FORAGE QUALITY AND THE NEED FOR PROTEIN AND ENERGY SUPPLEMENTS

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INTRODUCTION

The term "forage quality" has been defined in many ways. High-quality forages have often been described as green, leafy, high-protein, digestible, palatable, etc. One of the best definitions was stated by a hay producer who supplied alfalfa to dairies in the Midwest. When asked what forage quality meant to him, he replied immediately, "milk in the bucket." He knew very well, as do most livestock managers, that differences in forage quality have little meaning unless there are differences in animal performance.

In Florida's beef industry, managers are concerned with calf weaning weight, heifer development, and cow condition at breeding. The tropical perennial grasses used as summer pasture or hay in Florida do not always have adequate nutrient composition or quality to meet the nutrient needs of these animals. These grasses are often high in fiber, especially when mature, and high-producing cattle are unable to consume them in adequate quantities to meet their requirements for Crude Protein (CP) and Total Digestible Nutrients (TDN). Thus, protein and energy supplements are often required.

The objectives of this paper are (1) to compare the composition and quality of Florida's improved forage grasses to the protein and energy requirements of representative beef cattle, and (2) to show how results of forage testing may be used to determine the need for protein and energy supplements. Forage quality information in this paper is based on 637 samples of grass (569 of hay and 68 of pasture) submitted by producers to the Florida Extension Forage Testing Program at the Ona Agricultural Research and Education Center between 1985 and 1989. These samples included 69 of bahiagrass, 246 of bermudagrass, 71 of digitgrass, 182 of stargrass and 69 of limpograss. Laboratory analyses were conducted using conventional wet chemistry procedures, and estimates were made of CP, TDN and Quality Index (QI). Data on hay and pasture were combined within species because there was no consistent difference between hay and pasture samples in their composition.

CRUDE PROTEIN

The CP requirements of representative beef cattle range from 7 to 11% (Table 1). Except for bermudagrass, most samples of Florida's grasses were in the range of 5 to 7% CP (Figure 1). There was an equal proportion (34%) of bermudagrass samples in the ranges of 5 to 7% and 8 to 10% CP. There was less than 5% CP in a high proportion of digitgrass (35%) and limpograss (28%) samples. For levels of performance above maintenance, most samples of all grasses except bermudagrass were deficient in CP and would require protein supplement in order to meet requirements. The higher CP in bermudagrass may reflect a higher rate of nitrogen fertilizer applied to bermudagrass hay fields and a lower maturity at harvest.

Floralta limpograss is unique in that it often has low CP percentages, even when immature and highly digestible. Overseeding limpograss with aeschynomene improved daily gains by steers (Rusland, et al., 1988) but it was not clear whether the effect was due to added CP or TDN. The effect of supplemental protein on gains by growing steers grazing limpograss pastures was tested during two summers at the Forage Evaluation Field Laboratory, Beef Research Unit, Gainesville (Holderbaum et al. 1991). The CP percentage of limpograss averaged 5.8 and 8.0% during the two seasons, respectively. Urea-corn meal supplements were formulated with two levels of CP (low = 21% CP and high = 50% CP) and fed in amounts to provide a minimum amount of energy (corn meal intake was .17% of BW). In addition, another treatment involved overseeding with aeschynomene. Over both seasons, daily gains were increased to the same extent by the supplements and aeschynomene (Figure 2). These results suggest that low protein in limpograss was the major factor limiting animal performance during the summer grazing season.

TOTAL DIGESTIBLE NUTRIENTS

Required TDN percentages of the representative cattle range from 54 to 62% (Table 1). For all grass species analyzed at Ona, except limpograss, the largest proportion of samples had 48 to 51% TDN (Figure 3). For limpograss, 68% of samples had more than 51% TDN. In contrast, only 11% of bahiagrass samples had more than 51% TDN. It is apparent that most samples were low in TDN. Low TDN percentages are expected because the grasses are of tropical origin and most samples were of hay made at late stages of maturity. Because it is not possible for cattle to increase consumption of these grasses enough to overcome the low TDN percentage, the intake of TDN will generally be lower than needed. The problem of low intake and the need for supplemental energy will be discussed later in this paper.

