		12	15	18

[a] International Feed Numbers

of 13 to 15% calcium, 7% phosphorus, 30 to 36% salt, and varying amounts of other minerals, was fed at a level of 10 grams per head per day to assure sufficient intake of these minerals. In addition, water and a trace mineralized salt supplement containing 96 to 99% salt and 1 to 4% minerals was available for ad libitum consumption (Table VIII).

Feed refusals were collected for six days beginning on the sixth morning of each period. Collection of feces began on the ninth day of each period, which was the fourth day of feed refusal collection, and was continued for six days also. Feed refusal collection was made in the morning, and feces were collected immediately prior to the time of the afternoon feeding.

All feed refusals were weighed each day during the six-day period and kept for subsequent composites. The feces from each lamb were weighed and a representative sample amounting to 10% of the total weight was dried in an oven at 55° C for 24 hours. After the last day of collection and drying for each period, samples for each wether were composited and ground in a Wiley mill equipped with a 1 mm screen.

Duplicate aliquots of all feed, feed refusals, and fecal samples were analyzed for dry matter, crude protein (AOAC, 1975), ADF (Van Soest, 1963), NDF (Van Soest and Wine, 1967), lignin, and cellulose, both by the permanganate oxidation procedure (Van Soest and Wine, 1968).

Data from the digestion trial were analyzed using the

Statistical Analysis System (SAS). Analysis of variance was performed and statistical significance of treatment differences was determined based on pre-planned comparisons between treatment means consisting of the following: (1) average of both cuttings of alfalfa vs. average of both cuttings of gamagrass, (2) average of both cuttings of alfalfa vs. first cutting gamagrass, and (3) average of both cuttings of alfalfa vs. second cutting gamagrass.

Results and Discussion

Trial I

Dry matter (DM) intake from the grain was the same regardless of the type of hay consumed (Table III). Intake of DM from the hay was higher ($P<.01$) for cows consuming alfalfa hay than for those fed gamagrass hay. Thus, total intake of dry matter was greater ($P<.03$) for cows fed alfalfa hay. There was also a tendency for the cows to consume more of the first cutting than the second cutting gamagrass hay. This tendency was attributed to the presence of various types of weeds and a higher percentage of stems in the second cutting gamagrass hay. Apparently stage of maturity was not responsible for greater palatability of the first cutting gamagrass since both cuttings were harvested at approximately the same stage of growth.

It was originally planned that protein intake would be equalized by feeding the grain mixtures of different protein content. The cows did have a higher intake of protein from

TABLE III

INTAKE BY COWS DURING FEEDING TRIAL

Variable	Alfalfa	Eastern gamagrass
	---------(kg/day)---------	
Dry Matter Intake		
Grain	10.22	10.22^{h}
Hay	9.85^{a}	8.99^{b}
Grain & hay	20.07^{c}	19.21^{d}
Protein Intake		
Grain	1.36^{a}	1.86^{b}
Hay	2.09^{a}	1.27^{b}
Grain & hay	3.45^{a}	3.13^{b}
Protein, % of DM	17.2	16.3

^{a,b} Intake was significantly different (P<.01)
^{c,d} Intake was significantly different (P<.01)

the grain mixtures fed with gamagrass hay than from the grain mixture fed with alfalfa ($P<.01$). However, this did not fully compensate for the lower protein content of the grass hay since consumption of the grass hay was less than that of the alfalfa. Cows fed gamagrass hay did not receive as much total protein ($P<.01$) as those fed alfalfa hay (Table III); nevertheless, the amount of total protein consumed was adequate to meet NRC requirements even at the highest level of production during the first period. This allowed comparison of the hays as energy sources in this trial.

