# Nutritional Comparison of Feed Resources for Ruminant Animals Feeding in Ethiopia Using Relative Forage Quality

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**Abstract**
Feed resources are distinctive mixtures of forages that differ in their qualities. This study was conducted to explain forage quality and compare the feeds value nutritionally. The study was based on three feed types that are dry forages and roughages, energy supplements, and protein supplements. All samples were collected from different regions and research centers of Ethiopia. Representative samples of each feed materials collected from respective sites were prepared and made ready for standard methods of chemical analysis. Then, the relative forage qualities (RFQ) were calculated from chemical analysis result following standard equations and were analyzed using statistical package. In comparison of RFQ for each feed categories, the highest RFQ content was found to be 136.11, 137.86, 131.88, 157.53, 168.83, and 154.30 for thatch grass, sorghum stover, sorghum grain, moringa leaf, alfalfa, and noug seed cake respectively. In contrary, the lowest was found to be 118.69, 122.21, 51.16, 140.44, 98.56, and 93.90 in panicum, tef straw, cassava root, luceneana leaf, cowpea, and cotton seed cake respectively. Crude protein (CP) content of feed resources which are prominent indicators in determining forage quality did not show to go with the RFQ. Understanding forage quality and also the factors that have an effect on its constituents can facilitate improve farm animal production by creating choices that optimize forage utilization. Therefore, combination of the protein supplements and energy supplements with the monocots will give correct feeding and daily protein/energy needs of farm animal grazing in the study area and the country Ethiopia at large.
**Keywords:** monocots; protein supplements; energy supplements; nutritive value

## 1. Introduction

Ruminant animals feed resources being distinctive mixtures differ in forage quality, and creates complexness making it tough to characterize for feeding practices (Allison, 1985; Pinkerton et al., 1991; Pinkerton, 2005). On the contrary, in tropics seasonal variation in animal performance is anticipated primarily as a manifestation of variation in feed quality and amount consumed (Javed et al., 2004). Forage quality assessment of pastures helps to elucidate nutrition and grazing capability of ruminants (Arzani and Naseri, 2007; Baumont et al., 2008), that ends up from the combined effects of environmental factors like altitude and climate (Buxton and Fales, 1994; Buxton, 1996; Todorova et al., 2002), and management practices (Blackstock et al., 1999; Ducourtieux and Theau, 2008; Cop et al., 2009; Duru et al., 2009; Gaujour et al., 2012). To estimate the particular carrying capability of pastures, information on the quality of pastures forage plants is important.

In nutritional terms, animal performance principally depends on the standard of forage (Lazzarini et al., 2009; Woolley et al., 2009).

Forage quality is outlined as the capability of forage to supply the desired nutrients to the ruminant animal (Adesogan et al., 2006; Newman et al., 2006; Muir et al., 2007) hence the nutrient in forages is very important as a result of production effectively is expounded to the quantity of nutrients within the forage (Schut et al., 2010). Total digestible Nutrient (TDN) and crude protein are typically used as indicators of forage quality where the quantity is determinant (White and Wight, 1984; France, 2000; Pinkerton, 2005). El-Waziry (2007) and Rhodes and Sharrow (1990) thought of the dry matter digestibility is the main index for forage quality which is the factor of ADF. ADF estimates the content on cellulose and lignin in forage which closely related to digestibility, and NDF determines the total fiber content including hemicelluloses in addition to the ADF value (cellulose and lignin) which is related to intake because it evaluates the bulkiness of forage (Van Soest et al., 1991, Van Soest, 1994). However, it would be of interest and sensible to use an index to compare and contrast forage quality as feed resource for ruminant animals.

Hence, the aim of this study was to explain forage quality and compare nutritional values of the ordinarily utilized ruminant animal feed resources in the country Ethiopia exploiting the Relative Forage Quality (RFQ) Index.

## 2. Material and Methods

This study was base on three feed types

*Dry forages and roughages* (grasses: Napier grass, Natural pasture, Thatch grass (*Hyparrenia rufa)*, Sugarcane top, Hay, Panicum, and Rhodus, and crop residues: Barley straw, Sorghum stover, Maize stover, Oats straw, Tef straw, Wheat straw),

*Energy supplements:* Cassava root (tuber), Cassava peal, maize grain/flour, Rice bran, Sorghum grain, Wheat bran, Wheat middling, Wheat short, and

*Protein supplements*

Foliage: Acacia leaf, Cassava leaf, Lucanea leaf and/or twig, Moringa leaf and/or twig, Sesbania leaf and/or twig;

Legumes: Alfalfa, Cowpea, Pigeon pea, Vetch (Vicia spp.); and

Oil seed cakes: Cotton seed cake, Linseed cake, Noug seed cake)

### 2.1. Sampling sites

All samples were collected in Ethiopia. That is, samples of dry forage and roughages (grasses and crop residues), energy supplements, and protein supplements (foliages, legumes, and oil seed cakes) were collected from DZARC (Debre zeit agricultural research center) area, Andassa area, Bako area, Shashemene area, Adamitulu area, Addis Ababa area, HARC (Holetta agricultural research center) area, Areka area, and Hashenge area as per availability of the feed samples.