TDN:CP RATIO VS FORAGE INTAKE

When the CP percentage of forages is less than 7% of dry matter, there may be inadequate protein to supply the needs of rumen bacteria, and forage intake may be decreased. With such forages, supplemental protein may increase both forage intake and animal performance. Forage intake does not always increase, however, when low-protein forages are supplemented. A key to the difference in the intake response to protein supplementation may be the ratio between the percentages of TDN and CP. The TDN:CP ratios calculated from CP and TDN requirements range from 5.6 to 7.7 (Table 1).

When TDN:CP ratios are low (less than 8), there may be a balance between TDN and CP; that is, there is adequate protein to match the energy in the forage. Low TDN:CP ratios are expected with immature hays when both TDN and CP percentages are high (e.g., when TDN=60% and CP=12%, TDN:CP=5). In mature grasses, TDN:CP ratios may be low because both TDN and CP percentages are low (e.g., when TDN=49% and CP=7%, TDN:CP=7). On the other hand, high TDN:CP ratios (above 8) indicate that there is a deficiency of protein relative to energy (e.g., when TDN=54% and CP=6%, TDN:CP=9).

Among the Florida grasses, there were marked differences in TDN:CP ratios (Figure 4). Low ratios (less than 8) were very common for bahiagrass (65% of samples) and bermudagrass (75% of samples). Most bahiagrass samples were low in both TDN and CP while most bermudagrass samples were intermediate in both TDN and CP. High ratios (above 8) were very common for digitgrass (73% of samples), stargrass (55% of samples), and limpograss (81% of samples) because of their higher TDN and lower CP percentages.

The relationship between TDN:CP ratio and the effect of supplemental protein upon hay intake was investigated in three experiments using sheep. In the first study (Moore, et al., 1970), three Pensacola bahiagrass hays were harvested after 6, 10 and 14 weeks regrowth. The CP percentages of the hays were 7.6, 5.8 and 6.3%, respectively. Hays were fed either with or without supplemental soybean meal (SBM) at the rate of .12% of BW. Hay intake was increased only with the 10-week hay which had a TDN:CP ratio of 8.8 (Figure 5). When TDN:CP ratio was 7.7 (6-week hay) or 7.4 (14-week hay) there was no effect of supplement on intake.

In the second study, four Pangola digitgrass hays were harvested after 4, 6, 8.5 and 11 weeks regrowth (Ventura, et al., 1975). Hay CP percentages were 17.8, 13.7, 5.8 and 6.5%, respectively. Hays were fed to sheep either with or without supplemental SBM at the rate of .17% of BW. With the 4-week hay (TDN:CP = 3.5), supplemental protein decreased hay intake, perhaps due to an excess of dietary protein (Figure 6). There was no effect of supplement on intake of the 6-week hay (TDN:CP = 4.5) or the 11-week hay (TDN:CP = 7.7). Supplemental protein increased the intake of the 8.5-week hay (TDN:CP = 9.0).

In the third study with four bermudagrass hays harvested after 6, 8, and 10 and 12 weeks regrowth (Moore, unpublished), there was no effect of supplemental protein on hay intake. Hay CP percentages ranged from 5.3 to 8.1% and TDN:CP ratios ranged from 6.8 to 8.5. These studies suggest that supplemental protein will increase intake of low-protein hays only when the TDN:CP ratio of the forage is high (above 8.5). Therefore, with many mature hays which are low in both CP and TDN, protein supplement may not increase forage intake. There may, however, be a need for supplemental protein to meet the protein requirements of the animal.

QUALITY INDEX

In beef cattle extension activities in Florida, the authors have used the term "Quality Index" (QI) as an overall indication of forage quality. Laboratory analyses used to calculate QI include CP, TDN and fiber percentages of the forage. Quality Index is defined as the voluntary intake of forage TDN divided by the animal's maintenance TDN requirement. It is assumed that the forage is fed free-choice without energy supplementation, and that TDN:CP ratio is adequate to avoid a decrease in forage intake. Thus, if a forage has a QI of 1.0, the animal would just maintain itself if the forage was the only source of dietary energy.