Milk yield was higher ($P<.01$) for cows fed alfalfa than for cows fed gamagrass hay (Table IV). This can be attributed to the fact that dry matter intake of cows consuming alfalfa hay was somewhat higher than that of those fed gamagrass hay. It was estimated that the additional .86 kg/day DM intake by cows consuming alfalfa hay could have accounted for 1.5 kg more milk being produced per day, although the actual difference in milk yield was 1.1 kg per day. This estimate was based on the assumption that the alfalfa hay contained 1.30 Mcal NE_l/kg yielding 1.12 Mcal additional energy (.86 kg x 1.30 Mcal NE_l/kg = 1.12 Mcal). According to NRC requirements, .74 Mcal NE_l are required to produce 1 kg of milk with 4.1% fat. Therefore the 1.12 Mcal additional energy would be sufficient for the 1.5 kg more milk. Type of hay fed had no significant effect on milk fat content nor average body weight change. Although cows consuming Eastern gamagrass gained .12 kg/day more than those consuming alfalfa, this difference was not significant due to the high variability in weight change among individual cows in each group.

An overall lower feeding value for Eastern gamagrass than for alfalfa hay was consistent with what might be expected by consideration of the chemical composition of the two types of hay (Table I). The crude protein values reported for the alfalfa hay in the present study were higher than values obtained with the gamagrass hay and also higher than values for alfalfa harvested at similar stages of maturity by Thornton and Minson (1973) and Parker and Moss (1981). Although ADF content of the hays (Table I) did not have a substantial effect on their feeding value, both cuttings of alfalfa were slightly lower in ADF as compared to the two cuttings of gamagrass and similar to values obtained by Parker and Moss (1981). ADF values were also lower for the first cutting of each of the hays being 35.3 and 37.6% for first cutting alfalfa and first cutting gamagrass, respectively.

NDF values (Table I) were substantially higher for both cuttings of Eastern gamagrass than for alfalfa hay, reflecting a higher concentration of hemicellulose in the gamagrass than in the alfalfa hay. The high NDF and hemicellulose content of the gamagrass as compared to the alfalfa

TABLE IV

PERFORMANCE OF COWS FED ALFALFA AND EASTERN GAMAGRASS HAY

Variable	Alfalfa	Eastern gamagrass
Milk yield, kg/day	24.06[a]	22.93[b]
Milk fat content, %	4.08	4.18
Body weight change, kg/day	0.05	0.17

[a,b] Treatment means were different (P<.01)

hay was in agreement with data of others who have compared various grasses with alfalfa (Kilmer et al., 1975; Rohweder et al.; 1978). The higher NDF content and consequently a lower percentage of soluble carbohydrates, along with less crude protein, resulted in an overall lower feeding value for Eastern gamagrass than for alfalfa hay.

Lignin and cellulose content of the hays was determined. However, due to possible errors attributed to analytical procedure, these values are not reported in the main context of this study, but are shown in Table IX.

Trial II

Intake of the hays by the sheep was at a level of approximately 8% more than needed to meet their average energy requirements for maintenance (Table V). In accordance with the formula of Garrett et al. (1959) for calculating digestible energy (DE), $DE = 119\ Wkg^{.75}$, the average DE requirement for maintenance of the lambs was 2046 kcal per day. The estimated amount consumed was 2200 kcal per day which was an excess of 154 kcal per day. Based on the assumption that 2613 kcal of DE above maintenance should produce 1 kg of weight gain, the total amount of 8624 kcal consumed above maintenance during this eight-week trial should have resulted in an average weight gain of 3.3 kg per lamb. This difference might be explained by a combnation of the following: (a) possible errors in determining individual weight gain due to fluctuation in body fill during the trial, (b) use of an incorrect DE value for the hays, and (c) an inaccurate estimate of the maintenance requirement for the lambs.

Intake of hay DM was similar, being over 900g per day for each type of hay. This was an average DM intake of about 2.25% of body weight. Increased palatability due to the early stage of maturity of the hays probably accounted for this relatively high level. Intake of CP from the hays ranged from 93g for second cutting gamagrass to 185g per day for first cutting alfalfa. The NRC maintenance requirement for CP of approximately 90g per day for the group of lambs utilized in this study was achieved in all cases.

