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Effect of Processing Tapioca Leaves on Rumen Fermentation

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Abstract: Degradability studies of processed tapioca leaves in the form of hay and silage for both the varieties (White Rose (H226) and Mulluvaadi (MVD-1)) conducted in RUSITEC and compared with unprocessed tapioca leaves. It was found that unprocessed tapioca leaves had high soluble degradable dry matter and high effective degradability than processed (hay and silage) tapioca leaves. The RDN and UDN values were found to vary between unprocessed and processed leaves but the total absorbable nitrogen values were similar between processed and unprocessed for both the varieties. A study was also undertaken to examine the need for supplementation for improvement of microbial production. Supplementation of digestible organic matter to the extent of 10.99 to 12.31% was suggested as a tool to exploit the full potential nutritive value of processed and unprocessed tapioca leaves. Further *in vitro* rumen fermentation studies also revealed Higher pH (7.30), lower propionic acid (8.05 mM L^{-1}) and TVFA (36.90 mM L^{-1}), higher ammonia nitrogen (12.17 mg%) and lower microbial protein synthesis (45.17 mg%) clearly tilt the favour against unprocessed tapioca leaves and suggestive that processing of tapioca leaves (White Rose (H226) and Mulluvaadi (MVD-1)) was desirable over unprocessed tapioca leaves. Hence this study recommends processing of tapioca leaves as hay or silage for year round availability.

Key words: Tapioca leaves, hay, silage, rumen fermentation, RUSITEC

INTRODUCTION

In the tropics and sub tropics, majority of feed resources for ruminant consist of leftovers from the grain harvest, grasses and foliages growing on roadsides or waste land. The grasses are generally with high fibre and low protein contents. This results in poor animal performance, especially in the dry season. However, alternative feed resources and crop residues are locally available and used to increase the livestock production in the tropical and subtropical areas. Dried leaves, baby corn stovers, kapok meal, cotton seed meal, broken rice and leuceana leaves are good example for feeding ruminants during the dry season.

Tapioca (*Manihot esculenta* crantz) also called as cassava is an annual tuber crop grown widely in the tropical regions of Latin America, Africa and Asia. In Asia it is especially grown in India. It is a tuber crop, which is mainly cultivated by small farmers. Roots are the principal product of tapioca, while thippi, starch waste and peal meal are the by-products Dung *et al*. (2005) reported that the yield of tapioca leaves was 10.1 tonnes dry matter/hectare. Tapioca leaves contain an average of 21% crude protein, contributing nearly six tonnes of crude protein per hectare per year (FAO, 1998). Though tapioca leaves are fed to cattle occasionally, an indepth analysis on their nutritive value is lacking.

Earlier work has demonstrated that tapioca leaves could be processed as hay or silage (Murugeswari *et al*., 2006). However their utility as fodder resources in terms of rumen fermentation

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and supplementary strategies required to exploit their nutritional value remains to be investigated. It is in this context, a study was undertaken to evaluate the rumen fermentation characteristics of unprocessed (freshly harvested) and processed (hay and ensiled) tapioca leaves in rumen simulation technique (RUSITEC) as well as supplementary strategies required to exploit their nutritional value.

MATERIALS AND METHODS

Two commonly cultivated varieties namely White Rose (H226) and Mulluvaadi (MVD-1) tapioca leaves chosen for this study Tapioca leaves were collected at six different fields after harvesting the roots of tapioca. The study was conducted at Department of Animal Nutrition, Madras Veterinary College, Chennai, India during summer season.

Processing of Tapioca Leaves

Silage

Tapioca leaves of both the varieties from each area of collection were chopped into pieces of 4-5 cm length and allowed to wilt under shade for three hours. Laboratory silage was prepared in a desiccator by adding 2% molasses and 1% salt to the chopped tapioca leaves which were then tightly packed and compressed to prevent any air space. The lid of the desiccator was sealed airtight with wax and tightly secured with thread. The desiccators were labeled and stored in a dark room. The desiccators were opened after two months and thus ensiled tapioca leaves were used for further studies.

