Original Article

Erythrina Edulis as A Potential Fodder Alternative For Improving Livestock Nutrition by Small Livestock Farmers

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Abstract

Erythrina edulis (E. edulis) is a leguminous plant which can improve the diet of ruminants fed with low-quality forages. **Aim:** To determine the chemical composition, amino acid profile, in situ dry matter (DM), and crude protein (CP), degradability of leaves and the whole sheath of *E. edulis* for use in ruminant feeding. **Materials and Methods:** The leaf samples were collected in January (vegetative stage) and were cut 50–60 cm from the tip of the second youngest branch at the top of each tree. Whereas the whole sheath was collected in June (fructification stage). The samples were then pooled and dried in a forced air oven at 60°C for 48hr. Then they were milled and homogenized through a cyclone mill with a 1 mm mesh for determining chemical composition. For *in situ* rumen incubation, the samples were milled with a 2 mm mesh. **Results:** High CP contents (>20%) and a modest amino acid profile were found in both phenological stages. Nevertheless, the leaves showed greater cell wall content than the whole sheath (P=0.006; 0.030) and greater methane gas production (132.8 vs 132.0±0.01g CH4 animal^{-1} day^{-1}; P=0.012). Whereas, the highest in situ DM and CP degradability was observed in the sheath after 24 h^{-1} (P<0.001). **Conclusion:** The whole sheath seems to be a good option in terms of nutritive values and degradability for inclusion as supplementation in ruminant feeding by small livestock farmers.

Keywords: Amino acid; Degradability; *Erythrina edulis*; Forage grass

Introduction

Livestock will continue to play an important role in future food security strategies for much of the global population. [1] Forage grasses generally enhance nutritive value for livestock if they contain a greater proportion of readily fermentable components, such as sugars, organic acids, proteins, and a lower proportion of fiber.[2] In the grassland-based livestock systems, the most important limitans are crude protein (CP) and energy values.[3,4] Although the total cost of meat or milk production decreases when the proportion of grass in the annual diet of the cows increases, nevertheless the management of nutrient supply is directly related to the proportion of the requirements that are met by herbal intake and subsequent ruminal digestion.[3] At the same time, climate change is a significant threat to the humans and livestock agriculture has been a prominent source of greenhouse gases.[2] Most of the livestock systems are interested in using plants as fodder sources as they provide greater nutritive value without causing environmental degradation.[5] Consequently, new feeds and feeding systems offer the potential for ruminant production to improve nutrient use, thereby reducing associated greenhouse gas emissions. *In situ* method to estimate ruminal degradability rate of dry matter (DM) and CP, has therefore become one of the most common and widely used methods to evaluate the nutritional value of ruminant feed. *Erythrina edulis* (*E. edulis*) is a leguminous plant

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widely used in diet of humans (mainly seeds) and animals (forage), as well as in the recovery of soil nitrogen content.[6] However, data on chemical composition, degradability kinetics, and amino acid profile are limited. Therefore, the present study aimed to assess the nutritional potential of *Erythrina edulis* as a forage alternative for improving diet in ruminant feeding by small livestock farmers.

Materials and Methods

Ethical approval

All degradation trials were previously approved and performed in National Institute for Agricultural Research (INIAP), Pichincha, Ecuador (Reference # 2016- 2018).

Samples collection

The samples of *E. edulis* were randomly collected from 80 different trees in the Pichincha Province (2200 meters above sea level) located in the northern Highland region of Ecuador. This Province has an average temperature of 22.9°C, a mean rainfall of 1200 mm/year, and 78% relative humidity. In January 2017 (vegetative stage), the leaf samples were collected by cutting them 50–60 cm from the tip of the second youngest branch at the top of each tree. Whereas, the whole sheath was collected in June 2017 (fructification stage). Thereafter, the samples were dried in a forced air oven at 60°C for 48hr. After that, they were milled and homogenized through a cyclone mill (Retsch SM2000, Haan, DE) with a 1mm mesh to determine chemical composition. For *in situ* rumen incubation, the samples were milled with a 2mm mesh.[7]

