**NUTRITIONAL VALUE AND IN SITU DEGRADABILITY OF SELECTED FORAGES, BROWSE TREES AND AGRO INDUSTRIAL BY-PRODUCTS**

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**ABSTRACT**

*The in situ dry matter and crude protein degradability of grasses, legumes, browse trees and agro industrial by products was evaluated by the fistulated bulls (Boran × Holstein-Friesian with mean body weight 580 kg and age= 29±3 months). The lower (p < 0.05) crude protein content was reported in bracharia grasses than the other grasses. The higher (p < 0.05) washing loss in bracharia and Rhodes grasses and the better (p < 0.05) potential and effective degradability for DM and CP was observed in desho grass compared with other grasses. The content of crude protein, relative feed value and potential DM degradability were higher (p < 0.05) in Sesbania than Pigeon pea and tree lucerne.* *Potential and effective DM degradability was better (p < 0.05) in tree lucerne than the other browses. Acacia Nilotica and Wanza had the greater (p< 0.05) washes loss, potential and effective degradability for dry matter and crude protein than the other browse trees. Cactus and Shola had the highest (p < 0.05) undegradable protein than Acacia Nilotica and Wanza. The two energy source feeds (maize and wheat bran) had the greater (p < 0.05) potential and effective dry matter degradability than the other by products. The rumen undegradable protein was higher in vetch than lablab. The in situ dry matter degradability values obtained in this study can be useful to identifying the best materials used ruminant feeds.*

KEY WORDS: Rumen degradability steers, forage, browse, by-products

1. **INTRODUCTION**

The majority of ruminant animals in tropical Africa are raised on natural pastures which drop rapidly in quality(Ademosun, 1973). Many systems have been developed to predict the quality of forages fed to ruminants(Moore, 1994). To parameterize the relative feed value system, the National Forage Testing Association selected equations that relate forage neutral detergent fiber and acid detergent fiber to dry matter intake and digestible dry matter with a base DDMI of 1.29% of daily body weight(Linn and Martin, 1989). Fluctuations in nutritional values result in very irregular growth and marked fluctuations in seasonal weights(Wilson, 1987). From understanding, and to a lesser amount from the extension of research results, small-scale farmers are increasingly relying on browse and by-products to supplement roadside grazing during the dry season(Odunlami, 1988). Others animal feeds had poor degradability so that they may require some improvement before they can contribute to animal feed (Smith et al., 1988). This study was considered to evaluate the potential nutritive value of different animal feeds including forage, browse trees, and by-products commonly fed by ruminant animals.

# MATERIALS AND METHODS

**2.1. Study site and Feed samples**

The study was conducted at Holetta agricultural research center at animal nutrition research laboratory. The forages (grasses and legumes), browse trees and agro industrial by-products (protein and energy source concentrate feeds) were collected and used for this study. The browse and agro industrial by-products animal feed samples were collected during the low rain period while grasses and legumes animal feed samples were harvested during the growing period.

## 2.2. Chemical analysis

The green and fresh samples including grass and legume forages, browse trees and brewery spent grain were dried at 60 °C for 72 h and ground to pass through 1mm and 2mm sieve sizes, for chemical analysis and in situ dry matter degradability, respectively. The samples and residues after insacco dry matter degradability were analysed through a standard procedure of (Williams, 1984), this was used for dry matter, crude protein and ash content determination. The fiber fractions (neutral detergent fiber, acid detergent fiber and lignin) were analysed by the procedures of (Van Soest and Robertson, 1985). (Tilley and Terry, 1963) two-stage technique was employed to analyse invitro digestibility of organic matter in the feed.

# 2.3. In situ dry matter and crude protein degradability

The rumen degradability of the feeds was evaluated through (Orskov, 1982) procedure. Duplicated feed samples were weighted (3 g) in a 6.5 × 14 cm nylon bag (50 μm pore size) and incubated in the rumens of three fistulated Boran × Holstein-Friesian male bulls. The average body weight and age of the bulls were 580kg and 29±3 months, respectively. The bulls were fed natural pasture hay (with 5.6% CP) *adlibitum* and about 2 kg concentrate (with 19.86% CP) feed per day. The bulls were offered the concentrate feed at every morning of 8 A.M. The bulls were housed in individual pens and provided water *adlibitum.* The bags with feed samples were incubated for 6, 12, 24, 48, 72, and 96 h. After removing the bag from rumen, it was washed in running water. Washing losses were determined in duplicate by weighing nylon bags with 3 g feed and then soaked in a tap water for about 30 minutes. The nylon bags were dried in oven at 60oc for 72h and then weighed to determine the dry weight of the residues. Based on the following formula dry matter degradability was determined.

