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Ameliorating the Effects of High-Tannin Jackfruit (Artocarpus Heterophyllus Lam.) Forage by Urea-Treatment and Ensiling on Crude Protein Utilization in Native Goats (Capra hircus Linn.)

Hershey P. Mondejar, and Lolito C. Bestil

***Abstract*—**A digestibility trial was conducted to determine the effects of ameliorating high -tannin Jackfruit forage (*Artocarpus heterophyllus* Lam..) by urea treatment and ensiling on the intake and digestibility of dry matter, crude protein , and organic matter in goats, and to determine the sensory attributes of chevon. Nine (9) Philippine native goats were randomly assigned to the following three treatment diets :T_0 fed fresh: T_1-urea–treated, and T_2- ensiled *Artocarpus heterophyllus* Lam. leaves. The experiment was laid out in a completely randomized design (CRD).

Urea treatment (T1) and ensiling (T2) significantly increased the organic matter intake, crude protein, organic matter and dry matter digestibility but did not significantly affect the DM and crude protein intake of the forage.

***Keywords*—** High- tannin forage, urea treatment, ensiling, crude protein utilization.

I. Introduction

Ruminant animals raised in arid, semi-arid and mountainous regions in various parts of the world rely heavily on shrub and legume tree species as the main diet component. The major constraint to the use of these species as livestock feed is the presence of toxic and anti-nutritional constituents. These constituents have different adverse effects on animal performance including loss of appetite and reduction in dry matter intake and protein digestibility (Ben Salem, *et al.*, Undated). Tannins are the most widely occurring anti-nutritional factor found in plants, and these compounds are present in numerous tree and shrub foliages (Makkar and Becker, 1996).

Tannins limit voluntary intake of nutrients through astringency, inhibits enzyme action, and reduce forage digestibility (Onwuka, 1986 as cited by Mtenga, Undated). Tannins form complexes primarily with proteins, with carbohydrates, amino acids and several minerals, thereby reducing intake, digestion and animal growth (Makkar, 2006).

Hershey P. Mondejar is with Cebu Technological University,Barili,Cebu.

Lolito C. Bestil is with Visayas State University, Baybay City,Leyte, Philippines.

However, the formation of complexes of tannins with nutrients, especially proteins, also has positive effects on feed utilization such that condensed tannins protect proteins from rumen degradation, thus, increasing the availability of amino acids for direct absorption in the intestine (Reed, 1986).

High tannin levels in the shrubs and legumes should be reduced to prevent the negative effects of tannin in those plants when fed to the animals. Various methods have been attempted to de-activate tannins in a wide range of browse species (Makkar, 2000). A number of physical, chemical, biological and miscellaneous approaches have been developed to inactivate or remove tannins and enhance the feeding value of tannin-rich forages in order to improve their nutritive value. The methods are based on the knowledge that tannins are water-soluble polymers which form complexes, essentially with proteins and these complexes are broken under conditions of high acidity at pH 3.5 or high alkalinity at pH 7.5 (Mueller-Harvey, 2006). Urea is the preferred alkali for treatment due to its availability, low cost, and ease of handling (Kiangi and Kategile ,1981 and Sahnoune *et al.*, 1991). On the other hand, silages prepared from tanniniferous plants tend to have reduced soluble nitrogen content, which improves their feeding value (Albrecht and Muck, 1991; Rioux *et al.*, 1995).

There is a need for more *in vivo* experimental and pilot-scale studies for complete validation of these methods. The aim of future studies would be to explore the potential of these approaches for a wide range of tanniniferous fodder like *Artocarpus heterophyllus* Lam. and then to develop simple and economically viable detannification technologies for use by farmers. These technologies will help in the value addition and utilization of various tanniferous feeds, and agro-industrial byproducts and solve the problem of shortage of conventional feeds in developing countries.