Forages with QI values above 1.0 are expected to support animal performance in proportion to the QI value. To test this idea, 11 bermudagrass hays were fed as the only source of energy and protein to growing steers at the Pine Acres Research Farm near Citra. Complete mineral supplement and water were offered along with the hays. The hays were harvested and cured in spring and summer under practical conditions. Even though the results were obtained in four different years with animals of different sizes and breeding, there was a very close relationship between QI and daily gain (Figure 7). These results show that QI values could be used to estimate the performance of cattle when a forage is fed alone. Daily gains at QI values of 1.2, 1.5 and 1.8 were about .5, 1.0, and 1.5 lb per day, respectively.

In all Florida grass samples, a high proportion (37 to 40%) of QI values were in the range of 1.1 to 1.2 (Figure 8). Bahiagrass had a high proportion of samples (39%) below 1.1. In the range of 1.3 to 1.6 QI, the proportions of samples were 17% for bahiagrass, 38% for bermudagrass, 32% for digitgrass and stargrass and 43% for limpograss. Only 7% of all samples had QI values above 1.6.

The forage QI required to meet an animal's requirement for TDN is determined by the size and production level of the animal (Figure 9). The low requirements of a non-pregnant, non-growing heifer (Figure 9a) could be met with a forage having a QI=1.0, but if the same heifer was pregnant and gaining 1 lb/day (Figure 9b) the TDN requirement is increased, and a forage having a QI=1.3 would be required. A smaller heifer weighing 600 lb and gaining at 1.25 lb/day (Figure 9c) cannot eat enough forage to meet her TDN requirement unless the forage has a QI=1.9. A lactating cow producing 15 lb milk/day (Figure 9d) requires a forage with QI=1.4 to meet her TDN requirements. When the forage offered has a lower QI than needed, supplemental TDN is required.

Figure 9 shows, also, that there is a place in beef production for forages of different qualities. For example, low-quality forages (QI=1.0) can be fed to animals at maintenance, while high-quality forages should be reserved for animals with higher requirements or lower intake capacity.

SUBSTITUTION OF GRAIN FOR FORAGE

In theory, the amount of supplemental TDN required for an animal on a particular forage is the difference between the animal's TDN requirement and the intake of forage TDN, as shown in Figure 9. In practice, however, it is generally not possible to meet an animals TDN requirement by just offering an amount of TDN equal to the difference between requirement and intake. That is because when grain is offered the voluntary intake of forage may be decreased. This has been called "substitution" of grain for forage.

Growing steers at the Pine Acres Research Farm were offered four bermudagrass hays either alone or with a grain mixture providing TDN in amounts equal to .6% of body weight (BW). There was a wide range in QI of the hays (1.05 to 1.79). When hays were fed alone, daily gains were related to QI as expected. When grain was fed, hay intake was decreased (Figure 10). When calculated as TDN intake, the decrease in hay intake due to feeding the grain was about .3% of BW for all hays, giving a substitution rate of 50%. The actual total intake of TDN from forage plus grain was, therefore, about .3% of BW less than expected.

Other research has indicated that the substitution rate on high-quality forages (QI above 1.8) may be higher than the 50% shown in Figure 10. Also, substitution rate may not be the same for different types and amounts of supplemental energy sources. At this time we do not have enough data to estimate reliable substitution rates for all circumstances.

In order to meet the supplemental TDN needs for a given animal on a given forage, it is necessary to consider both the difference between TDN intake and requirement (Figure 9) and the substitution rate (Figure 10). For example, the 600 lb heifer gaining 1.25 lb/day (Figure 9c) has a TDN requirement of 10.1 lb/day. If the forage being fed had a QI = 1.3, then expected TDN intake would be 7.3 lb/day (Figure 9c), or 2.8 lb/day less than required. Assuming a substitution rate of 50%, it would require 5.6 lb/day of supplemental TDN in order to meet the requirement of 10.1 lb/day. If the supplement was 80% TDN, 7 lb/day of supplement would be needed to meet the TDN requirement.