Hay

Tapioca leaves of both the varieties from each area of collection were dried in the shade for two days. Frequent turning was done to facilitate even drying. The tapioca hay thus prepared was then brought to the laboratory and representative samples were ground to pass a 1 mm screen for *in vitro* rumen degradability.

Duplicate samples of each treatment were analysed and average was taken as the final result.

Studies on Degradability and Rumen Characteristics

The *in vitro* dry matter and protein degradability characteristics of unprocessed, hay and silage of tapioca leaves were determined using rumen simulation technique (RUSITEC) described by Czerkawski and Breckenridge (1977).

The rumen liquor for RUSITEC was collected from adult Jersey crossbred cattle maintained on grazing. The liquor was collected from three animals, pooled and this composite sample was strained in 4-layered muslin cloth to represent strained rumen liquor. The solid rumen content was collected using tongs from the same animals and was used as solid inoculum to initiate the fermentation in the reaction vessel. Experimental trial consisted of seven days adaptation period followed by collection period

The test material viz., unprocessed, hay and ensiled tapioca leaves were randomly allotted to one of the six reaction vessels. Freshly harvested tapioca leaves (unprocessed) and ensiled tapioca leaves cut to small pieces were used along with their juice for degradability studies. Five grams of the hay, ground through 1 mm sieve and equivalent weight on fresh matter basis of unprocessed or ensiled sample macerated in a homogeniser were placed in separate nylon bags of 100 μ pore size in different reaction vessels. These were incubated 3, 6, 9, 12, 24, 36, 48 and 72 h in the reaction vessel of RUSITEC. The study was carried out in duplicate as follows in three sequential runs. In order to ensure the culture of bacteria associated with solids in the reaction vessel, 3 bags were simultaneously incubated during the experimental period. Two bags were dedicated for culture maintenance by alternatively placing and rejecting bags after 48 h of incubation. The third bag was incubated to study the rate of degradation at specified time intervals.

At the end of the incubation period, the bags were removed from the reaction vessel, washed twice with 40 mL of artificial saliva. The washed saliva was returned to the reaction vessel. The bags were then washed under running water and then spin-dried. The bags were dried to a constant weight at 70°C in an incubator and weighed. The degraded samples were preserved in airtight plastic bags for further analysis. The effective degradability of dry matter was calculated at the flow rate of 0.05 mL min^{-1}. *In vitro* dry matter and nitrogen degradability studies.

The *in vitro* degradability (%) of samples were calculated using the following formula

$$\textit{In vitro}\ \text{degradability} = \frac{\begin{array}{c}\text{Weight of nylon bag with sample before incubation -}\\ \text{weight of the nylon bag with sample after incubation}\end{array}}{\text{Weight of the sample}} \times 100$$

The results of dry matter degraded at various time intervals were fitted to exponential equation of (McDonald, 1981). The equation is

$$P = a + b\ (1 - e^{-ct})$$

Where,

P = Efficiency degradability

t = Time

$a + b$ = Potential degradability

c = Rate of degradability

a, b and c are constants in exponential equation

The Neway (1992) Software was used to derive effective dry matter degradability.

The nitrogen degradability was analysed in the samples incubated for 3, 6, 9, 12 and 24 h. The residual dry matter in the nylon bag is generally contaminated with significant amount of microbial nitrogen (Nocek *et al.*, 1979). This contaminated nitrogen was estimated by incubation of nitrogen free cellulosic materials in a nylon bag under similar conditions and making appropriate correction prior to calculating effective degradability (Negi *et al.*, 1988). The Rumen Degradable Nitrogen (RDN) was thus calculated based on effective degradability. The Acid detergent fibre nitrogen was estimated by determination of nitrogen in the acid detergent fibre residue.

