Nutritional Value and *In sacco* Rumen Degradability of Pod and Leaf Meals from Raintree (*Samanea saman*) in Comparison with a Commercial Dairy Feed

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The objective of this study was to evaluate nutritive values and *in sacco* rumen degradability of pod and leaf meals, derived from raintree (*Samanea saman*), in comparison with a commercial dairy feed for decision making of smallholder dairy farmers for efficient management of local feed resources. Treatments were: raintree pod meal (RPM), raintree leaf meal (RLM), and commercial dairy feed (CDF). The experiment was assigned in a completely randomized design. The results indicated that RPM, RLM, and CDF had the same amount of crude protein (CP) content (*P* = .17), whereas RLM was the highest in neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents while CDF was the lowest in NDF and ADF (*P* = .001). Dry matter disappearances at various incubated times were the highest for RPM, followed by CDF, and RLM, respectively (*P* = .001).

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Keywords: Raintree; pods; leaves; dairy feed.

1. INTRODUCTION

Dairy cattle are typically raised underfeeding regimes intended to maximize their productive performance with low feed costs. Forage trees and shrubs are alternative locally feed sources as energy and protein sources for the subsistence of smallholder dairy production in the tropics due to their availability during drought periods while other grasses or legumes are in shortage. Raintree (Samanea saman), a native plant that originated in South America through Central America, is widely cultivated and naturalized as a multi-purpose tree throughout the tropics [1]. Raintree has been considered an alternative feed resource for ruminants for a long time, especially its locally available leaves year-round and pods available in dry periods [2,3]. Several studies have been conducted intensively to determine various nutritional aspects of the raintree pod or leaf in terms of nutritive value, degradability, and animal performance of ruminant animals [2,4,5]. However, there is limited data on in sacco degradability among raintree pod and leaf compared to commercial dairy feeds used in smallholder dairy farms. Therefore, the objective of the study was to determine the nutritive value and in sacco degradability of raintree pods, raintree leaves, and a commercial dairy feed to obtain more data for decision making of smallholder dairy farmers to efficiently manage local feed resources, especially in the drought period to enhance dairy production.

2. MATERIALS AND METHODS

2.1 Diets and Animals

There were three dietary treatments, including raintree pod meal (RPM), raintree leaf meal (RLM), and commercial dairy feed (CDF). The raintree pods and leaf samples were collected at the university dairy farm unit locates at altitude 18°21′1.4N 99°35′49.4E; approximate 268.80 m above sea level, annual temperature 26.94 °C, and averaged rainfall 1,108.64 mm while the commercial dairy feed (CDF) was purchased from a local market. Samples were dried at 60°C for 72 h in a hot air oven, ground through a 1 mm diameter sieve, and stored for further chemical analysis protocols. For the in sacco study, the ruminally fistulated Holstein nonlactating cow was assigned in duplicate with 14-d of resting between periods. It was housed in an individual pen and fed green chopped guinea grass (Panicum maximum TD58) as a basal diet for ad libitum intake with complimentary water and mineral block access.

2.2 Chemical Analysis and Rumen Degradability

Samples were measured for dry matter (DM), crude protein (CP) by the method of AOAC [6], neutral detergent fiber (NDF), and acid detergent fiber (ADF) by the method of Van Soest et al. [7]. For the rumen degradability study, each treatment was weighted approximately 6.0 grams into nylon bags made from dacron cloth with a pore size of 38-μm and prepared in triplicates. All samples were anchored with a 30-cm length of braided fishing lines and placed in the ventral rumen sac of the animal for 0, 4, 8, 16, 24, 48, and 72 h of ruminal incubation. Then, bags were removed from the rumen simultaneously and washed with tap water until the rinsed water was clear. Samples were dried for 72 h at 60°C in a hot air oven; the nylon bags were weighted, and residues were collected. Data for dry matter degradability was calculated according to the equation of Ørskov and McDonald-[8]: P = a + b (1 – e^{–ct}) where P = DM disappearance in the rumen at time t (%), a = the rapidly soluble fraction (%), b = the insoluble but fermentable fraction (%), c = the constant rate of degradation of fraction b (percentage per h), t = time of rumen incubation (h). Potential degradability (PD) = a +...
b. Effective dry matter degradability (ED) = \( a + (bc/(c+k)) \) where \( k \) = the estimated rate of outflow from the rumen at 0.05 fraction/h, and \( a \), \( b \), and \( c \) were the same parameters as described earlier [8].

**2.3 Statistical Analysis**

Data were analyzed for Analysis of Variance (ANOVA) for completely randomized design (CRD), and significance was set at \( P \)-value less than .05. The statistical model was: \( Y_{ij} = \mu + \tau_i + e_{ij} \) where \( Y_{ij} \) = observations under the study criteria, \( \mu \) = overall mean, \( \tau_i \) = effect of having treatment, \( e_{ij} \) = random error. Treatment means were compared by the least significant difference [9,10]. The overall correlations between nutrient contents and values of degradability characteristics were determined [10].