The digestibility of alfalfa and Eastern gamagrass hays was evaluated utilizing three pre-planned treatment comparisons, as previously mentioned. The dry matter digestibility (DMD) of first cutting gamagrass was significantly higher ($P<.01$), whereas the DMD of second cutting gamagrass was significantly lower ($P<.05$), than that of the average of the two cuttings of alfalfa hay (Table VI). The DMD values for alfalfa hay observed in this study were higher than those obtained by Jones et al. (1978) and Kilmer et al. (1979). Values obtained for Eastern gamagrass were higher than values reported for other grass forages, e.g., pangola grass (Laredo and Minson, 1973), coastal bermudagrass (Chapman et al., 1972), and green panic (Thornton and Minson, 1973). On the other hand, values reported for Eastern gamagrass in this study were lower than those obtained for a physically similar sorghum-sudangrass forage (Ademosum et al., 1968) and also

TABLE V

INTAKE BY SHEEP DURING DIGESTION TRIAL

Hay	Dry matter[a]	Crude protein
	(g/day)	
Alfalfa, 1st Cut	941	185
Alfalfa, 2nd Cut	949	148
Gamagrass, 1st Cut	921	108
Gamagrass, 2nd Cut	943	93

[a] Values include 10g of minerals per day

lower than rhodes grass (Laredo and Minson, 1973).

Digestibility of protein was positively correlated with CP content of the hays, as reported in previous studies by McCroskey (1968). Digestibility of protein was higher ($P<.01$) for the average of both cuttings of alfalfa than for the average of the gamagrass hays or either cutting thereof. According to Crampton and Harris (1969) as protein content and intake increase, the apparent digestibility of protein is also increased due to dilution of the metabolic fecal nitrogen (MFN). So, the higher CP digestibility obtained for alfalfa hay in this study was most likely a result of both a higher CP content and a higher CP intake for the alfalfa as compared to Eastern gamagrass. Church (1977) suggested that lignin appears to have a more detrimental effect on digestibility of grasses than legumes. Although the grass contained less lignin, the lower CP digestibility obtained for Eastern gamagrass was possibly a reflection of more intense binding of the lignin to protein occuring in the gamagrass than in the alfalfa. Values for digestibility of CP of alfalfa in this study were higher than those obtained by Jones et al. (1972) and Wilson et al. (1978), yet lower than values reported by Parker and Moss (1981).

Digestibility of ADF was higher ($P<.01$) for each cutting of gamagrass compared to the average of the two cuttings of alfalfa. This superiority in ADF digestibility was probably due to the somewhat lower lignin content of the gamagrass. Values obtained with alfalfa in this study were

TABLE VI

DIGESTIBILITY OF VARIOUS COMPONENTS OF FIRST AND SECOND CUTTING ALFALFA AND EASTERN GAMAGRASS HAYS

Hay	DM[a]	CP[b]	ADF[c]	NDF
	(%)			
Alfalfa, 1st Cut[1]	53.8	68.7	42.1	49.4
Alfalfa, 2nd Cut[2]	54.2	70.4	38.3	41.1
Gamagrass, 1st Cut[3]	56.8	57.7	59.9	65.2
Gamagrass, 2nd Cut[4]	51.8	50.2	54.1	59.1

[a] Difference in DMD of [1,2] vs. [3,4] was not significant
Difference in DMD of [1,2] vs. [3] was significantly lower ($P<.01$)
Difference in DMD of [1,2] vs. [4] was significantly higher ($P<.01$)

[b] CPD was significantly higher for [1,2] vs. [3,4] or [3] or [4] ($P<.01$)

[c] ADFD and NDFD was significantly higher for [3,4] or [3] or [4] vs. [1,2] ($P<.01$)

similar to those reported by Kilmer et al. (1979). However, values obtained with Eastern gamagrass were higher than those reported for four different orchardgrass hays (Robles et al., 1981) and lower than values obtained with a physically similar sorghum-sudangrass hay (Ademosum et al., 1968).

