

Nutritional Assessment of Mulberry (*Morus nigra*) and Inga (*Inga Spp*) for Use in Ruminant Feeding

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Received: June 26, 2020; Published: July 09, 2020

Abstract

With the goal of nutritionally assess through trials of *in vitro* digestibility (Tilley and Terry) in Mulberry (*Morus nigra*) and Inga (*Inga spp*) plants for a possible use in feeding ruminants, the present research work was carried out at the National University of Asunción, in the Department of Animal Nutrition and Feeding of the School of Veterinary Sciences, San Lorenzo, Paraguay. In order to do so, samples of different parts of Mulberry (*Morus nigra*) e Inga (*Inga spp*) from the University Campus site. Samples taken were processed by five treatments, T1: Mulberry leaves; T2: Inga leaves; T3: Mulberry branches and leaves; T4: Inga branches and leaves; T5: Inga fruits. Each one of the treatments were dried in forced air drying kiln at 65°C, ground and later subject to analysis in order to determine their chemical composition (AOAC, 2000) and the *in vitro* digestibility coefficients of the Dry Matter (IVDMD) and Organic Matter (IVOMD) as per Tilley and Terry (1963). IVDMD values were higher for T3 (84.72%) followed by T1 (60.63%); T5 (48.6%); T2 (39.33%) and lastly T4 (17.77%); even though the difference was not statistically significant between T5 and T2 and T1. The same tendency was observed for IVOMD values, although in this case there were significant differences for all treatments (T3: 84.98%; T1: 69.77%; T5: 53.4%; T2: 29.92% and T4: 21.93%).

Keywords: Feeding Alternatives; In Vitro Digestibility; *Morus nigra*; *Inga spp*

Introduction

Animal feeding represent 60 - 70% of production cost in any cattle raising establishment [1].

That is why it is necessary to include alternatives to animal feeding that permits to lower costs and maintain production. Concentrated costs increase according to supply and demand of raw matters which is why the use of native and available plants could be a valid option to introduce in animal feeding.

Utilization of shrubs and trees as fodder has received considerable attention, noting the following advantages: availability in farms; accessibility; gives variety to the diet; laxative influence in the digestive tract; reduces feeding costs, and it is a source of nitrogen, energy, minerals and vitamins [2].

For small and medium producers, a potential strategy for increasing availability and quality of ruminant feeding could be by means of using shrubs and trees as fodder [3].

One of these alternatives could be mulberry (*Morus nigra*) and inga (*Inga spp*). The mulberry is a tree or bush of multiple use that is traditionally used as food for the silk worm, but it can also be used as fodder for cattle, be it bovine, goats and monogastric (pigs, fowl, rabbits). Its fruit is consumed by humans and it also has medicinal uses [4].

Mulberry leaves have an excellent nutritional value due to their high level of protein (20 - 24%) and digestibility (75 - 85%) which made them comparable to commercial concentrate values for milk cows. Bromatologic composition variations are product of the age of the material, leaves position in the branches, and level of fertilization [5].

(*Inga spp.*) is a leguminous plant used to cover and improve soils, protect water courses and provide shade to cattle in extensive production systems, besides being used sporadically and empirically as animal feed due to its availability in times of crisis.

Digestibility of a feed can be defined as the quantity of feed that the animal ingests and does not eliminate with feces which is why it is supposed to be absorbed [6]. Knowledge of feed digestibility is basic in order to establish its nutritional value, and, therefore, for formulation of rations for ruminant animals.

Due to scant information on these plants, which are widely used locally, there is need for their nutritional assessment via determination of chemical composition of both, through trials of *in vitro* digestibility.

Materials and Methods

Raw material

For this study, four types of samples or treatments were randomly selected and in quantity of approximately 1 Kg (required by the laboratory for processing): T1 = Mulberry leaves; T2 = Inga leaves; T3 = Mulberry leaves + branches; T4 = Inga leaves and branches; and T6 = Inga fruits.

Chemical composition

The samples were extracted manually until complete 1 kg for each treatment. The bromatological analyzes were carried out in the Bromatology, Nutrition and Animal Feeding laboratory of the FCV-UNA. Samples were dried in a forced air stove at 60°C for 48 hours, then ground and sifted through a sieve of 1 mm diameter.

The analysis of total DM, CP and CF were performed using the method of AOAC [7] and the NDF and ADF were analyzed according to [8] and Gross Energy by total burning of samples in adiabatic calorimetric bomb.

In vitro digestibility

For the *in vitro* digestibility of the dry matter (IVDMD) and Organic Matter (IVOMD), the technique described by Tilley and Terry [9] was applied, a 2-year-old sheep cannulated in rumen was used as ruminal fluid and five repetitions were incubated (n = 5) for each treatment for 48 hours in ruminal fluid (extracted after 12 hours of fasting) with a Buffer medium corresponding to the first phase and a second phase was digestion in HCL-pepsin for 48 hours, the amounts of DM and OM that disappeared after incubations were considered "digested". The digestibility results of MS and MO were statistically processed by calculating average with their standard deviation.