Neway Software programme was used to calculate the effective nitrogen degradability (Neway, 1992) and RDN (Rumen Degradable Nitrogen), UDN (Undegradable Nitrogen) and DUN (Digestible Undegradable Nitrogen) were calculated as fllows. The RDN was calculated from the effective nitrogen degradability multiplied to total nitrogen and organic matter apparently digested was derived by multiplying organic matter with effective dry matter degradability. The digestible RDN was derived by multiplying RDN with 0.75 followed by 0.85 to account for microbial true protein and its digestibility (Alderman and Cottrill, 1993). The potential microbial nitrogen production was derived by dividing organic matter apparently digested by 33.30. The DUN was obtained by subtracting RDN from total nitrogen and UDN by subtracting ADFN. The total absorbed nitrogen was calculated as sum of digestible RDN as percent of total nitrogen and DUN as per cent of total nitrogen. The difference between RDN and potential microbial nitrogen production reveals the scope for either NPN supplementation or digestible organic matter supplementation to fully exploit the nutritive value of substrate. The scope for digestible organic matter supplementationis worked out by multiplying 33.3 to the difference between RDN and potential microbial nitrogen production (AFRC, 1992).

Rumen Fermentation Pattern Studies

The overflow from the RUSITEC was collected into the effluent flask containing a few drops of mercuric chloride connected by a tube from the reaction vessel. The total volume of effluent was measured at the end of specific incubation time.

Liquid effluent sample from each reaction vessel were taken at end of 24 h incubation and tested for pH, ammonia nitrogen and microbial protein. Microbial protein in the effluents of the RUSITEC was calorimetrically determined as per the method described by Makkar *et al.* (1982). Rumen dilution was followed as per Makkar *et al.* (1982) and protein estimation was done by the method described by Lowry *et al.* (1951).

Total bacterial count was carried out as per the procedure described by Gall *et al*. (1949) using Gram's staining. Protozoal count was done by the method described by Moir (1951).

Statistical Analysis

The data obtained in different parameters were subjected to statistical analysis as per the procedure of Snedecor and Cochran (1967).

RESULTS

Studies on Degradability and Rumen Characteristics

Dry Matter Degradability

Processing of tapioca leaves significantly ($p<0.05$) reduced dry matter degradability in both the varieties from three hours of incubation until 36 h of incubation beyond which there was no difference in dry matter degradability (Table 1). The reduction in dry matter degradability was significantly ($p<0.05$) higher in hay than silage in White Rose (H226) during these hours of incubation. However no such difference was noticed in Mulluvaadi (MVD-1) between hay and silage.

Nitrogen Degradability

As against the results observed in dry matter degradability, the nitrogen degradability was higher in hay compared to unprocessed leaves for both the varieties at 3 h of incubation, but attained similar degradability as incubation hours increased. However, there was difference in the time taken by each variety to reach similarity in nitrogen degradability. While White Rose (H226) required 12 h to reach similarity in nitrogen degradability among unprocessed, hay and silage, Mulluvaadi (MVD-1) required only 6 h.

Degradable Soluble Dry Matter

The degradable soluble dry matter of White Rose (H226) and Mulluvaadi (MVD-1) varieties of tapioca leaves were 52.33 and 53.12%, respectively in unprocessed leaves (Table 2. The results of this study indicates that the degradable soluble dry matter was significantly ($p<0.05$) lower for hay and silage made from both the varieties of tapioca leaves.

Degradable Insoluble Dry Matter

Ensiling and hay making of White Rose (H226) and Mulluvaadi (MVD-1) variety of tapioca leaves led to significant ($p<0.05$) increase in the insoluble but degradable dry matter compared to unprocessed tapioca leaves. This clearly indicates that they have higher potential for degradation of insoluble dry matter compared to unprocessed leaves. It is inferred that the solubility is affected during processing, but the conversion to insoluble fraction remains degradable thus regulating the nutrient delivery in the rumen.