**3. RESULTS AND DISCUSSION**

The nutritive values of RPM, RLM, and CDF are present in Table 1. Dry matter contents of RPM, RLM, and CDF were 75.50, 40.63, and 93.55 %, respectively (\( P = .001 \)). All feed samples did not differ in CP contents, ranged from 17.60 to 19.94 % (\( P = .170 \)). In general, the average CP content of RPM was in agreement with two previous reports [11,12], while the CP content of RLM was comparable to the mean reported values of two studies with the raintree leaves [13,14], but a little lower than that reported by Foiklang et al. [15]. The raintree leaf (RLM) had the highest in neutral detergent fiber (NDF) and acid detergent fiber (ADF) than those the Raintree pod (RPM) (\( P = .001 \)). However, NDF and ADF were found the lowest in the commercial dairy feed (\( P = .001 \)). The fiber contents in terms of NDF and ADF for RLM were higher than those RPM and similar to those obtained by Delgado et al. [3]. The variation of nutrient contents may be affected by several environmental factors such as soil fertility, weather, rainfall.

The mean dry matter disappearance at various times and degradability characteristics across the feeds are presented in Table 2. The overall mean of dry matter disappearance rates ranged from 41.80 to 67.75 % and was the highest with RPM, intermediate with CDF, and the lowest with RLM (\( P = .001 \)). Dry matter disappearance characteristics of feed are combined effects between microbial digestion rates and passage rate of digesta detected by in sacco rumen degradability of the nylon bag system using cloth bags with controlled pore size reflecting the physicochemical attributes of feed samples [16,17]. The lowest rate of dry matter disappearance for RLM reveals its high in fiber contents, both NDF and ADF. In general, high NDF limits animal feed intake, and high ADF reduces digestibility or dry matter disappearance of feed [16]. The mean for the rapidly soluble fraction (a) of dry matter ranged from 32.36 to 50.56 % and was greatest for RPM (50.56 %) but lowest for RLM (32.36 %), and CDF (32.70 %) (\( P = .023 \)). The highest rate of the a fraction for RPM may attribute to its high sugar content and be available for rumen microbial digestion [18]. The mean percentage of the insoluble but fermentable fraction (b) ranged from 19.13 to 53.46 % (\( P = .001 \)). The highest and lowest degradable b fraction was recorded for CDF (53.46 %), and RPM (20.33 %), as well as RLM (19.13 %), respectively (\( P = .001 \)). The lower in degradable b fraction may be due to the nature of structural and functional components of RPM and RLM that are naturally rich in bioactive compounds intended to protect from natural pests and probably reflect the optimized proportions among starch, protein, and fiber contents for efficient microbial digestion in the rumin [3,5,12,19]. The mean values of the constant degradation rate of b (c) or the ruminally undegradable dry matter were similar for all feedstuffs, ranging from 0.03 to 0.16 (\( P = .095 \)). Guadayo et al. [20] reported the c fraction value of raintree leaves, but in buffaloes, at 0.021 %/h. However, Chanjula et al. [21] reported the c fraction value of seven tropical feeds ranged from 0.05 to 0.23 %/h. The mean value of the potential degradability (PD), the amount of feed that can be dissolved and degraded within the rumen with given sufficient time, was also the greatest for CDF (86.20 %), intermediate on RPM (70.93 %), and lowest for RLM (51.53 %) (\( P = .001 \)). As expected, the PD is maximized for CDF feed because it has been undergone through the formulation and mixed processes with various feed ingredients that could promote more outstanding rumen fermentation rather than sole natural feed resources. However, the RPM was slightly 17.71 % lower in PD than that CDF, compared to 40.22 % of RLM. The highest effective dry matter degradability (ED) was recorded for RPM compared with RLM and CDF, assuming outflow rates at 0.05 (fraction/h), respectively (\( P = .001 \)). The higher ED of DM for RPM might be partially explained by its high soluble fraction (50.56 % of DM) and secondary metabolites in the whole fruit [3].
Table 1. Nutrient contents (%DM)

<table>
<thead>
<tr>
<th>Items</th>
<th>RPM</th>
<th>RLM</th>
<th>CDF</th>
<th>SE</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM</td>
<td>75.50&lt;sup&gt;a&lt;/sup&gt;</td>
<td>40.63&lt;sup&gt;b&lt;/sup&gt;</td>
<td>93.55&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.99</td>
<td>0.001</td>
</tr>
<tr>
<td>CP</td>
<td>17.60</td>
<td>19.72</td>
<td>19.74</td>
<td>1.37</td>
<td>0.170</td>
</tr>
<tr>
<td>NDF</td>
<td>37.90&lt;sup&gt;a&lt;/sup&gt;</td>
<td>50.52&lt;sup&gt;b&lt;/sup&gt;</td>
<td>28.26&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.88</td>
<td>0.001</td>
</tr>
<tr>
<td>ADF</td>
<td>30.10&lt;sup&gt;a&lt;/sup&gt;</td>
<td>34.30&lt;sup&gt;b&lt;/sup&gt;</td>
<td>20.48&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.42</td>
<td>0.001</td>
</tr>
</tbody>
</table>