Dry matter degradability was calculated by

Where: BW = Bag weight, RW = Residue weight, S1 = Sample weight, DM = Absolute dry matter of the original sample

Degradability (Y) of DM/CP was calculated by using the following equation

Y = P = a + b (1 - e-ct), where:

a = soluble fraction

b = insoluble but potentially degradable fraction

c = degradation rate constant of the b fraction

t = degradation time (0, 6, 12, 24, 48, 72, and 96 h) and e = base for natural logarithm

# 2.4. Statistical analysis

The degradability parameters (a, b, and c) were estimated by using the general linear model procedures of statistical analysis, version 9.3 (Guide, 2010). Mean separation test was made using least significant differences analysis at p≤ 0.05.

The linear model used was: Yij= μ + Fi + eij where:

Yij = response variable, μ = Overall mean, Fi = ith feed effect and eij = residual error.

Potential degradability (PD) for DM and CP was determined by the equation: PD = a + b,

Effective degradability (ED) for DM and CP was calculated through, ED = a + bc/k + c where: a = soluble fraction b = insoluble but potentially degradable fraction c = degradation rate constant of the b fraction k = rumen outflow rate (assumed to be 0.03/h). The effective degradability crude protein is similar to rumen degradable protein (RDP). The rumen undegradable protein (RUP) of each the sample was calculated as: RUP = 100 - RDP

# RESULT

## 3.1. Nutrient content and Relative feed value

The mean nutrient content different forages feeds, browse species and by product feeds are presented (Table 1). The poor crude protein content in bracharia and the superior (*p* < 0.05) relative feed value and net energy content were considered in bracharia and Rhodes grasses compared with the other grasses. Sesbania had the better (*p* < 0.05) crude protein, relative feed value and net energy than the other browse forages. Vetch had a better (*p* <0.05) nutritional value than lablab. As compared with the other browse species, the superior (*p*<0.05) crude protein content and the better (*p* <0.05) relative feed value was observed in wanza and cactus, respectively. Among concentre feeds, Noug seed cake had the greater (*p* < 0.05) crude protein content, relative feed value and net energy than the other than concentrate feeds.

## 3.2. Digestibility and fiber component

The average fiber fractions, digestibility and dry matter intake of grass and legume forages, browse species and agro industrial by product feed is presented in Table (2). The elephant grasses had the greater (*p* < 0.05) ADF, ADL and NDF content than the other grasses. The invitro dry matter digestibility, the calculated total digestible nutrient and dry matter intake were better (*p* < 0.05) in Bracharia and Rhodes grasses than elephant and desho grasses. Sesbania had the lower (*p* < 0.05) ADF, ADL and NDF contents compared with the other browse legumes. Vetch had a better (*p* <0.05) invitro dry matter digestibility and dry matter intake than lablab As compared with the other browse species, the least (*p* <0.05) fiber components in cactus and the greater (*p* <0.05) total digestible nutrient in Acacia Nilotica and Agam were reported in this finding. The superior (*p* < 0.05) NDF, ADF and ADL content was reported in brewery spent grain and cotton seed cake than the other by products. Noug seed cake and wheat bran have the better (*p* < 0.05) invitro dry matter digestibility, calculated total digestible nutrient and dry matter intake compared with the other concentrate feeds.

## Dry matter degradability

The mean dry matter degradability of different grass, legume, browse species and agro industrial by product feeds is presented in (Table 3). The washing loss (a) was higher (*p* < 0.05) in bracharia and Rhodes grasses than the other grasses but the higher (*p* < 0.05) potential and effective DM degradability was observed in desho grass compared to other grasses. As compared with the other browse legumes, the lower (*p* < 0.05) washing loss and the higher potential and effective DM degradability (*p* < 0.05) were recorded in Pigeon pea and tree lucerne, respectively. Sesbania had the higher potential DM degradability while Pigeon pea and tree lucerne had the lowest values, meaning that the amount of dissolved material in Sesbania was the highest. Acacia Nilotica and Wanza (Cordia Africana) browses have the higher (*p* < 0.05) washes loss, potential and effective degradability than the other browse species. Among concentrate feeds, maize bran and wheat bran had he superior (*p* < 0.05) water wash fraction, potential and effective dry matter degradability than the other concentrate feeds.