SUMMARY

The samples of forage grasses submitted to Ona for analysis, which were primarily hay, were frequently low in overall quality. A few samples were high in nutrient composition and quality, and these may have represented less mature forage. The data suggested that there are differences among species of grass. Bahiagrass had the lowest quality in terms of CP, TDN and QI, but energy and protein may have been in balance for most samples. Most bermudagrass samples were intermediate in CP, TDN and QI, and TDN:CP ratios were acceptable for most samples. The relatively higher quality of bermudagrass than bahiagrass may have reflected the effort made to make good hay. Most digitgrass, stargrass and limpograss samples had intermediate QI values, but their high TDN and low CP percentages resulted in high TDN:CP ratios, suggesting that protein was low in comparison to energy. Forage testing, particularly of hay, can be helpful in estimating quality of a particular forage and determining the need for supplemental protein and energy.

When CP percentages of forages are below 7%, supplemental protein would likely increase animal performance. When TDN:CP ratios are 8 or less, however, it is unlikely that supplemental protein will increase forage intake even when CP percentages are less than 7%. When TDN:CP ratios are above 8.5, protein supplement should increase forage intake as well as animal performance.

The low QI values of most Florida forage grass samples suggests that low TDN intake may be a major factor limiting performance of growing and lactating cattle. The amount of supplemental TDN needed will depend on the difference between intake and requirement, and the decrease in forage intake when supplemental energy feeds are fed. More information about this last point is needed, however, in order to calculate the amount of supplement to feed with a particular forage.

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Table 1. Requirements for Crude Protein (CP) and Total Digestible Nutrients (TDN), and the TDN:CP Ratio for Representative Beef Cattle (from NRC, 1984).

Animal	***Requirement (% of DM)***		**TDN:CP *Ratio***
	CP	***TDN***	
Heifer, 800 lb body weight (BW):			
Non-Pregnant, 0 lb gain/day	7	54	7.7
Pregnant, 1.0 lb gain/day	*8*	*55*	*6.9*
Heifer, 600 lb BW, 1.25 lb gain/day	*9*	*59*	*6.6*
Lactating Cow, 1000 lb BW, 15 lb milk/day	*11*	*62*	*5.6*

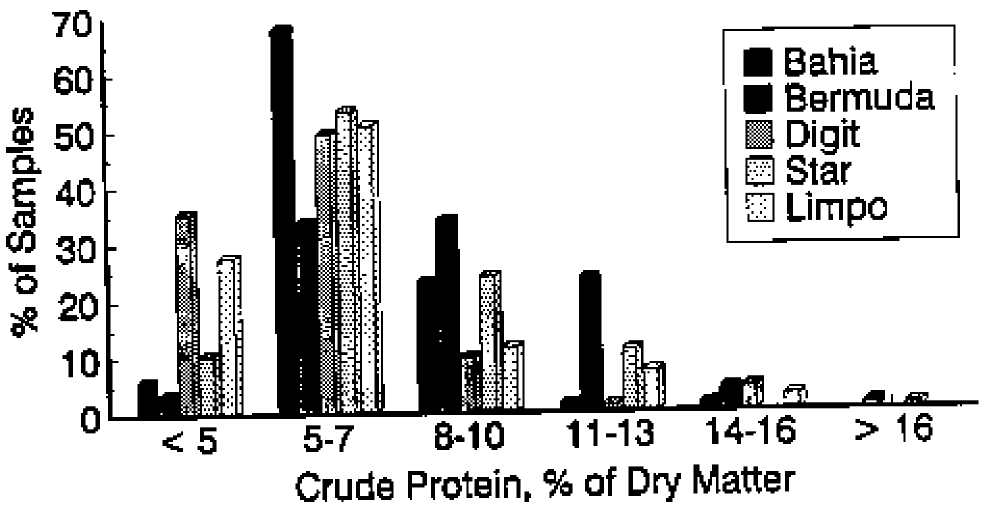

Figure 1. **Proportion of forage samples found in different ranges of Crude Protein percentages, by species of forage (producer samples submitted to Florida Extension Forage Testing Program, AREC, Ona; Brown, unpublished).**