### 2.2. Collection and sample processing

Representative samples of each material collected from respective sites were prepared and made ready for chemical analysis. The neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined according to (Van Soest and Robertson, 1985; Undersander *et al.,* 1993)and Crude protein (CP) was determined according to AOAC (1990) procedure.

NDF is an evaluation of the total fiber content which includes hemicelluloses in addition to the cellulose and lignin content. The NDF content is related to intake because it evaluates the bulkiness of forage. Dry Matter Intake (DMI) is an estimate of the relative amount of forage an animal will eat when only forage is fed. DMI was estimated from NDF using the following equation:

$\mathrm{DMI} = \frac{120}{\%\mathrm{NDF}}$ (Rohweder et al., 1978; Rohweder, 1984; Mertens, 1985; Linn et al., 1987)

ADF is a feed constituent that evaluates the content on cellulose and lignin in forage and is closely related to digestibility. It was used to determine TDN using the following equation:

$\%\ \mathrm{TDN} \approx 2.06 \times \%\ \mathrm{ADF}$ (Mertens, 1987; Oba and Allen, 1999)

Therefore, relative forage quality (RFQ) index can help management on making decisions based on values of NDF, ADF, TDN and DMI. That is, RFQ as a quality index ranks forages based on potential digestible dry matter and digestible dry matter intake. RFQ was estimated using the following equation:

$\mathrm{RFQ} = \frac{(\mathrm{DMI},\%\ \mathrm{of\ BW}) \times (\mathrm{TDN},\%\ \mathrm{of\ DM})}{1.23}$ (Moore and Undersander, 2002)

### 2.3. Developing index:

Relative forage qualities were calculated following an equation developed [36]. Data were analyzed using MINITAB statistical package (MINITAB for Windows release 17).

## 3. Results and Discussion

The study contained 6 feed types: grasses from seven feed sources, crop residues from six feed sources, energy supplements from eight feed sources, foliages from five feed sources, legumes from four feed sources, and oil seed cakes from three feed sources. The afore mentioned feed resources play a significant role in livestock nutrition where feed cost accounts 70% of the total cost of production and in Ethiopia approximately 85% of all feed sources are from pasture, hay and crop residues. Natural pasture is estimated to contribute 80 – 90% of livestock feeds while crop residues contribute up to 50% of the feed in mixed farming system (Negesse *et al.,* 2009). In well-managed systems, these feed resources can supply year-round nutrition to the livestock with minimal supplementation from foliages, legumes, and agro-industrial byproducts to match with their nutrient requirements.

The results of forage quality tested in this study are presented in Table 1, 2, and 3. In comparison of RFQ for each feed categories, the highest RFQ content was found to be 136.11, 137.86, 131.88, 157.53, 168.83, and 154.30 for thatch grass, sorghum stover, sorghum grain, moringa leaf, alfalfa, and noug seed cake respectively. In contrary, the lowest was found to be 118.69, 122.21, 51.16, 140.44, 98.56, and 93.90 in panicum, tef straw, cassava root, luceneana leaf, cowpea, and cotton seed cake respectively. Crude protein (CP) content of feed resources which are prominent indicators in determining forage quality did not show to go with the RFQ index values (Table 1, 2, and 3). Among the dry forages and roughages out of the grasses tested thatch grass was the highest in RFQ while was the least in CP, and among the crop residues tested out of the stovers sorghum stover was the best in RFQ while was lower in CP and out of the straws wheat straw had have the highest RFQ value while it was the least in CP, among the energy supplements tested sorghum grain was high in RFQ while was 5$^{th}$ in CP, among the protein supplements out of the feed type called foliage moringa leaf was high in its RFQ while was the 2$^{nd}$ from the least, out of the legumes alfalfa was the best in RFQ being 2$^{nd}$ in CP from its group.