## 3.3. Crude protein degradability

The average crude protein degradability of grass and legume forages, browse species and by product feeds was significantly affected by type and is presented in (Table 4). The washing loss fraction (a) of crude protein was higher (*p* < 0.05) in bracharia and Rhodes grasses than the other grasses but the upper (*p* < 0.05) potential and effective degradability of crude protein was observed in desho and bracharia grasses. The desho and elephant grass have a smaller soluble CP fraction than bracharia and Rhodes grasses. The rumen undegradable protein was better (*p* <0.05) in vetch (30.4%) than lablab (24.98%) forage. The rumen undegradable protein of Pigeon pea and Sesbania was increased by 23-26% than the rumen undegradable protein of tree lucerne. Acacia Nilotica and Wanza (Cordia Africana) browse species had the higher (*p* < 0.05) crude protein potential and effective degradability than the other browse species. The maize bran and wheat bran had the greater (*p* < 0.05) soluble nutrient fraction, potential and effective crude protein degradability than the other concentrate feeds.

# DISCUSSION AND CONCLUSIONS

In line with earlier finding (Hadjipanayiotou and Economides, 2001) vetch had the highest CP content (28.35% DM basis) whereas the CP content of lablab relatively closes (22.55% DM basis) The low digestibility and dry matter intake of the feed could be attributed by the higher fiber components which might be limited a microbial access to digest feed and fiber content. The small amount of soluble DM fraction in desho and elephant grass is supported by results of (Kabi et al., 2005). The Sesbania browse have the greater potential dry matter degradability value while Pigeon pea and tree lucerne had the lowest values, meaning that the amount of dissolved material and the degradable components in Sesbania was the highest but this value is relatively lower as compared with the other report (Rahmat and Permana, 2021), the potential and effective dry matter degradability of vetch in this study is comparable with the previous study (Hadjipanayiotou and Economides, 2001). The potential and effective degradability of DM and CP in Acacia Nilotica and Wanza browse species in this study in agreement with the previous report (Rahmat and Permana, 2021). In this study desho and elephant grass have a smaller soluble CP fraction than bracharia and Rhodes grasses, which is supported by the results of (Kabi et al., 2005). Comparable potential and effective crude protein degradability in the vetch has been reported by (Hadjipanayiotou and Economides, 2001). The results obtained in this study indicate that different forages, browse species, and by-products have good nutritional value. The *in situ* dry matter degradability and rumen undegradable protein in the studied feeds possibly useful to predict the highest materials used for ruminant feeds

1. **Data Availability**

The data used to support the ﬁndings of this study are available from the corresponding author on reasonable request.

1. **Authors' contributions**

Conceptualization, Investigation methodology, and writing - original draft by GT, data curation, and software by MF, formal analysis and writing - review & editing by GM

1. **Conflicts of Interest**

The authors declare that they have no conﬂicts of interest.

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Table 1:-Nutrient content and relative feed value of grass and legume forages, browse species and by product feeds