Chemical analyses

The chemical analyses were carried out in duplicate according to the Association of Official Analytical Chemist.[8] Dry matter (DM) was determined at 103ºC for 24hr and ashes were burnt at 550ºC for 5hr. For the calculation of crude protein from determined nitrogen concentration, a conversion factor of 6.25 was used according to Kjeldahl method AOAC[8]. Amino acid analyses of *E. edulis*, were performed in triplicate by wet chemistry at Evonik-Degussa Laboratory (Hanau, DE) by using a cation exchange high-pressure liquid chromatography (HPLC). For most amino acids, samples were prepared by the acid hydrolysis method, whereas for methionine and cystine, performic acid oxidation with acid hydrolysis-sodium metabisulfite method was used. Crude fiber (CF) was analyzed according to Weende method AOAC[8] in which acid hydrolysis was done with 1.25% H_2SO_4, followed by alkaline hydrolysis with 1.25% NaOH. Nitrogen free extract (NFE) was calculated by difference among organic matter, crude protein and crude fiber. In contrast, the Van Soest determinations i.e., neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL), were sequentially determined on an ash-free basis[9] by adding sodium sulphite and thermostable α-amylase (Ankom Technology, Fairport, NY, USA). Besides, in this study, the methane gas was estimated and expressed as g CH4 animal^{-1} day^{-1} by using NDF contents and assuming that DMI for tropical pasture species is 7.7 kg day^{-1}.[2]

Animals

Two non-lactating Holstein cows (average body weight 650 ± 5.0 kg) fitted with rumen cannulas were used. The cows were housed in individual pens and were fed with a diet of 16 kg *Pennisetum clandestinum* (CP 13.2%; NDF 38%; ADF 26%; CF 25.0%; ash 7% and EE 1.53%). The cows were fed in equal proportion every 12hr to maintain a relatively stable rumen environment. Mineral and vitamin block obtained from (Favetex, ECU) was freely available during the experimental period and comprised 12g Na, 20g Ca, 10g P, 0.10g Mg, 0.29g S, 0.16g Zn, 0.12g Mn, 0.12g Fe, 0.02g I, 0.002g Co, 0.003g Se, 0.16g Zinc, and 0.002g Cu. In addition, clean water was supplied ad libitum at an ambient temperature.

Degradation trials

Nylon bags (10 × 20 cm, 47 µm pore size) were filled with 10 g of DM and ground samples and were closed using glue. Each feed sample was incubated in 6 replicates (3 replicates for each cow). For this, all bags were tied to a 1.45 kg steel chain and inserted into the rumen before feeding at 0830hr. The samples were incubated for 3, 6, 12, 24, 36, 48 and 72hr.[10] After each incubation time, the bags were washed with clean water several times (three washing cycles of 5 min). They were also placed in ice-cold water to halt the activity of bacteria. The 0hr samples were estimated by washing duplicate bags containing feed samples in cold water (without passing through the rumen). After that, the bags were dried in a forced air oven at 60°C for 48hr and cooled in a desiccator before weighing. The incubation time was calculated by assuming that residual time is equal to effective escape of DM and CP from the rumen. For most lactation feeding conditions, the effective degradability (ED) was calculated at a flow rate of 0.06%/hr according to INRA[11].

Statistical analyses

In sacco degradation kinetics was described using the exponential equation of Ørskov *et al.*[12]. The data were analyzed statistically using the GLM procedure of SAS (Institute Inc., Cary, NC, USA). The means were determined using the PDIFF option of SAS, and Tukey's multiple range tests were used to compare the means. Differences were declared to be statistically significant at $P<0.05$, while $P<0.10$ was considered to represent tendencies.