Table 1: Percent dry matter and nitrogen disappearance of tapioca leaves (unprocessed, hay and silage) of White Rose (H226) and Mulluvaadi (MVD-1) at different incubation periods (h)-Mean±SE

Incubation period (h)	White rose (H226)			Mulluvaadi (MVD-1)		
	Unprocessed	Hay	Silage	Unprocessed	Hay	Silage
Dry matter degradability						
3	60.30±7.34^{c}	36.34±7.25^{a}	41.54±8.99^{b}	59.07±7.78^{b}	37.60±7.80^{a}	39.93±8.50^{a}
6	63.12±7.89^{c}	39.04±6.94^{a}	44.56±8.58^{b}	64.58±7.30^{b}	45.87±7.07^{a}	44.61±9.34^{a}
9	69.57±8.68^{c}	44.32±7.12^{a}	50.76±9.42^{b}	68.62±8.64^{b}	53.54±7.26^{a}	52.75±9.67^{a}
12	73.45±8.67^{c}	51.97±8.89^{a}	58.86±9.48^{b}	73.82±8.86^{b}	60.32±7.47^{a}	61.67±9.04^{a}
24	79.67±8.16^{c}	62.87±9.37^{a}	66.61±9.54^{b}	78.04±9.87^{b}	69.36±6.46^{a}	70.05±9.18^{a}
36	80.65±9.01^{b}	76.67±8.89^{a}	75.92±9.67^{a}	81.72±8.37^{b}	74.73±8.07^{a}	76.42±9.78^{a}
48	82.72±9.06	79.45±9.88	80.37±9.39	83.67±8.25	79.82±8.38	81.34±8.56
72	83.81±7.12	84.41±7.32	78.59±6.23	85.56±7.16	82.13±6.07	82.14±8.82
Nitrogen degradability						
3	41.54±6.73^{a}	47.58±6.35^{b}	44.34±6.86^{a}	42.52±6.49^{a}	44.31±6.28^{b}	42.56±7.32^{a}
6	55.63±7.64^{a}	61.72±7.47^{b}	57.53±6.98^{a}	55.54±7.82	55.12±7.01	54.13±8.31
9	62.67±8.82^{a}	69.65±8.66^{b}	63.57±8.86^{a}	64.34±8.74	62.23±7.31	60.52±8.78
12	71.72±8.69	73.54±8.41	71.74±8.64	71.04±7.56	69.10±7.91	67.35±8.11
24	80.82±9.03	78.72±9.56	79.64±9.53	80.23±9.85	77.05±9.58	76.12±9.08
36	---	---	---	---	---	---
48	---	---	---	---	---	---
72	---	---	---	---	---	---

Mean of six observations, Means with different superscripts within a row differ significantly ($p<0.05$) for dry matter degradability and nitrogen degradability of the respective variety

Effective Degradability

Effective degradability of dry matter was the highest ($p<0.05$) in unprocessed of both varieties of tapioca leaves and lowest in hay prepared from both the varieties.

Degradable Soluble Nitrogen

Preserving of tapioca leaves, as silage enhances ($p<0.05$) the soluble nitrogen degradability in both verities. Preserving tapioca leaves as hay enhances ($p<0.05$) the nitrogen solubility in Mulluvaadi (MVD-1).

Degradable Insoluble Nitrogen

Degradability of insoluble nitrogen fraction was higher ($p<0.05$) in unprocessed tapioca leaves of both the varieties over their respective hay and silage.

Effective Degradability of Nitrogen

Processing lowered the effective degradability of nitrogen as compared to un-processing in White Rose (H226) and Mulluvaadi (MVD-1) varieties of tapioca leaves. The difference was greater ($p<0.05$) in Mulluvaadi (MVD-1). As effective nitrogen degradability is only a tool in determining the partition of RDN and DUN, not much importance needs to be assigned to this parameter.