Among the tested grasses panicum had maximum crude protein (CP) level (9.87%) while lowest (3.71%) was on thatch grass, on crop residues the maximum (6.89%) was found in oats straw and minimum (2.85%) in wheat straw, on energy supplements the maximum (18.44%) was found in wheat bran whereas minimum (2.02%) in cassava root, among the protein supplements noug seed cake had the maximum (35.05%) while the lowest CP level (14.54%) was found in acacia leaf.

The statistical results of relative forage quality (RFQ) and as well CP value showed important variations among the feed resources within their classes with exception to the case of the feed type ‘stovers’.

The results of statistical analysis indicated that the forage quality of feed resources studied was considerably completely different. The variations between all forage quality indicators were highly significantly different, except between the two stovers types (Table 1). The results showed that the feed resources studied that were classified into three categories (dry forages and roughages, energy supplements, and protein supplements) and these three grouping was supported by entities CP, NDF, ADF, TDN, DMI and RFQ.

The Tukey’s check results additionally showed important variations in forage quality among the feed types within the categories indicated above. The Tukey’s test clearly showed the similarities and differences of the feed types within their respective classes. Hence in their RFQ, thatched grass, rhodus, sugar cane top, and hay found to be best among the grasses; wheat and oats straw among the crop residues; sorghum grain among the energy supplements; all except luceana leaf among the foliages; alfalfa among the legumes; and noug seed cake among the oil seed cakes (Table 4).

Whereas in CP content, panicum appeared to be the best among the grasses; Oats among the crop residues; wheat bran and middling among the energy supplements (which was not in the case of RFQ); sesbania and luceana leaf among the foliages; cowpea among the legumes (which was not in the case of RFQ); and noug seed cake among the oil seed cakes (Table 1, 2, and 3). RFQ can be used to categorize feed resources into quality grades. Hence, according to Undersander (2003) and Hancock (2011) categorization, the feed resources tested in this study graded in their quality (Table 4).

In the long history of agriculture, pastures area are the primary and most significant forage resource for ruminant feeding, considering the economic and social views. While the long run pastures utilization increased over-grazing which does not regarded grazing capability, increasing pressure on the pastures scheme. To alleviate such pressure, there's a necessity of increasing forage production that can keep up a balance between ruminant populations and forage pastures.

It’s likely for the grazing capability of pastures to be properly determined. As a result of the low quality of forages, information of pastures forage quality is critical to work out requirements of ruminants in several developing countries feeds. Quality and amount of roughages vary seasonally. Plants grow throughout the time of year ensuing decline in quality as they mature, their quality being sensible within the early season (Khanum et al., 2007). Within the designing and utilization of pasture and achieving optimum performance of ruminants, deciding the needs of the animals in terms of energy and protein is fundamental.

This is solely practical once the standard of pastures forage plants for every region in terms of chemical composition is understood. Quality of forage species is plagued by environmental factors. Pastures forage quality varies with time. Therefore, information of forage quality at different atmospheric condition ought to be thought of for correct utilization of pastures. The results of this study showed that forage quality of the studied feed types/resources were completely different. Alfalfa and cassava root had the best and lowest forage quality, respectively in RFQ terms. Whereas, noug seed cake and cassava root had the best and lowest forage quality, respectively in CP terms. Distinction in quality of forage species additionally indicates their inherent ability to get nutrients from the soil and convert them to plant structure with a positive leaf to stem ratio, crude protein and crude fiber proportion. The results of this study showed that the RFQ of panicum, tef straw, cassava root, luceana leaf, cowpea, and cotton seed cake was the least from grasses, crop residues, energy supplements, foliages, legumes, and oil seed cakes respectively. Likely the CP of thatch grass, wheat straw, cassava root, acacia leaf, pigeon pea, and linseed cake was the least from grasses, crop residues, energy supplements, foliages, legumes, and oil seed cakes respectively.

The result of this study had stressed on the upper quality of legumes compared to grasses as well crop residues which agrees with most research out puts as in the case of Arzani et al. (2005) and was comparable with foliages, unlike that of cowpeas’ RFQ. However, the NDF and ADF of grasses and crop residues were more than that of legumes, foliages and oil seed cakes. These results are consistent with results obtained in preceding studies. High fiber content in grasses and crop residues is assumed to be the function of the higher proportion of stems within the forage unlike the other feed types studied. Similarly, the upper edibleness of legume and foliages as compared to the grasses and crop residues was also attributed to leaf shape and structure (Rawnsley et al., 2002; Pontes et al., 2007).