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Feeds | Nutrient Parameters (%, DM basis) | | | | |
| **Forage Grasses** | DM | Ash | CP | RFV | NE1(Mcal Kg-1) |
| Bracharia grass | 92.92a | 8.92b | 7.35b | 90.19a | 1.45a |
| Desho grass | 90.82d | 13.06a | 9.85a | 81.62b | 1.30b |
| Elephant grass | 91.53b | 11.74a | 8.78a | 74.36c | 1.24c |
| Rhodes grass | 91.16c | 12.66a | 9.96a | 92.37a | 1.45a |
| SE | 0.09 | 0.51 | 0.35 | 1.07 | 0.01 |
| CV | 0.19 | 8.80 | 8.01 | 2.54 | 1.94 |
| LSD | 0.28 | 1.63 | 1.12 | 3.44 | 0.04 |
| **Browse Legumes** |  |  |  |  |  |
| Pigeon pea | 92.58 | 13.39a | 20.55c | 108.01b | 1.33b |
| Sesbania | 91.96 | 10.14b | 30.81a | 224.02a | 1.67a |
| Tree lucerne | 91.20 | 5.56c | 25.55b | 100.19b | 1.40b |
| SE | 0.21 | 1.13 | 0.53 | 17.74 | 0.05 |
| CV | 0.43 | 7.91 | 3.92 | 24.16 | 5.90 |
| LSD | 0.51 | 0.67 | 0.45 | 3.24 | 0.01 |
| **Forage Legumes** |  |  |  |  |  |
| Lablab | 91.10b | 14.28 | 22.55b | 120.58a | 1.40 |
| Vetch | 93.16a | 14.57 | 28.35a | 116.52b | 1.41 |
| SE | 0.21 | 1.13 | 0.53 | 17.74 | 0.05 |
| CV | 0.43 | 7.91 | 3.92 | 24.16 | 5.90 |
| LSD | 0.51 | 0.67 | 0.45 | 3.24 | 0.01 |
| **Browse Trees** |  |  |  |  |  |
| Acacia Nilotica | 90.63bc | 2.25e | 14.78b | 188.03b | 1.89ab |
| Agam (*Carissa spinarum*L.) | 90.20c | 8.75d | 8.34c | 167.53bc | 1.90a |
| Cactus (*Cleistocactus sextoianus)* | 91.00b | 19.72a | 8.92c | 359.46a | 1.86b |
| Wanza (*Cordia African)* | 93.23a | 11.84b | 22.83a | 191.70b | 1.64c |
| Shola *(Ficus sure)* | 93.37a | 10.15c | 15.85b | 142.33c | 1.63c |
| SE | 0.16 | 0.30 | 0.45 | 9.54 | 0.01 |
| CV | 0.31 | 4.87 | 5.45 | 7.88 | 1.07 |
| LSD | 0.53 | 0.97 | 0.59 | 31.12 | 0.4 |
| By products |  |  |  |  |  |
| Brewery grain | 23.17b | 4.23c | 25.43c | 96.77d | 1.57c |
| Cotton seed cake | 90.55a | 4.99b | 29.51b | 117.82c | 1.34d |
| Maize Bran | 91.31a | 5.39b | 11.06e | 192.05b | 1.99a |
| Noug seed cake | 91.31a | 8.04a | 34.08a | 280.71a | 1.87b |
| Wheat bran | 90.6a | 4.00c | 16.60d | 206.66b | 2.01a |
| SE | 0.77 | 0.16 | 0.44 | 4.96 | 0.03 |
| CV | 1.73 | 5.26 | 3.18 | 4.81 | 2.51 |
| LSD | 2.52 | 0.53 | 1.45 | 16.18 | 0.08 |

*Mean values in the columns without common superscripts are significantly different at (p<0.05),* DM= dry matter, CP = Crude protein, RFV =Relative feed value, NE = Net energy, SE= standard error, CV= coefficient variation and LSD =least significance differences

Table 2:- Means of fiber fraction, digestibility (%, DM basis) and dry matter intake (g Kg-1 of body weight) of forages browse and by product feeds