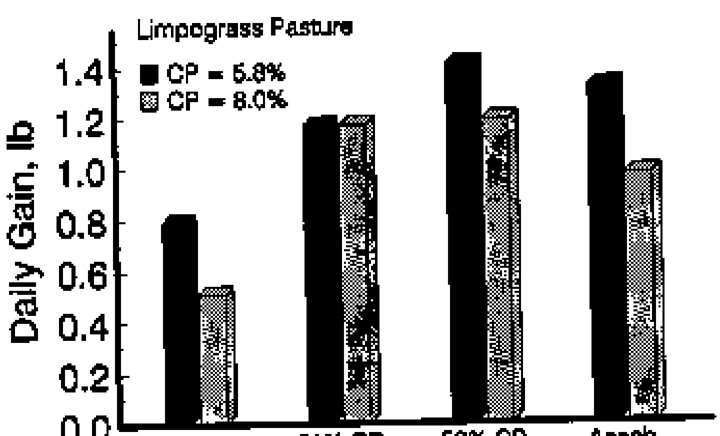

Figure 2. **Effect of protein supplementation upon daily gain by steers grazing Floralta limpograss pasture in two years (21% and 50% CP supplements were urea and corn meal; Aesch. refers to overseeding of limpograss with aeschynomene; Holderbaum et al., 1991).**

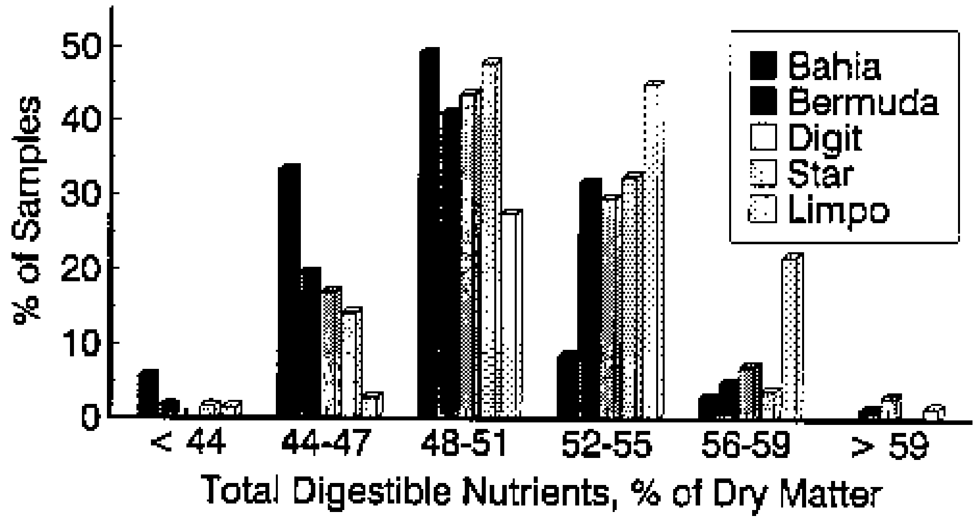

Figure 3. Proportion of forage samples found in different ranges of Total Digestible Nutrient percentages, by species of forage (producer samples submitted to Florida Extension Forage Testing Program, AREC, Ona; Brown, unpublished).