Parts of grasses and crop residues are inherently long and versatile with relatively low densities that are complicated, whereas vascular parts of foliages and legumes are short and thick with a high bulk density. This explains the potential of legumes to be digestible simply. High crude protein and dry matter intake within the foliages and legumes, including energy supplements and oil seed cakes, relative to grasses and crop residues has placed this family of plants as being a lot of fascinating in terms of quality. Therefore, the mix of energy and protein supplement sources, and dry forage and roughages within the study feed resources will give correct feeding and daily requirement needs for ruminant animals grazing. The results additionally showed that some feed resources with low edibleness, like the grasses and crop residues tested, if combined with higher-quality feed resources like energy and protein supplements included in this study, will give the animal's daily requirement. In addition to this, it will be important to keep in mind the value of silage making in improving problems associated to palatability.

## 4. Conclusions

Understanding forage quality and also the factors that have an effect on its constituents can facilitate improve farm animal production by creating choices that optimize forage utilization. The choice either from grazing or a way to choose the most effective hay makings ought to be supported by forage quality. A forage analysis is so vital to gauge the nutrition of the forage to be grazed or fodder to be purchased or marketed. Knowing what affects forage quality will facilitate in creating acceptable choice of forages and supplements which will match animal needs and end in economically optimum farm animal performance. The results of the statistical analysis showed that, foraging quality of the feed resources studied (dry forages and roughages except the stovers, energy supplements, and protein supplements) were considerably and completely different ($P<0.001$). The feed resources from monocot family (dry forages and roughages) showed considerably higher ADF and NDF than the energy and protein supplement source feed resources. Furthermore, on average the RFQ of foliages (150.00) and legumes (137.21) was beyond that of grasses (128.24) and crop residues (131.11). Therefore, combination of the protein supplements (foliages, legumes, and oil seed cakes) and energy supplements with the monocots (grasses and crop residues) will give correct feeding and daily protein/energy needs of farm animal grazing in the study area and the country Ethiopia at large.

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**Table 1.** Dry forages and roughages

| Feed type | Feed name | %CP | %NDF | %ADF | %TDN | DMI | RFQ |
|---|---|---|---|---|---|---|---|
| Grasses | Thatch grass (*Hyparrenia rufa)* | $3.71^{d}\pm1.088$ | 67.76 | 45.87 | 94.50 | 1.77 | $136.11^{a}\pm4.21$ |
| | Rhodus | $6.78^{bc}\pm1.436$ | 74.51 | 49.64 | 102.26 | 1.61 | $133.94^{ab}\pm3.76$ |
| | Sugar cane top | $4.20^{d}\pm1.203$ | 63.94 | 41.92 | 86.35 | 1.88 | $131.79^{ab}\pm3.33$ |
| | Hay | $4.93^{cd}\pm0.530$ | 72.16 | 46.41 | 95.60 | 1.66 | $129.29^{abc}\pm4.06$ |
| | Napier grass | $7.30^{b}\pm0.867$ | 69.88 | 43.92 | 90.48 | 1.72 | $126.33^{bcd}\pm3.19$ |
| | Natural pasture | $6.42^{bc}\pm0.375$ | 64.60 | 39.05 | 80.45 | 1.86 | $121.51^{cd}\pm5.37$ |
| | Panicum | $9.87^{a}\pm0.878$ | 70.03 | 41.36 | 85.20 | 1.71 | $118.69^{d}\pm2.85$ |
| | p-value | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Crop residue | Sorghum stover | $3.62^{ns}\pm0.877$ | 72.48 | 49.71 | 102.41 | 1.66 | $137.86^{ns}\pm4.32$ |
| | Maize stover | $4.35^{ns}\pm1.085$ | 70.65 | 47.28 | 97.40 | 1.70 | $134.55^{ns}\pm2.76$ |
| | p-value | 0.277 | 0.086 | 0.019 | 0.019 | 0.084 | 0.186 |
| | Wheat straw | $2.85^{c}\pm0.896$ | 75.89 | 50.86 | 104.77 | 1.58 | $134.69^{a}\pm2.174$ |
| | Oats straw | $6.89^{a}\pm0.874$ | 72.90 | 48.41 | 99.73 | 1.65 | $133.48^{a}\pm2.76$ |
| | Barley straw | $4.46^{b}\pm0.530$ | 73.74 | 45.44 | 93.60 | 1.63 | $123.87^{b}\pm3.76$ |
| | Tef straw | $4.39^{b}\pm0.634$ | 76.15 | 46.30 | 95.38 | 1.58 | $122.21^{b}\pm2.59$ |
| | p-value | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