Another effect of tannins is on providing a desirable pastoral flavour in the meat of ruminant animals. Undesirable pastoral flavor in meat which occurs when animals graze pasture or forages low in tannin content can have a negative impact on the consumer acceptance of sheep meat and the feeding of condensed tannin- containing forages holds the great potential to improve pastoral flavor (Schreurs *et al.*, 2007).

Thus this study has aimed to assess the effectivity of ensiling and urea treatment of high-tannin jackfruit forage on improving forage utilization and crude protein digestibility in goats.

II. Materials And Methods

A. Preparation of experimental area and test animals

The initial average body weights (BW) of the goats were taken before the experiment started. The goats were confined in open-top metabolism cages (Bestil and Espina, 1992) that allow measurement of intake and separation of feces from the urine for digestibility measurements. The animals were dewormed with Albendazole (oral preparation) before the experiment started.

B. Treatment of the forage

The experiment utilized Jackfuit leaves (*Artocarpus heterophyllus* Lam.) which is high in tannin content as supplement to an all-cogon (*Imperata cylindrica*) basal diet. For urea treatment of high tannin forages, the forage was immersed in urea solution made of 40 grams urea dissolved in 1 liter of water per kilogram of forage and incubated for 24 hours (Wanapat *et al*., 1982) and drained before feeding to the experimental animals (Figure 8). Such urea concentration, however is commonly used for treating fibrous feedstuffs to break the lignin-cellulose bonding (Bestil, 2008). Incidentally, such concentration of 4 % of the feed material also fell into the range of 2-8% used by Makkar and Becker (1996), Russel and Lolley (1989) and Vitti et *al*., (2005) in their experiments.

Jackfruit leaves silage was prepared by chopping the fresh leaves at 2-4 inches long, packed adequately, then stored in plastic drums and sealed properly to minimize, if not eliminate oxygen and to allow anaerobic fermentation for three weeks. Prior to feeding, the ensiled Jackfruit with the cogon (*Imperata cylindrica*) component fodder was mixed to obtain a homogenous distribution of high-tannin containing forage.

The feed was offered in individual troughs at 3% of the BW, DM basis; 1 % BW came from Jackfuit fodder and 2 % BW came from cogon grass. The animals were weighed before the conduct of the experiment for the determination of its initial weight as basis for determining daily feed allowance and on the last day of the experiment for the calculation of weight changes.

C. Dietary treatments and experimental design

The dietary treatments tested were as follows:

T_0 - control, all-cogon basal diet (ad *libitum*) plus fresh *Artocarpus heterophyllus* Lam. leaves (1% BW, DM basis)

T_1- all-cogon basal diet (ad *libitum*) plus urea-treated *Artocarpus heterophyllus* Lam. leaves (1% BW, DM basis)

T_2- all-cogon basal diet (*ad libitum*), plus ensiled *Artocarpus heterophyllus* Lam. leaves (1% BW, DM basis)

The experiment utilized nine (9) male goats aging 12-14 months of age and of the same breed (Philippine native), distributed to the different treatments in a completely randomized design (CRD).

D. Feeding the experimental animals

The cogon (*Imperata cylindrica*) fresh forage were chopped at 2-4 inches long before feeding and was offered at *ad libitum* twice in a day (8:00 a.m. and 4:00 p.m). The supplement (treated *Artocarpus heterophyllus* Lam. was given at 1% BW, DM basis, twice a day (8:00 a.m. and 4:00 p.m) by mixing it with the basal all-cogon diet.

Drinking water was made available at all times.

E. Digestibility trial

The *in vivo* digestibility trial was conducted according to the procedures of (Bestil, 2008), The Adjustment period started from day 1 to day 10 where there was easurement of the initial weight of experimental animals; determination of *ad libitum* intake of the basal diet by providing 20-30 percent allowance based on previous day's intake. The daily feed intake was carefully recorded during this period. The collection period followed wherein the voluntary feed intake was measured, and samples of feed offered and refused were collected. Fecal outputs were weighed and representative samples were collected for dry matter and crude protein analysis.