Partitioning of Total Nitrogen of Tapioca Leaves of White Rose (H226) and Mulluvaadi (MVD-1)) - Unprocessed, Hay and Silage

Haymaking as well as silage making reduces ($p<0.05$) nitrogen content in White Rose (H226) whereas, haymaking enhances ($p<0.05$) nitrogen content in Mulluvaadi (MVD-1) (Table 2). Similarly haymaking as well as silage making reduces ($p<0.05$) RDN content in White Rose (H226) and through RDN content was reduced in Mulluvaadi (MVD-1) by haymaking the difference between hay and unprocessed was not significant. Silage making reduces ($p<0.05$) RDN content in Mulluvaadi (MVD-1). The digestible RDN as percentage of total nitrogen was significantly lowered ($p<0.05$) due to hay making as well as silage making. Consequently the organic matter apparently digested in the rumen and potential microbial nitrogen production were also significantly lowered ($p<0.05$) due to hay making as well as silage making in both verities.

Table 2: Percent dry matter and nitrogen degradation characteristics, partitioning of total nitrogen and scope for supplementation to increase the utilization of nutrients along with Rumen fermentation characteristics of tapioca leaves- unprocessed, hay and silage at 24 h of incubation in RUSITEC

	White rose (H226)			Mulluvaadi (MVD-1)		
Treatment	Unprocessed	Hay	Silage	Unprocessed	Hay	Silage
Dry matter						
Degradation rate/h	0.09±0.01	0.04±0.01	0.06±0.01	0.07±0.01	0.07±0.01	0.07±0.01
Degradable soluble dry matter	52.33±0.32^{b}	27.90±0.13^{a}	32.09±0.24^{a}	53.12±0.41^{b}	27.99±0.21^{b}	28.57±0.19^{a}
Degradable insoluble dry matter	30.10±0.22^{a}	61.18±0.27^{b}	48.76±0.29^{b}	30.98±0.25^{a}	52.77±0.47^{b}	53.52±0.43^{b}
Undegradable dry matter	17.57±0.15^{b}	10.92±0.06^{a}	19.15±0.07^{b}	15.90±0.08^{a}	19.24±0.06^{b}	17.91±0.05^{b}
Effective degradability of dry matter	76.85±0.58^{b}	67.74±0.47^{a}	67.92±0.49^{b}	77.51±0.56^{b}	68.79±0.48^{a}	69.67±0.51^{b}
Nitrogen						
Degradation rate/h	0.13±0.01	0.20±0.01	0.12±0.01	0.19±0.01	0.12±0.01	0.12±0.01
Degradable soluble Nitrogen	21.35±0.11^{a}	23.58±0.12^{b}	26.09±0.13^{b}	23.93±0.11^{a}	27.59±0.15^{b}	26.24±0.14^{ab}
Degradable insoluble Nitrogen	61.70±0.42^{b}	54.89±0.32^{b}	55.41±0.44^{a}	59.04±0.46^{b}	52.24±0.41^{a}	52.77±0.40^{a}
Undegradable Nitrogen	16.95±0.13	21.53±0.12	18.50±0.11	17.03±0.21	20.17±0.16	20.99±0.13
Effective degradability of Nitrogen	74.72±0.51	73.24±0.57	73.60±0.46	77.39^{b}±0.71	72.6±0.54^{a}	71.46±0.56^{a}
Total nitrogen	3.24±0.02^{b}	3.07±0.01^{b}	2.99±0.03^{a}	3.32±0.02^{a}	3.5±0.03^{b}	3.25±0.01^{a}
RDN	2.42±0.01^{b}	2.25±0.02^{a}	2.20±0.01^{a}	2.57±0.01^{b}	2.54±0.02^{b}	2.32±0.01^{a}
Digestible RDN	1.54±0.01^{b}	1.43±0.01^{a}	1.40±0.01^{a}	1.64±0.01^{b}	1.62±0.01^{b}	1.48±0.01^{a}