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Feeds | Fiber fractions and other components (%, DM basis) | | | | | |
| **Forage Grasses** | ADF | ADL | NDF | IVDMD | TDN | DMI |
| Bracharia grass | 32.34c | 3.88c | 65.71bc | 62.26a | 59.61a | 18.3ab |
| Desho grass | 38.39b | 4.76b | 67.26b | 63.08a | 51.79b | 17.8b |
| Elephant grass | 40.72a | 5.17a | 71.54a | 46.72c | 48.79c | 16.8c |
| Rhodes grass | 32.59c | 4.11c | 63.96c | 51.35b | 59.29a | 18.8a |
| SE | 0.50 | 0.13 | 0.66 | 1.17 | 0.64 | 1.23 |
| CV | 2.76 | 5.69 | 1.98 | 4.22 | 2.34 | 1.99 |
| LSD | 1.59 | 0.41 | 2.12 | 3.77 | 2.05 | 0.5 |
| **Browse Legumes** |  |  |  |  |  |  |
| Pigeon pea | 36.96a | 8.32 | 51.77a | 55.28c | 53.63b | 23.2b |
| Sesbania | 24.11b | 7.16 | 31.32b | 66.27a | 70.23a | 40.7a |
| Tree lucerne | 34.37a | 8.01 | 57.70a | 61.64b | 56.97b | 20.8b |
| SE | 1.64 | 0.37 | 2.87 | 1.10 | 2.13 | 2.62 |
| CV | 9.23 | 10.44 | 11.45 | 3.53 | 7.06 | 18.59 |
| LSD | 1.45 | 0.32 | 1.23 | 2.14 | 4.67 | 5.67 |
| **Forage Legumes** |  |  |  |  |  |  |
| Lablab | 34.54 | 7.07 | 47.86b | 61.40a | 56.76 | 25.1 |
| Vetch | 34.09 | 6.78 | 49.90a | 58.06b | 57.34 | 24.1 |
| SE | 1.64 | 0.37 | 2.87 | 1.10 | 2.13 | 2.62 |
| CV | 9.23 | 10.44 | 11.45 | 3.53 | 7.06 | 18.59 |
| LSD | 1.45 | 0.32 | 1.23 | 2.14 | 4.67 | 5.67 |
| **Browse Trees** |  |  |  |  |  |  |
| Acacia Nilotica | 17.30bc | 9.69a | 37.32c | 58.20a | 79.02ab | 32.1bc |
| Agam (*Carissa spinarum*L.) | 16.57c | 10.67a | 42.20b | 50.75c | 79.96a | 28.5cd |
| Cactus (*Cleistocactus sextoianus)* | 18.43b | 4.02d | 26.40e | 53.13bc | 77.56b | 62.2a |
| Wanza (*Cordia African*) | 26.71a | 8.45b | 33.03d | 55.59b | 66.86c | 36.4b |
| Shola *(Ficus sure)* | 26.72a | 6.93c | 44.49a | 58.43a | 66.86c | 26.9d |
| SE | 0.37 | 0.34 | 0.60 | 0.78 | 0.48 | 1.44 |
| CV | 3.05 | 7.33 | 2.93 | 2.45 | 1.12 | 6.68 |
| LSD | 1.21 | 0.34 | 1.45 | 1.11 | 1.57 | 4.68 |
| By products |  |  |  |  |  |  |
| Brewery grain | 27.93b | 6.43a | 64.63a | 63.10c | 65.29c | 18.57d |
| Cotton seed cake | 36.72a | 6.05a | 47.65b | 51.35d | 53.94d | 25.20c |
| Maize Bran | 12.12d | 3.16b | 38.50c | 76.19b | 85.73a | 31.17b |
| Noug seed cake | 16.38c | 4.14b | 25.26d | 79.46a | 80.20b | 47.57a |
| Wheat bran | 10.97d | 3.16b | 36.17c | 82.01a | 87.18a | 33.17b |
| SE | 1.00 | 0.33 | 0.92 | 0.90 | 1.29 | 0.7 |
| CV | 8.33 | 12.66 | 3.73 | 2.20 | 3.01 | 3.93 |
| LSD | 3.01 | 1.10 | 2.98 | 2.92 | 2.52 | 18.28 |

*Mean values in the columns without common letters are significantly different at (p<0.05),* NDF= Neutral detergent fiber, ADF= Acid detergent fiber, ADL= Acid detergent lignin, IVDMD=Invitro dry matter digestibility, TDN= Total digestible nutrient, DMI= dry matter intake, SE= standard error, CV= coefficient variation and LSD =least significance differences.