Feed and fecal samples were analyzed for its dry matter (DM), crude protein (CP), and organic matter (OM) contents according to the methods of AOAC (1990) at the Department of Agriculture, Regional Feed Analysis Laboratory in Cebu City. The tannin content of the forages tested was analysed at Lipa Quality Control Center (LQCC) in Lipa City, Batangas.

F. Data Gathered

1. Dry Matter Intake (DMI)

$$\text{DMI,kg} = (\text{Feed given} \times \%\,\text{DM of given}) - (\text{Feed refused} \times \%\,\text{DM of refused})$$

2. Dry Matter Digestibility (DMD, %)

$$\text{DMD} = \frac{\text{DM Intake} - \text{DM excreted}}{\text{DM Intake}} \text{ x } 100$$

Where: DM excreted= Fecal Output, kg x % DM of feces

3. Crude Protein Intake= Voluntary Feed Intake x % CP, DM basis, of feed

4. Crude Protein Digestibility (CPD)

$$\text{CPD} = \frac{\text{CP Intake} - \text{CP excreted}}{\text{CP Intake}} \text{ x } 100$$

Where: CP excreted= Fecal output, kg x % CP of feces (DM basis)

5. Organic Matter (OM) Intake

$$OMI,\text{kg} = (Feed\ given \times \%\ OM\ of\ given) - (Feed\ refused \times \%\ OM\ of\ refused)$$

6. Organic Matter Digestibility (OMD)

$$OMD,\% = \frac{OM\ Intake - OM\ Excreted}{OM\ Intake} \text{ x } 100$$

Where: OM excreted= Fecal Output, kg x % of feces, DM basis.

G. Analysis of Data

The data on intake and digestibility were subjected to one – way Analysis of Variance (ANOVA) for a Completely Randomized Design (CRD) and comparison of treatment means was done using Honestly Significant Difference (HSD) Test using the Statistical Package for the Social Sciences (SPSS) version 17.

III. Results And Discussion

A. Tannin Content

Table 5 shows the tannin content (%) of the six forage samples tested. It can be seen from the table that ipil-ipil has the highest, followed by madre de cacao, and pasture peanut then Jackfruit leaves. However, only Jackfruit (*Artocarpus heterophyllus* Lam.) was abundant in the site when the experiment was conducted so it was decided to use jackfruit leaves instead of any of the top three (3) legume forages.

Table I

Tannin Content Of The Different Forages Tested

Forage Sample	Common Names	Tannin Content (%)
Gliricidia sepium Jacq.(Jacq.)	Madre de cacao	0.97
Artocarpus heterophyllus Lam.	Jackfruit	0.81
Arachis pintoi Krapov.	Pasture peanut	0.96
Leucaena leucocephala Lam.	Ipil-ipil	1.14
Centrosema pubescens Benth.	Centro	0.47

B. Dry Matter Intake and Digestibility

Table 6 and Figure 12 showed that dry matter intake basal (*Imperata cylindrica*, grass forage) and the total diet in absolute amount as percent of body weight and percent dry matter intakes were not significantly different among the treatment groups, although higher values were obtained from T_1 and T_2 groups than that of the control (T_0). On dry matter digestibility, differences were highly significant in the urea-treated (T_1) and ensiled (T_2) significantly higher than the fresh form (T_0). The higher DM intake of urea-treated (T_1) and of ensiled Jackfruit leaves (T_2) showed that these processes of ameliorating high tannin content of the forage do not affect the palatability or acceptability the fresh Jackfruit leaves.

Keir *et al* (1997) and Phengvilaysouk and Kaensombath (2006) as cited by reported that fresh jackfruit leaves can be a valuable feed resource for goats when combined with nitrogen sources, such as urea or non-protein nitrogen (NPN).The seemingly higher intake and significantly higher digestibility of dry matter of urea treated (T_1) as compared to that of the T_0 group (fresh forms) manifested such an added advantage of increasing the nitrogen content of the forage on top of its effects on tannin amelioration.