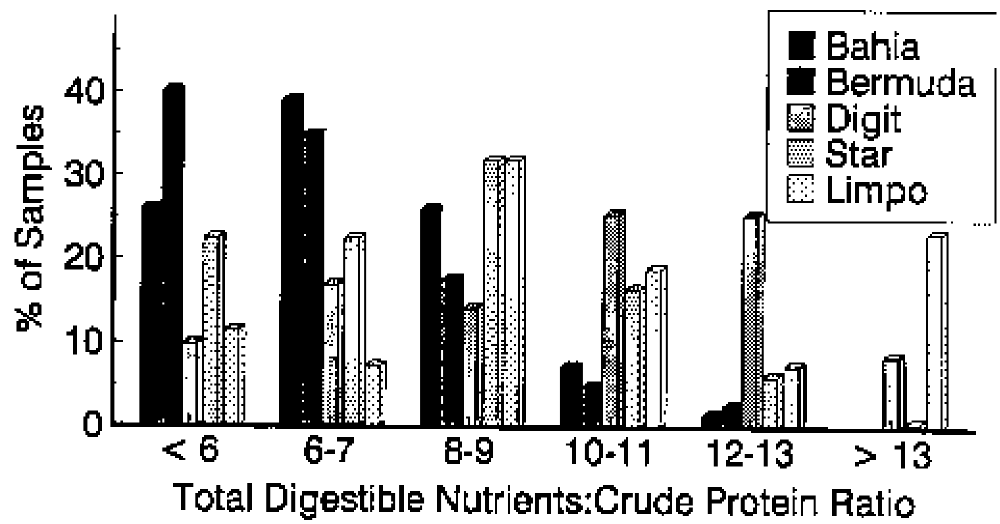

Figure 4. Proportion of forage samples found in different ranges of Total Digestible Nutrient:Crude Protein ratios, by species of forage (producer samples submitted to Florida Extension Forage Testing Program, AREC, Ona; Brown, unpublished).

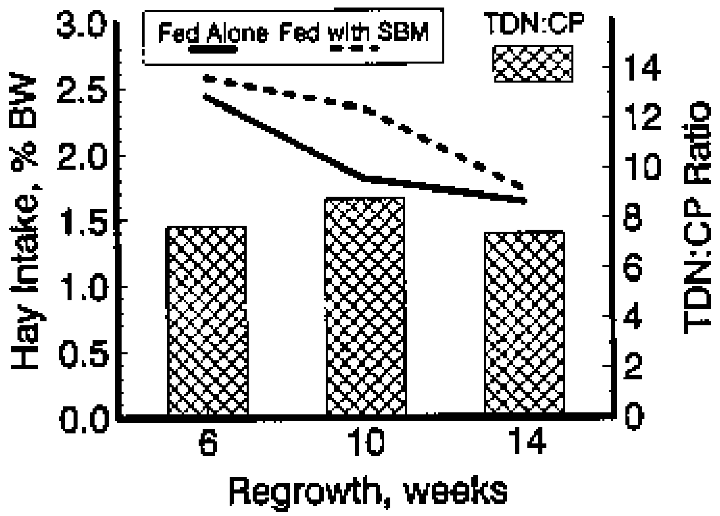

Figure 5. Relationship between the Total Digestible Nutrient:Crude Protein (TDN:CP) ratio and the effect of supplemental soybean meal (SBM) on intake of Pensacola bahiagrass hay (BW = body weight; SBM fed at .12% of BW; Moore et al. 1970).

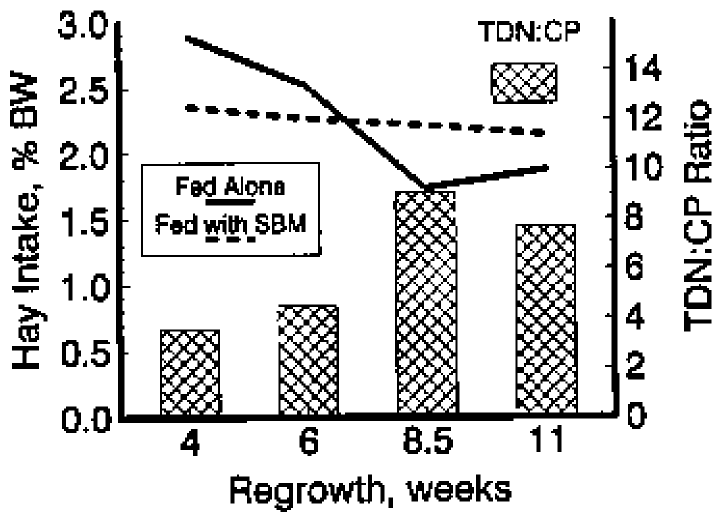

Figure 6. Relationship between the Total Digestible Nutrient:Crude Protein (TDN:CP) ratio and the effect of supplemental soybean meal (SBM) on intake of Pangola digitgrass hay (BW = body weight; SBM fed at .17% of BW; Ventura et al. 1975).