Results and Discussion

Chemical composition of Erythrina edulis

The chemical composition including CH_4 gas production, total AA, essential AA (EAA), nonessential AA (NEAA) of *E. edulis* is shown in Table 1. Leaves of *E. edulis* showed greater DM, ash, CP, CF, NDF, ADF, LAD and hemicellulose contents than those obtained from whole sheath ($P=0.001$ and 0.030). Similar to our results, a study also reported a slight lower CP content in leaves.

[13] Another study observed low CP content both in leaves and sheath.[14] Likewise, a study reported lower CP content in leaves of other *Erythrina* varieties (19%, on average) than edulis (28.74%).[15]

Table 1. Chemical composition, methane gas production, total AA, essential AA (EAA), nonessential AA (NEAA) of Erythrina edulis (% of DM).

Item	*Erythrina edulis*		SEM	*P-value*
Chemical composition, % DM	**Leaf**	**Sheath**		
Dry matter	38.3	10.6	4.7	0.006
Ash	10.5	7.7	0.8	0.001
Organic matter	89.5	92.3	0.7	0.030
Eter extract	1.5	1.1	0.2	0.68
Crude protein	28.7	23.6	1.6	0.012
N-free extract[1]	35.8	53.7	4.5	0.002
Crude fiber	24.9	15.0	2.2	0.030
Neutral detergent fiber	62.4	35.2	6.4	0.021
Acid detergent fiber	51.2	26.0	7.2	0.022
Lignin acid detergent	13.8	7.2	2.2	0.006
Hemicellulose[2]	11.3	9.2	0.5	0.023
CH_4 production CH_4 (g CH_4 animal^{-1} day^{-1})[3]	132.8	132.0	0.01	0.012
AA	87.5	74.9	0.3	0.001
EAA	41.7	36.4	0.2	0.001
NEAA	45.8	38.6	0.5	0.001
EAA				
Thr	3.7	3.6	0.1	0.86
Val	4.8	5.2	0.2	0.020
Ile	3.8	3.8	0.3	0.92
Leu	7.3	6.5	0.4	0.54
Phe	4.5	3.9	0.1	0.020
His	2.9	2.9	0.2	0.99
Lys	6.3	5.1	0.5	0.030
Arg	6.1	4.2	0.2	0.010
Met	2.4	1.2	0.1	0.010
NEAA				
Asp	9.3	9.2	0.2	0.66
Ser	4.2	4.5	0.2	0.52
Glu	15.3	11.5	0.1	0.010
Pro	5.2	4.3	0.3	0.030
Gly	5.4	3.7	0.2	0.010
Ala	5.3	4.0	0.1	0.020
Cys	1.2	1.3	0.2	0.89

Note.
[1]NFE, OM−CP−CF; [2]Hemicellulose calculated as NDF−ADF; [3]Methane gas production was estimated (CH_4=17.0 (± 0.99)×DMI+0.03 (±0.01)×NDF); SEM, standard error of the mean.

Forages with CP content less than 7% in DM have been found to reduce DMI.[16] Therefore, leaves or whole sheath of *E. edulis* should have enough CP content which is above the protein and ammonia requirement of bacteria in the rumen.[17]

Regarding fiber content, a study obtained similar NDF content in leaves (61%)[13] as in this study (62%), however, another study obtained lesser NDF i.e. 50%.[18] On the contrary, other studies[15,19] observed lower NDF content in leaves of other *Erythrina* varieties than *E. edulis*.

As for amino acid contents, the leaves were found to have the highest total AA, EAA and NEAA contents (P<0.001) as compared to the whole sheath. Furthermore, the Met and Lys contents were also found greater in leaves than in sheath (P<0.030). Conversely, a study reported lesser Met (2.7%) and Lys (0.4%) content in leaves.[20] Similarly, in this study, leaves and sheath had greater non-essential amino acid contents than those observed by Intiquilla *et al.*[20].