The high dry mater digestibility in Treatment 2 group, comparable to goat of urea-treated (T_1) reflected an increase in the values of water-extractable DM in the ensiled leaves and the breakdown of protein and other fractions as a result of the fermentation which happens during the ensiling process Bunyeth and Preston(Undated) as cited by Mcdonald *et al.*,(1995).

Table II

Dry matter intake and digestibility of high- tannin Artocarpus heterophyllus Lam. leaves fed to goats in fresh, urea-treated, and ensiled forms

Treatments	Dry Matter Intake (DMI)			DMD
	Basal, g	Total DMI, g	% BW	%
T_0 (Fresh Jackfruit Leaves)	109	214	2.91	46.70^a
T_1(Urea-treated Jackfruit Leaves)	138	276	2.93	55.72^b
T_2 (Ensiled Jackfruit Leaves)	141	288	2.93	52.87^b
p-value	0.299^{ns}	0.239^{ns}	0.278^{ns}	0.000

Means within the same column having different letter superscripts are significantly different ($p<0.05$)

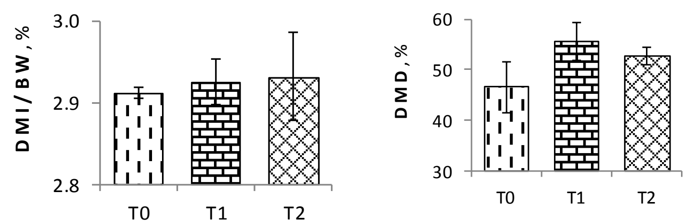

Fig. 1 Dry matter intake and digestibility of high- tannin *Artocarpus heterophyllus* Lam. leaves fed to goats in fresh, urea-treated, and ensiled forms

C. Intake and Digestibility of Other Nutrients

Crude protein intake and digestibility of *Artocarpus heterophyllus* Lam.forage in fresh, urea-treated, and ensiled forms are shown in Table 7 and Figure 13. Results revealed that in terms of crude protein digestibility, T_1 and T_2 group were significantly higher than the T_0 group, but in terms of crude protein intake there were no significant differences among the three treatment groups, although higher values were obtained from T_1 and T_2 groups showing a similar pattern of differences as that of crude protein digestibility. Although differences in CP intake among treatment groups were not significant , The slightly higher values in T_1 and T_2 groups showed that urea treatment and ensiling do not affect the palatability of the forage with an added advantage of increasing the nitrogen content of the diet due to the supply of ammonia from urea (T_1 group) and microbial nitrogen from fermentation bacteria which proliferate during the ensiling process.

In terms of crude protein digestibility, treatment $_0$ (fresh form) has the least value. According to Keir, (1997) fresh Jackfruit leaves are widely used as this feed contain high-tannin which apparently caused low protein digestibility.

On the other hand, Makkar *et al.* (1989) stated that tannins have been established to lower protein digestibility by forming tannin-protein complexes and reduced the digestibility of nitrogen. The use of urea-treatment which resulted to the highest crude protein digestibility in this study is in agreement with the findings of Makkar and Becker (1996), Russel and Lolley (1989) and Vitti et *al*., *(*2005) that destabilization of tannin–protein complexes at various urea levels (2–8 %) has satisfactory results with 72–89 % decrease in tannins .Moreover, increased tannin inactivation observed on urea addition could be because of the higher pH caused by the evolution of ammonia from urea thus increases the crude protein intake digestibility (Bhat *et al*, 2013). Urea as non-protein nitrogen compound, is broken down into ammonia during the normal microbial fermentation process in the rumen, and combine the ammonia with products of carbohydrate metabolism to form amino acids and hence, proteins.