**Table 2.** Energy supplements

| Feed name | %CP | %NDF | %ADF | %TDN | DMI | RFQ |
|---|---|---|---|---|---|---|
| Sorghum grain | $11.14^{c}\pm0.837$ | 28.11 | 18.42 | 37.94 | 4.28 | $131.88^{a}\pm6.88$ |
| Maize grain/flour | $10.00^{c}\pm1.165$ | 42.06 | 18.97 | 39.09 | 2.85 | $90.70^{b}\pm5.33$ |
| Cassava peal | $3.70^{d}\pm0.700$ | 33.78 | 15.26 | 31.43 | 3.55 | $90.67^{b}\pm6.98$ |
| Wheat short | $15.61^{b}\pm0.737$ | 51.72 | 20.52 | 42.27 | 2.32 | $79.76^{c}\pm4.28$ |
| Rice bran | $14.48^{b}\pm0.640$ | 40.63 | 15.83 | 32.62 | 2.95 | $78.35^{cd}\pm3.06$ |
| Wheat middling | $17.67^{a}\pm0.837$ | 46.49 | 15.96 | 32.88 | 2.58 | $69.04^{de}\pm4.08$ |
| Wheat bran | $18.44^{a}\pm1.146$ | 48.62 | 14.92 | 30.73 | 2.47 | $61.69^{ef}\pm4.90$ |
| Cassava root | $2.02^{d}\pm1.290$ | 38.86 | 9.88 | 20.35 | 3.09 | $51.16^{f}\pm5.00$ |
| p-value | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

**Table 3.** Protein supplements

| Feed type | Feed name | %CP | %NDF | %ADF | %TDN | DMI | RFQ |
|---|---|---|---|---|---|---|---|
| Foliages | Moringa leaf | $16.09^{c}$±1.110 | 42.79 | 33.51 | 69.03 | 2.81 | $157.53^{a}$±7.40 |
| | Cassava leaf | $20.33^{b}$±1.496 | 30.22 | 22.69 | 46.75 | 3.97 | $151.11^{ab}$±8.97 |
| | Sesbania leaf | $23.97^{a}$±0.408 | 41.72 | 31.33 | 64.54 | 2.88 | $151.07^{ab}$±5.06 |
| | Acacia leaf | $14.54^{c}$±0.928 | 52.81 | 38.82 | 79.96 | 2.30 | $149.84^{ab}$±5.00 |
| | Luceana leaf | $23.06^{a}$±0.433 | 54.16 | 37.84 | 77.95 | 2.22 | $140.44^{b}$±3.10 |
| | p-value | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Legumes | Alfalfa | $23.02^{b}$±1.413 | 29.75 | 24.99 | 51.48 | 4.04 | $168.83^{a}$±6.62 |
| | Pigeon pea | $16.64^{c}$±0.271 | 55.47 | 40.97 | 84.39 | 2.16 | $148.50^{b}$±4.66 |
| | Vetch (Vicia spp) | $21.49^{b}$±1.636 | 48.49 | 32.05 | 66.02 | 2.48 | $132.95^{c}$±6.03 |
| | Cowpea | $28.25^{a}$±0.726 | 46.60 | 22.84 | 47.04 | 2.58 | $98.56^{d}$±5.30 |
| | p-value | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Oil seed cakes | Noug seed cake | $35.05^{a}$±1.567 | 36.24 | 27.82 | 57.30 | 3.31 | $154.30^{a}$±4.35 |
| | Linseed cake | $29.90^{c}$±0.523 | 33.66 | 21.95 | 45.22 | 3.57 | $131.03^{b}$±6.54 |
| | Cotton seed cake | $31.58^{b}$±0.463 | 39.34 | 18.38 | 37.86 | 3.05 | $93.90^{c}$±4.89 |
| | p-value | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

**Table 4.** Feed types categorization in RFQ ranges

| RFQ | Quality category | Feed types | Feeds name |
|---|---|---|---|
| ≥ 140 | Premium | Foliages | Leaf of Moringa, Cassava, Sesbania, Acacia, Luceana |
| | | Legumes | Alfalfa and pigeon pea |
| | | Oil seed cake | Noug seed cake |
| 110 - 139 | Good | Grasses | Thatch grass (*Hyparrenia rufa),* Rhodus, Sugar cane top, Hay, Napier grass, Panicum, and Natural pasture |
| | | Crop residues | Sorghum and Maize stover; Wheat, Oats, Barley, and tef straw |
| | | Legumes | Vetch (*Vicia spp*) |
| | | Oil seed cake | Linseed cake |
| 90 - 109 | Fair | Energy supplements | Maiz grain/flour and Cassava peal |
| | | Legumes | Cowpea |
| | | Oil seed cake | Cotton seed cake |
| < 90 | Utility | Energy supplements | Wheat short, Rice bran, Wheat middling, Wheat bran, and Cassava root |