Calculations

Digestibility coefficients were measured by the following equations:

$$\begin{aligned} \text{Digestibility Coefficient of} & & \text{Incubated Dried Matter} - \text{Residual Dried Matter} \\ \text{Dried Matter (\%)} & & \hline & & \text{Incubated Dried Matter} \\ \text{Digestibility Coefficient of} & & \text{Incubated Organic Matter} - \text{Residual Organic Matter} \\ \text{Organic Matter (\%)} & & \hline & & \text{Incubated Organic Matter} \end{aligned}$$

Statistical analysis

The statistic model used was: $Y = \mu + T + \epsilon_i$; following a totally random variance model, with a level of significance $p < 0.05$ comparison of mediums will be done through the Tukey test Where:

- Y: Variable "Digestibility"
- μ : general medium
- T: Treatment (T1; T2; T3; T4; T5)
- ϵ : Error of medium.

Result and Discussion

In table 1, chemical composition of the different treatments are presented (T1: Mulberry leaves; T2: Inga leaves; T3: Mulberry branches and leaves; T4: Inga branches and leaves; T5: Inga fruits), as it is observed for each treatment, low humidity is present, average raw protein content is 17.13% for Mulberry treatments (T1 and T3) and 15.56% for Inga different treatments; concerning cellular wall components, these show NDF average values of 29.4% for Mulberry treatments and 74.4% on average for Inga different treatments, for ADF the average is 17.91% and 48.01% for different treatments of Mulberry and Inga respectively. Raw energy was similar for Mulberry and Inga treatments among themselves.

Chemical Composition ¹	Mulberry leaves T1	Inga leaves T2	Mulberry branches + leaves T3	Inga branches + leaves T4	Inga fruits T5
DM 105°C	90,05	91,01	95,05	90,86	88,93
TDM	32,42	36,4	20,66	35,33	69,87
OM	77,19	93,77	94,93	93,92	95,6
CP	15,16	16,61	19,09	12,99	15,56
CF	13,08	38,74	13,05	43,71	24,56
ADF	17,1	50,98	18,72	57,01	36,04
EE	6,5	3,03	4,29	2,11	1,05
NDF	28,11	67,68	30,69	74,62	80,91
Ash	25,33	6,85	5,33	6,69	4,95
Gross Energy (Kcal/Kg)	3405	4316	3418	4248	3432

Table 1: Chemical composition of Mulberry and Inga different parts.

¹DM: Dry matter 105°C, TDM: Total Dry matter; OM: Organic matter;

CP: Crude Protein; CF: Crude Fiber; FAD: Fiber Detergent Acid; FND: Detergent Neutral Fiber.

According to [10] mentions that raw protein content in mulberry leaves varies between 15 - 28% depending on the variety, age of leaves and growing conditions and in general they can be similar to the majority of leguminous foliage. These values match the findings in this research work, for T1 as well as for T3. Also [11] in five mulberry varieties studied found average values of CP 26.05%.

Along the same line [5] mentions that the mulberry foliage is characterized by high digestibility and an excellent level of protein (from 20 to 24%) and the variations in its bromatologic composition are product of the age of the material, position of leaves on the branch and level of fertilization.

Khyade [12] in reference to other authors, presented protein values in several Mulberry varieties. CP values go from 15 - 22% for leaves; 8 to 27.3% and leaves and young stalks and values of 4.7 to 11.9% only in young stalks, which also matches the values found in this work.

About Inga, its CP content shows us that it is a good protein concentration feed; Quinteros [13] in branches and leaves observed less values to those found in this work (11%).

Even though there is less amount of information in the case of Inga, these values, although lesser, are similar to those gotten by other authors in widely used species for animal feeding of the genders *Leucaena*, *Sesbania*, *Calliandra*, *Gliricidia*, *Albizia*, etc. [14,15], evaluated in different conditions.

Bressani [16] in different fractions of Inga fruits (Paterna variety) obtained average values of 17.29% and 12.8% in variety *I. vera*, such differences could have been due to the varieties researched. The same author mentions CP values of 16.69 - 23.39% in leaves of different species of Inga, matching the value of 16.61% obtained in this work.

About fibers in Mulberry [10] mentions that the fiber fractions in mulberry are low compared to other foliage. About these, [17] reported ADF contents of 20.8 - 36.9% for leaves and bark respectively, higher values to those found in this work.

In the case of Inga branches with leaves, in CF it was observed a similarity to 11%, which is the value found by [13].