Table 3:- Ruminal dry matter degradation kinetics of different animal feeds

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Feeds | Parameters (%, DM basis) | | | | |
| **Grasses** | a | B | C | PD | ED |
| Bracharia | 10.41a | 45.55b | 0.03bc | 55.96b | 33.38b |
| Desho grass | 7.73b | 56.83a | 0.037ba | 64.56a | 38.97a |
| Elephant Grass | 7.22b | 44.25b | 0.038a | 51.47c | 32.03b |
| Rhodes | 9.64a | 40.77c | 0.028c | 50.42c | 29.45c |
| **Browse Legumes** |  |  |  |  |  |
| Pigeon pea | 8.20c | 31.46c | 0.06b | 39.66b | 28.91b |
| Tree lucerne | 10.39b | 56.06a | 0.10a | 66.45a | 53.48a |
| Sesbania | 21.19a | 46.58b | 0.07b | 67.77a | 52.62b |
| **Forage Legumes** |  |  |  |  |  |
| Vetch | 25.07a | 35.79b | 0.08b | 60.86b | 51.13b |
| Lablab | 21.41b | 52.53a | 0.13a | 73.93a | 63.87a |
| **Browse Trees** |  |  |  |  |  |
| Acacia Nilotica | 9.15a | 75.70a | 0.05b | 84.85a | 57.00a |
| Cactus (*Cleistocactus sextoianus)* | 8.82b | 50.52d | 0.05b | 59.35d | 41.39c |
| Agam (*Carissa spinarum*L.) | 9.69b | 53.16cd | 0.07a | 62.84c | 46.40b |
| Wanza (Cordia Africana) | 11.96a | 61.16b | 0.04c | 73.12b | 47.44b |
| Shola (*Ficus sure)* | 8.58b | 55.54c | 0.04c | 64.12c | 41.43c |
| By products |  |  |  |  |  |
| Brewery grain | 8.82e | 60.05c | 0.07b | 67.87d | 42.96e |
| Noug seed cake | 9.27d | 64.18b | 0.24a | 73.45bc | 66.10c |
| Cotton seed cake | 14.94c | 56.55c | 0.03b | 71.49c | 43.57d |
| Wheat bran | 21.05b | 54.11c | 0.27a | 75.16b | 69.60b |
| Maize bran | 26.64a | 70.66a | 0.07b | 97.30a | 75.02a |

*Mean values in the columns without common superscripts are different at (p<0.05): a = soluble fraction, b = insoluble but potentially degradable fraction c = degradation rate constant of the b fraction, PD= Potential degradability and ED= Effective degradability (at 0.02)*

Table 4:- Ruminal crude protein degradation kinetics of different feeds

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Feeds | Parameters (%) | | | | | |
| **Grasses** | A | B | C | PD | ED | RUP |
| Bracharia grass | 5.14a | 45.15b | 0.031b | 50.29b | 27.86b | 72.14b |
| Desho grass | 1.04b | 56.43a | 0.037a | 57.47a | 32.24a | 67.76c |
| Elephant grass | 1.72b | 44.25b | 0.038a | 45.97c | 26.53b | 73.47b |
| Rhodes grass | 4.14a | 40.77c | 0.028b | 44.92c | 23.95c | 76.05a |
| **Browse Legumes** |  |  |  |  |  |  |
| Pigeon pea | 0.82c | 58.05b | 0.07b | 58.87c | 40.96c | 59.04a |
| Tree lucerne | 9.27b | 64.18a | 0.24a | 73.45a | 66.10a | 33.90b |
| Sesbania | 14.94a | 56.55b | 0.03b | 71.49b | 43.57b | 56.43a |
| **Legume crops** |  |  |  |  |  |  |
| Vetch | 21.05b | 54.11b | 0.27a | 75.16b | 69.60b | 30.40a |
| Lablab | 26.64a | 70.66a | 0.07b | 97.30a | 75.02a | 24.98b |
| **Browse Trees** |  |  |  |  |  |  |
| Acaica Nilotica | 7.23b | 75.46a | 0.05b | 82.69a | 54.82a | 45.18c |
| Cactus (*Cleistocactus sextoianus)* | 6.62b | 50.52d | 0.05b | 57.15d | 39.19c | 60.81a |
| Agam (*Carissa spinarum L*) | 7.49b | 53.16cd | 0.07a | 60.64c | 44.20a | 55.80b |
| Wanza (*Cordia Africana*) | 9.76a | 61.16b | 0.04c | 70.92b | 45.24b | 54.76b |
| Shola (*Ficus sure*) | 6.52b | 55.46c | 0.04c | 61.98c | 39.32c | 60.68a |
| **By products** |  |  |  |  |  |  |
| Brewery grain | 7.38d | 41.68c | 0.04b | 48.08e | 29.73d | 70.27a |
| Noug seed cake | 5.33c | 58.28b | 0.22a | 63.60c | 56.40c | 43.60b |
| Cotton seed cake | 1.95d | 56.08b | 0.02b | 57.03d | 24.20d | 75.80a |
| Wheat bran | 21.06b | 52.79b | 0.26a | 73.85b | 68.33b | 31.67c |
| Maize bran | 25.64a | 70.66a | 0.07b | 96.30a | 74.02a | 25.98c |

*Mean values in the columns without common superscripts are different at (p<0.05: a = soluble fraction, b = insoluble but potentially degradable fraction, c = degradation rate constant of the b fraction, PD= Potential degradability, ED= Effective degradability (at 0.02) and RUP=Rumen undegradable protein*