Digestibility of NDF was also higher ($P<.01$) for each cutting of gamagrass hay compared to alfalfa. This finding was most likely the result of a lower lignin content and a higher digestibility of cellulose and hemicellulose fractions in the gamagrass than in the alfalfa hay. In respect to the gamagrass, Keys and Van Soest (1970) reported similar values obtained with orchardgrass and bromegrass hays. However, Kilmer et al. (1979) obtained lower values with orchardgrass and higher values with alfalfa.

The most variation occured with lignin digestibility among treatments. Values ranged from -12.1% for second cutting alfalfa to 41.0% for second cutting gamagrass. Due to this relatively large difference among treatments, values are not reported in the context of this chapter but are shown in Table X. The extreme negative and positive values were possibly due to inaccuracies in the analytical procedure used for determining lignin content.

Eastern gamagrass had a higher digestibility of DM, ADF, and NDF which might indicate a higher feeding value. However, the higher CP digestibility and higher concentration of soluble carbohydrates in combination with superior cow performance in the feeding trial, indicate an overall higher feeding value for alfalfa hay than for Eastern gamagrass hay.

In summary, these data provide useful information in regard to the nutritional value of Eastern gamagrass relative to alfalfa hay. However, further evaluation of Eastern gamagrass hay in comparison with other grass hays used as common forage sources in dairy rations would possibly have merit.

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APPENDIX

TABLE VII

LATIN SQUARE DESIGN USED IN DIGESTION TRIAL

Period No.	Replication 1			
	11	1	12	10
1	A	B	C	D
2	B	D	A	C
3	C	A	D	B
4	D	C	B	A

Period No.	Replication 2			
	8	9	5	7
1	A	B	C	D
2	B	A	D	C
3	C	D	A	B
4	D	C	B	A

Period No.	Replication 3			
	2	3	4	6
1	A	B	D	C
2	B	C	A	D
3	D	A	C	B
4	C	D	B	A

A= Alfalfa Hay 1st Cutting
B= Alfalfa Hay 2nd Cutting
C= Eastern Gamagrass Hay 1st Cutting
D= Eastern Gamagrass Hay 2nd Cutting

TABLE VIII

TRACE MINERALIZED SALT MIXTURE

	Guaranteed Analysis:		
	Salt (NaCl)	Not more than	99.000%
	Salt (NaCl)	Not less than	96.000%
	Manganese (Mn)	Not less than	0.200%
	Iron (Fe)	Not less than	0.100%
TRACE MINERAL SALT	Magnesium (Mg)	Not less than	0.100%
	Sulfur (S)	Not less than	0.050%
	Copper (Cu)	Not less than	0.025%
	Cobalt (Co)	Not less than	0.010%
	Zinc (Zn)	Not less than	0.008%
	Iodine (I)	Not less than	0.007%
	Ingredients: Salt, Manganous oxide, Ferrous carbonate, magnesium oxide, calcium sulfate, copper oxide, cobalt carbonate, zinc oxide, calcium iodate, iron oxide. Color, natural and artificial flavors added. For animal feeding only.		

TABLE IX

LIGNIN AND CELLULOSE CONTENT OF FIRST AND SECOND CUTTING ALFALFA AND EASTERN GAMAGRASS HAYS[a]

Hay	Lignin	Cellulose
	------------(%)------------	
Alfalfa, 1st Cut	11.7	29.9
Alfalfa, 2nd Cut	10.5	30.5
Gamagrass, 1st Cut	8.7	33.7
Gamagrass, 2nd Cut	9.3	33.0

[a] Dry matter basis

TABLE X

LIGNIN AND CELLULOSE DIGESTIBILITY VALUES FOR FIRST AND SECOND CUTTING ALFALFA AND EASTERN GAMAGRASS HAYS

Hay	Lignin	Cellulose
	(%)	
Alfalfa, 1st Cut	-0.2	55.6
Alfalfa, 2nd Cut	-12.1	51.7
Gamagrass, 1st Cut	38.2	68.9
Gamagrass, 2nd Cut	41.0	61.9

VITA

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Master of Science

Thesis: NUTRITIONAL VALUE OF EASTERN GAMAGRASS HAY COMPARED WITH ALFALFA HAY

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