Digestible RDN as percent of total nitrogen	47.53±0.11^{b}	46.57±0.12^{a}	46.82±0.14^{a}	49.39±0.44^{b}	46.29±0.51^{a}	45.54±0.41^{a}
Organic matter apparently digested in the rumen	69.71±0.57^{b}	61.23±0.64^{a}	61.92±0.51^{a}	71.21±0.61^{b}	63.25±0.53^{a}	64.14±0.50^{a}
Potential microbial nitrogen production	2.09±0.02^{b}	1.84±0.03^{b}	1.86±0.01^{a}	2.14±0.02^{b}	1.9±0.02^{a}	1.93±0.01^{a}
UDN	0.82±0.01	0.82±0.01	0.79±0.02	0.75±0.01^{a}	0.96±0.02^{b}	0.93±0.01^{a}
ADFN	0.07±0.01	0.08±0.01	0.07±0.01	0.08±0.01	0.09±0.01	0.08±0.01
DUN	0.75±0.32	0.74±0.45	0.72±0.38	0.67±0.42^{a}	0.87±0.52^{b}	0.85±0.30^{b}
DUN as % of total nitrogen	23.15±0.21	24.10±0.27	24.08±0.29	20.18±0.25^{a}	24.80±0.21^{b}	26.15±0.31^{b}
Total absorbable nitrogen	70.68±0.64	70.67±0.69	70.90±0.53	71.96±0.51	71.09±0.49	71.69±0.61
Percent difference in nitrogen between RDN and Potential microbial nitrogen	-0.33	-0.41	-0.34	-0.43	-0.64	-0.39
Scope for digestible OM supplementation (%)	10.99	13.65	11.32	14.32	21.31	12.99
pH	7.30±0.06	7.20±0.09^{a}	7.23±0.07^{a}	7.35±0.07^{b}	7.25±0.05^{a}	7.24±0.08^{a}
Acetic acid (mM L^{-1})	25.05±1.25	27.10±1.46	27.00±1.29	26.60±1.29	27.65±1.31	27.15±1.33
Propionic acid (mM L^{-1})	8.05±0.29	9.20±0.35^{b}	9.45±0.25^{b}	8.60±0.54^{a}	9.25±0.39^{b}	9.40±0.28^{a}
Butyric acid (mM L^{-1})	2.90±0.89	3.05±0.95	3.00±0.67	3.15±0.12	3.10±0.35	3.05±0.56
TVFA (mM L^{-1})	36.90±1.33	40.21±1.37^{b}	39.92±1.43^{b}	38.04±1.05^{a}	41.25±1.10^{b}	41.07±1.07^{a}
Acetate to propionate ratio	3.11±0.96	2.95±0.45^{a}	2.86±0.35^{a}	3.09±0.83^{b}	2.98±0.20^{a}	2.88±0.36^{a}
Non glucogenic ratio	3.83±0.34	3.61±0.45^{b}	3.49±0.15^{a}	3.83±0.36^{b}	3.66±0.29^{a}	3.54±0.37^{a}
Ammonia nitrogen mg (%)	12.17±0.72	10.66±0.93^{a}	9.33±0.78^{a}	13.41±0.81^{b}	10.77±0.81^{a}	9.72±0.79^{a}
Microbial protein mg (%)	45.17±1.65	48.10±2.60^{b}	49.21±1.03^{b}	46.05±1.20^{a}	50.03±1.35^{a}	50.15±1.56^{a}
Bacterial count×10^{9}/mL	1.47±0.36	1.49±0.25	1.68±0.17	1.32±0.30	1.53±0.21	1.67±0.01
Protozoal count×10^{6}/mL	1.50±0.32	1.52±0.21	1.42±0.01	1.46± 0.02	1.51±0.28	1.41±0.01

Mean of six observations. Means with different superscripts within a row differ significantly ($p<0.05$) of the respective variety

The UDN, DUN and DUN as per cent of total nitrogen are enhanced ($p<0.05$) by processing in Mulluvaadi (MVD-1). However, the total absorbed nitrogen (sum of digestible RDN as percent of total nitrogen and DUN as per cent of total nitrogen) did not vary among the experimental groups. The assessment for the need of supplemental nutrients for unprocessed, hay and silage of tapioca leaves of both the varieties examined through the percent difference in nitrogen between RDN and potential microbial nitrogen indicate negative values in processed as well as unprocessed tapioca leaves of both verities.