RPM = pod meal from *S. saman*, RLM = leaf meal from *S. saman*, CDF = commercial dairy feed; <sup>ab</sup>Superscripted means within a row that do not the same highly significantly differ. (P<0.01)

Table 2. Dry matter disappearance at various times, and degradability parameters

<table>
<thead>
<tr>
<th>Items</th>
<th>RPM</th>
<th>RLM</th>
<th>CDF</th>
<th>SE</th>
<th>P-value</th>
</tr>
</thead>
</table>
| Dry matter disappearance (%)<br>`Incubation times (h)`
| 4    | 59.80<sup>a</sup> | 36.11<sup>b</sup> | 37.51<sup>b</sup> | 3.05 | 0.001   |
| 8    | 67.21<sup>a</sup> | 37.24<sup>b</sup> | 48.80<sup>c</sup> | 1.33 | 0.001   |
| 16   | 67.67<sup>a</sup> | 41.29<sup>b</sup> | 47.32<sup>c</sup> | 2.15 | 0.001   |
| 24   | 67.80<sup>a</sup> | 44.81<sup>b</sup> | 57.87<sup>c</sup> | 1.98 | 0.001   |
| 48   | 70.52<sup>a</sup> | 50.00<sup>b</sup> | 76.41<sup>a</sup> | 3.68 | 0.001   |
| 72   | 71.88<sup>a</sup> | 49.80<sup>b</sup> | 74.19<sup>c</sup> | 1.08 | 0.001   |
| Overall | 67.75<sup>a</sup> | 41.80<sup>b</sup> | 52.86<sup>c</sup> | 1.20 | 0.001   |

Degradability parameters<br>a = the rapidly soluble fraction, b = the insoluble but fermentable fraction, c = the constant rate of degradation of b (percentage per h), PD = potential degradability: a + b, ED = effective dry matter degradability at 0.05 fraction/h; <sup>ab</sup>Superscripted means within a row that do highly significantly differ (P<0.01)

Table 3. Correlation coefficient (r) of nutrients and degradability parameters

<table>
<thead>
<tr>
<th>Items</th>
<th>DM</th>
<th>CP</th>
<th>NDF</th>
<th>ADF</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>-0.913&lt;sup&gt;**&lt;/sup&gt;</td>
<td>-0.378</td>
<td>-0.856&lt;sup&gt;**&lt;/sup&gt;</td>
<td>0.267</td>
</tr>
<tr>
<td>b</td>
<td>0.598</td>
<td>0.155</td>
<td>-0.469</td>
<td>-0.940&lt;sup&gt;**&lt;/sup&gt;</td>
</tr>
<tr>
<td>c</td>
<td>-0.617</td>
<td>-0.691&lt;sup&gt;*&lt;/sup&gt;</td>
<td>0.721&lt;sup&gt;*&lt;/sup&gt;</td>
<td>0.124</td>
</tr>
<tr>
<td>PD</td>
<td>0.048</td>
<td>-0.083</td>
<td>0.057</td>
<td>-0.875&lt;sup&gt;**&lt;/sup&gt;</td>
</tr>
<tr>
<td>ED</td>
<td>-0.800&lt;sup&gt;**&lt;/sup&gt;</td>
<td>-0.618</td>
<td>0.902&lt;sup&gt;**&lt;/sup&gt;</td>
<td>-0.204</td>
</tr>
</tbody>
</table>

DM = dry matter, CP = crude protein, NDF = neutral detergent fiber, ADF = acid detergent fiber, a = the rapidly soluble fraction, b = the insoluble but fermentable fraction, c = the constant rate of degradation of b (percentage per h), PD = potential degradability: a + b, ED = effective dry matter degradability at 0.05 fraction/h; <sup>*</sup>Correlation is significant at 0.05 level (2-tailed). <sup>**</sup>Correlation is significant at 0.01 level (2-tailed).

The estimated values of degradability characteristics were also correlated with some nutrients in feedstuffs (Table 3). The rapidly soluble fractions (a) were strongly negatively correlated with DM and NDF (P = .01), whereas the insoluble but fermentable fraction (b) was strongly negatively correlated with ADF (P = .01). The constant rate of degradation of the insoluble but fermentable fraction (c) was moderately negatively correlated with CP (P = .05) but moderately positively correlated with NDF (P = .05). The potential degradability (PD) was strongly negatively correlated with ADF (P = .01). The effective dry matter degradability (ED) was strong and negatively correlated with dry matter (P = .01) but strongly positively correlated with NDF (P = .01).

4. CONCLUSION

This study indicates that the raintree pod was higher in degradability characteristics than rain tree leaf when compared with that commercial dairy feed. For efficient managing of local feed...
resources, rain tree pods should be the priority to be considered feedstuffs for dairy cattle, especially in the drought period, to enhance dairy production.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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