TABLE III
CRUDE PROTEIN AND, ORGANIC MATTER INTAKE AND DIGESTIBILITY OF HIGH-TANNIN ARTOCARPUS HETEROPHYLLUS LAM. LEAVES FED TO GOATS IN FRESH UREA-TREATED AND ENSILED FORMS

Treatments	CP Intake (grams/day)	CP Digestibility (%)	OM Intake (grams/day)	OMD Digestibility (%)
T_0 (Fresh Jackfruit Leaves	23	59.09^a	26.8^a	47.98^a
T_1(Urea-treated Jackfruit Leaves)	36	73.02^b	27.3^b	57.24^b
T_2(Ensiled Jackfruit Leaves	33	70.72^b	27.3^b	53.13^c
p-value	0.0681^{ns}	0.000	0.003	0.0027

Means within the same column having different letter superscripts are significantly different (*p*<0.05)

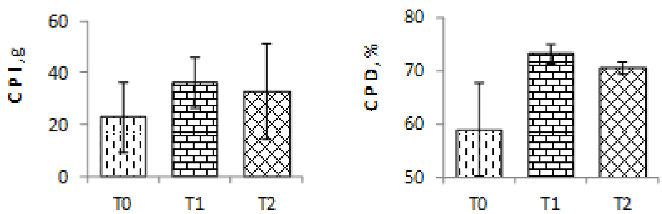

Fig. 3 Crude protein intake and digestibility of high- tannin *Artocarpus heterophyllus* Lam. leaves fed to goats in fresh, urea-treated, and ensiled forms

When forages are ensiled, bacteria ferment the forage, and breaks the forage protein into smaller fractions which are more degradable by rumen bacteria, thus the results of this study is supported by the findings of Bunyeth and Preston(Undated) as cited by Mcdonald *et al.*,(1995) that the increase in the values for water-extractable nitrogen in the ensiled leaves reflects the breakdown of protein and other fractions as a result of the initial fermentation during the ensiling process. Therefore, the fibre in feeds would have been pre-digested thereby enhancing better digestion and release of nutrients as reflected by high crude protein digestibility in T2 groups. (Onwuka, undated).

A similar pattern of differences in organic matter intake and digestibility as that of DM and CP was shown in Table 3, and observed in Figure 7. The organic matter intake showed highly significant differences among treatments with, urea-treated (T_1) and ensiled (T_2) jackfruit leaves is significantly higher than the fresh form (T0) . Organic matterdigestibility showed highly significant differences among the treatments and the pattern of the differences is similar as that of OMI intake with urea-treated (T_1) having the highest, followed by ensiled (T_2) and the fresh form (T_0) was lowest. Again the expected addition of nitrogen sources such as ammonia (NH^{3+}) from urea-treated (T_1) and microbial nitrogen from ensiled (T_2) Jackfruit leaves must have provided the needed ammonia which combined with carbon chain rumen pool to synthesized rumen microbial cells and consequently increase crude protein and organic matter intake and digestibility.

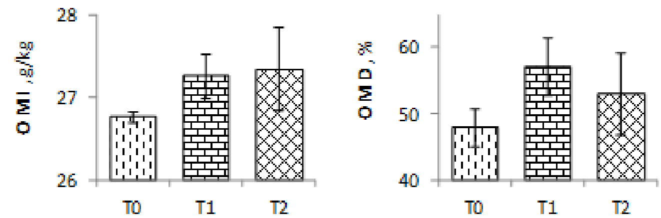

Fig. 4 Organic matter intake and digestibility of high- tannin *Artocarpus heterophyllus* Lam. leaves fed to goats in fresh, urea-treated, and ensiled forms

IV. CONCLUSION

Urea treatment and ensiling of *Artocarpus heterophyllus* Lam. leaves is effective in ameliorating tannin effects by increases in the DMI, CPI, OMI and OMD of goats suggesting that the anti-nutritional effects were ameliorated by both processes making the crude protein available to the animals.

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