Ruminal disappearance

Significant differences were found in disappearance levels for DM and CP between leaves and whole sheath (P<0.001; Figure 1). At 24hr incubation time, the leaves had lower DM (47.9 vs 75.4% h^{-1}) and CP (53.1 vs 61.3% h^{-1}) degradation than those obtained for whole sheath. Whereas, over 78 to 86% h^{-1} of DM and CP in the sheath were degraded in the rumen after 72hr of incubation (Figure 1). Greater NDF, ADF and LAD contents in the leaves could possibly explain the lowest disappearance levels. Despite that, no correlation was found between fiber contents and DM or CP degradability (P=0.95). A study reported lower DM degradability in leaves of *E. edulis* (40 vs. 53% h^{-1})[18] while another study observed a slightly higher DM degradability (63.17% h^{-1})[13] as compared to that found in present study. No data was found with whole sheath in this regard, so results of current study can be considered as referential.

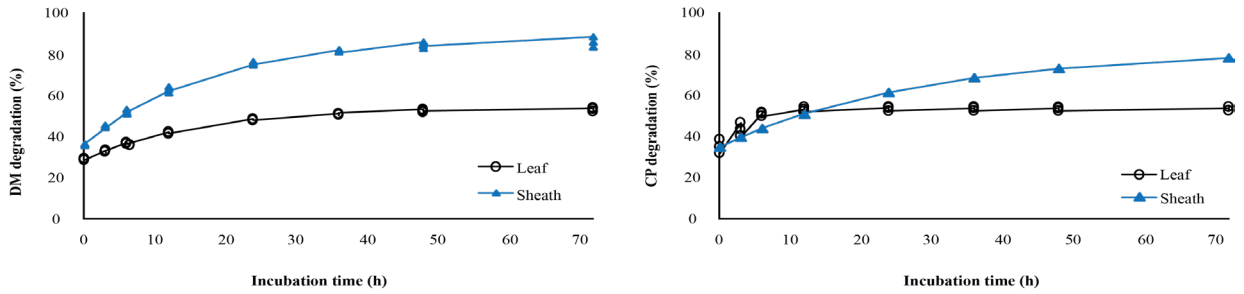

Figure 1. In sacco DM and CP degradability (%) over 72hr of incubation of *Erythrina edulis*.

On the other hand, the rapid (a%) and slow (b%) DM content in the whole sheath was found higher than in leaves (P<0.001). Moreover, ED of DM (60 vs 41% h^{-1}) was found highest in the sheath. The lower "a" and "b" fractions in DM of leaves might be due to its greater fiber content than the whole sheath. In contrast to our results, a study reported slightly greater "a" (41 vs. 29% h^{-1}) and "*b*" (50 vs. 25% h^{-1}) fraction in leaves of *E. edulis*[18].a Some studies also reported higher degradation parameters for "α", "b" and ED in other *Erythrina varieties* such as *indica, subumbrans, variegata and bergeron* than in *E. edulis*[15,21] a.

The "a" fraction in CP was found similar between leaves and whole sheath (35% h^{-1}, on average; P=0.79) in present study, however, the "b" fraction was found significantly higher in the whole sheath than in leaves (50 vs. 18% h^{-1}; P<0.001). Despite that, no differences in ED were observed between both phenological stages of *E. edulis* (52% h_{16}; on average; P=0.82). Based on the results of this study, the chemical composition, degradation parameters and amino acid profile observed in the *E. edulis* were found superior than other multipurpose fodder trees and shrubs such as *L. leucocephala, G. sepium, T. tetraptera, L. diversifolia, and L. sericeus* as reported by other studies.[22,23]

Conclusions

This study shows that *E. edulis* has high forage quality in terms of CP (20 to 28% in DM) and amino acid profile. Hence, it can be considered as an interesting forage source for ruminant feeding in livestock system of small livestock farmers. Furthermore, the study also found greater *in sacco* DM and CP degradability in whole sheath than that in leaves. However, further studies are required determine their suitable levels to include in ruminant feeding.

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Conflicts of Interest

The authors declare no conflict of interest

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