Shayo [17] mentions that a surprising characteristic of Mulberry is its high mineral content and mentions Calcium content as 1.8 - 2.4% and Phosphorus as 0.14 - 0.24%, being these similar to the ones found in this work.

Gonzalez., *et al.* [11] obtained Calcium values as 0.14 - 0.20% and Phosphorus as 0.15 - 0.26% in five varieties of Mulberry, being these values less than those found in this work in the case of Ca (1.12 - 2.76%), and higher in the case of Phosphorus (0.18 - 0.37%).

Espinoza., *et al.* [18] found Potassium values between 1.90 - 2.87% in leaves and between 1.3 - 1.53% in Mulberry tender stalks; the ones obtained in this work are within the above mentioned range for leaves and slightly higher for stalks and leaves (2.48% for leaves and 2.77% in branches and leaves). In relation to Magnesium, values obtained in this work were 0.41% for leaves and 0.28% for branches and leaves; this same author [18] mentions Magnesium content of 0.47 - 0.64% in leaves and between 0.26 - 0.35% in tender stalks.

About Inga [16] found Calcium values between 0.10 - 1.15%; Phosphorus 0.12 - 0.34% and Magnesium 0.19 - 0.29% in leaves of three species of Inga and Muñoz (2012) [19] in foliar tissue of *Inga edulis* obtained Calcium values of 1.68%, Phosphorus 0.14% and Magnesium 0.22%.

IDDD values are higher for T3 (84,72%) followed by T1 (60,63%); T5 (48,6%); T2 (39,33%) and lastly T4 (17,77%); even though the difference was not statistically significant ($p < 0.05$) between T2 and T5 and T5 and T1. The same tendency was observed for IVOMD values, in this case there were significant differences for all treatments (T3: 84,98%; T1: 69,77%; T5:53,4%; T2: 29,92% y T4: 21,93%), these findings were consistent with the chemical composition of each treatment, for example, ADF percentage for each treatment (as can be seen in table 2) is inversely proportional to the digestibility coefficients as presented on table 3.

Content %	Mulberry leaves	Inga leaves	Mulberry branches and leaves	Inga branches and leaves	Inga Fruits
Ca	2,76	0,97	1,12	1,03	1,03
P	0,18	0,15	0,37	0,18	0,18
Mg	0,41	0,17	0,28	0,16	0,16
K	2,48	0,6	2,77	0,57	0,57
Na	0,01	0,01	0,01	0,01	0,01
Fe (ppm)	189,84	106,73	369,98	97,08	97,08
Zn (ppm)	33,75	13,5	42,6	13,91	13,91
Cu (ppm)	6,09	10,54	10,43	11,98	13,11

Table 2: Mineral composition in different parts of Mulberry and Inga.

Treatments	IVDMD	SE	IVOMD	SE
T1 (Mulberry leaves)	60,63 ^c	2.94	69,77 ^d	1.14
T2 (Inga leaves)	39,33 ^b	2.94	29,92 ^b	1.14
T3 (Mulberry branches and leaves)	84,72 ^d	2.94	84,98 ^e	1.14
T4(Inga branches and leaves)	17,77 ^a	2.94	21,93 ^a	1.14
T5 (Inga Fruits)	48,6 ^{bc}	2.94	53,4 ^c	1.14

Table 3: IVDMD and IVOMD of different treatments of Mulberry (*Morus nigra*) and Inga (*Inga spp*). Means within row not sharing any alphabets are significant ($\alpha = 0.05$).

Gonzalez., *et al.* [11] with respect to mulberry, mentions that the nutritional quality of this fodder species was in evidence through the high index of degradability, 87.75% up to 72 hours of incubation.

Benavides [5] mentions that the mulberry foliage has an excellent nutritional value due to its high levels of protein (from 20 to 24%) and digestibility (from 75 to 85%).

Schenk 1974 cited by Rodríguez., *et al.* [20] mentions digestibility coefficients *in vitro* of 80.2% in mulberry leaves and Omar., *et al.* [21] reported IVOMD of 89 and 85% for mulberry leaves and stalks respectively, being these values superior to those found in this work, which may be due to differences in variety or age of the plant.

Conclusion

There exist statistical differences among different treatments, being the one with higher digestibility T3 (84.72%) followed by T1 (60.63%); T5 (48.6%); T2 (39.33%) and lastly T4 (17.77%). About DIVMO, the same tendency is observed, being the values 84.98% for T3; 69.77% for T1; 53.4% T5; 29.92% T2 and 21.93% for T4.

These results are what was expected according to the chemical composition of each treatment, which suggest a good potential for being used in ruminant feeding; mainly the Mulberry, leaves as well as branches, and leaves and fruits of the Inga. It is suggested to carry out

animal consumption trials and productive responses, taking into account the great availability and important production of these species at the local level.

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Volume 5 Issue 8 July 2020

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