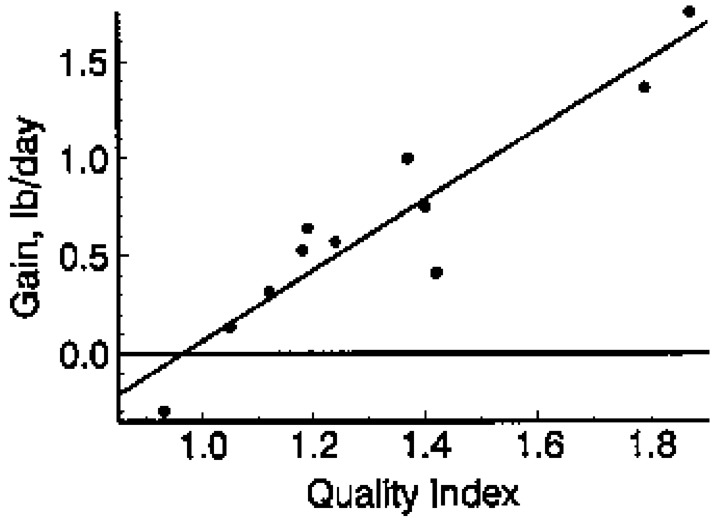

Figure 7. Average daily gain of growing steers in relation to Quality Index of forage (Moore and Kunkle, unpublished; data from four experiments).

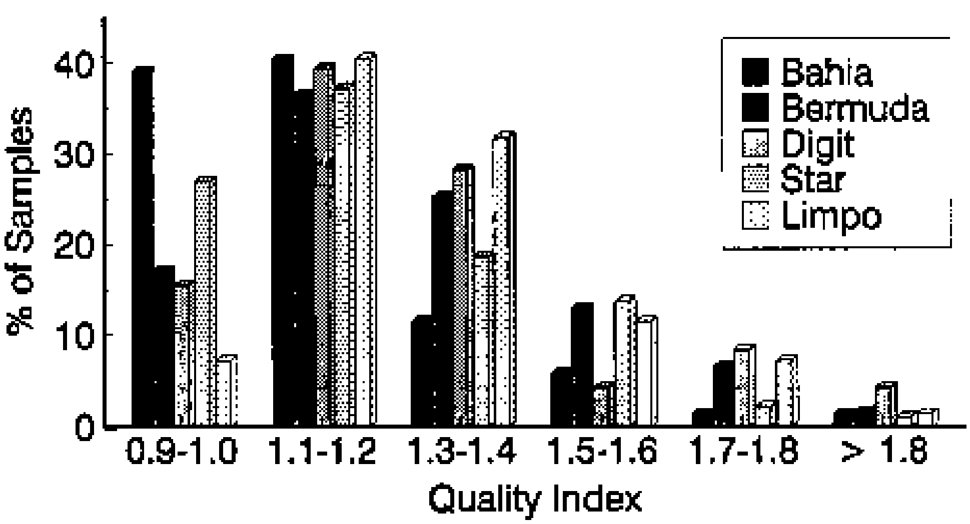

Figure 8. Proportion of forage samples found in different ranges of Quality Index, by species of forage (producer samples submitted to Florida Extension Forage Testing Program, AREC, Ona; Brown, unpublished).

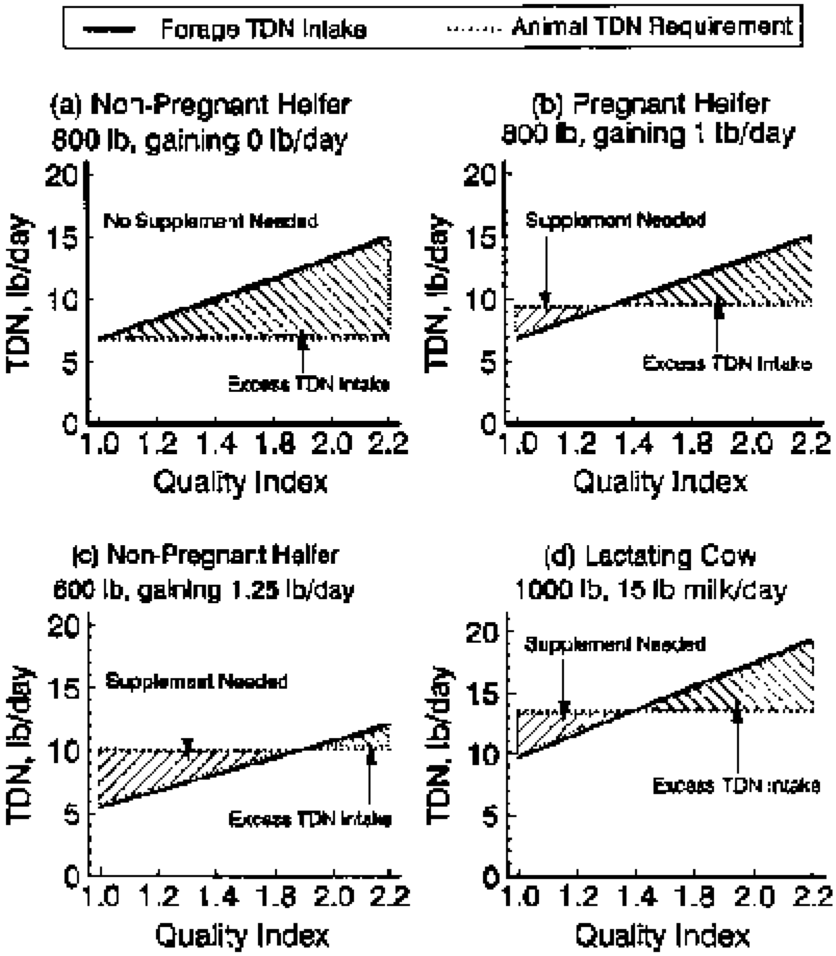

Figure 9. Intake of Total Digestible Nutrients (TDN) of forages varying in Quality Index in relation to TDN requirements of selected beef cattle.

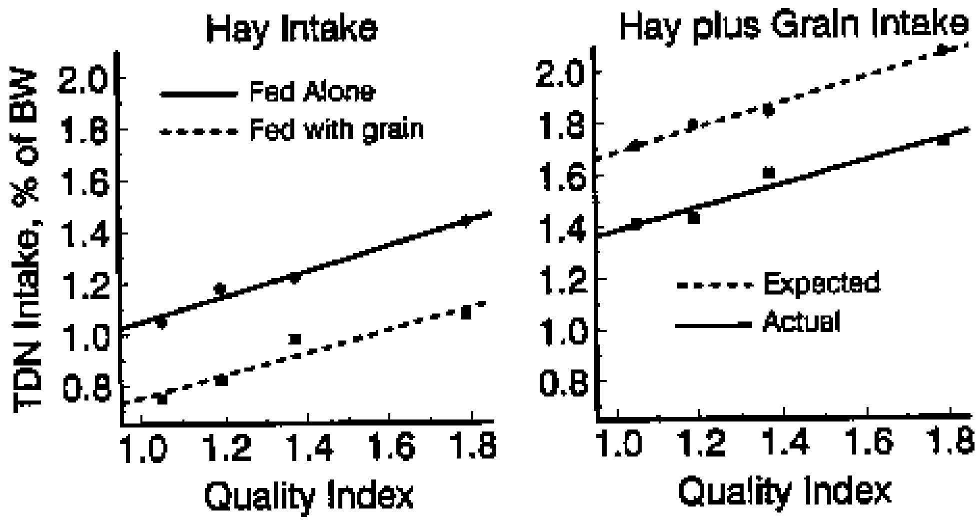

Figure 10. Intake of Total Digestible Nutrients (TDN) as % of body weight (BW) by steers fed four hays free choice with and without supplemental grain; grain provided TDN at .6% of BW (Higgins, Moore and Konkle, unpublished).