Rumen Fermentation Characteristics as Effected by Tapioca Leaves

The pH in the reaction vessel was observed to be significantly ($p<0.05$) higher in the unprocessed tapioca leaves of both the varieties than their respective processed tapioca leaves.

While the production of acetic acid, butyric acid was not affected due to processing of White Rose (H226) and Mulluvaadi (MVD-1) varieties of tapioca leaves, the production of propionic acid was significantly ($p<0.05$) higher in the processed tapioca leaves of both the varieties of tapioca leaves. Consequently, acetate to propionate ratio and non glucogenic ratios were significantly ($p<0.05$) lower in the processed tapioca leaves against the unprocessed tapioca leaves of respective variety.

Ammonia nitrogen level in the reaction vessels showed a significantly ($p<0.05$) higher level in unprocessed tapioca leaves against processed tapioca leaves in both the varieties. However, the microbial protein synthesis showed a different pattern. While maximum microbial protein was synthesized in hay and silage, unprocessed tapioca leaves synthesized a significantly ($p<0.05$) lower microbial protein in both the varieties.

The bacterial and protozoal count did not vary between processed and unprocessed tapioca leaves of both the varieties.

DISCUSSION

Studies on Degradability and Rumen Characteristics

Dry Matter Degradability

Reduction in dry matter degradability in both the varieties from three hours of incubation until 36 h of incubation may be due to the influence of succulence level. Hay being less succulence, the severity of reduction is higher than the rest. As the incubation hours increases, dried material becomes succulent and hence the difference in dry matter degradability sinks. Similar results of reduced dry matter degradability in tapioca leaves due to sun drying was recorded by Mahayuddin *et al.* (1988) who observed 88.65±0.05% dry matter degradability in unprocessed tapioca leaves at 48 h incubation and 75.50±1.10% on sun drying at 48 h of incubation using the nylon bag technique. The dry matter degradability at 24 h of incubation period for unprocessed leaves in both the varieties in this study was comparable to Payano and Ponce (1978) who recorded 76.2% degradability. However, the values recorded in their study at 3 h of incubation differed with present study. A comparatively higher DMD values at 3 h of incubation observed in the study may be attributed to the variety difference and presence of more soluble fraction in the leaves.

The effect of preservation could be a probable reason for reduced soluble fraction in hay compared to unprocessed tapioca leaves (Table 2). A lower soluble degradable dry matter in hay and silage than the unprocessed tapioca leaves may be due to the chemical changes taking place in the cell structure during processing. The enzyme linamerase is activated during processing and the HCN content is reduced. This process causes loss of cell integrity (Man and Wiktorsson, 2001). The increase in degradable insoluble dry matter in processed tapioca leaves over unprocessed tapioca leaves may be due to in chemical changes taking place by the action of enzymes. The lower effective degradability of dry matter in tapioca hay was corroborated by Sokkalingam (2002) when groundnut haulms are converted to hay. On the contrary a higher effective degradability of dry matter was observed in groundnut haulms silage (Sokkalingam, 2002). A similar increase in soluble but degradable dry matter was observed, when the fodder variety, VG(F) 9873 was ensiled (Sokkalingam, 2002).

Nitrogen Degradability

The increased soluble nitrogen degradability in silage could be due to degradation of plant proteins and amino acids during ensiling (Thomas *et al*., 1979). This increase in soluble nitrogen was supported by Sokkalingam (2002) in groundnut haulm silage. It is interesting to note that while processing (hay and silage) decreased the dry matter, their nitrogen solubility was increased. It could be thus inferred that the lowering of dry matter solubility is primarily due to non-nitrogenous nutrients.

Increased nitrogen degradability due to processing as against reduction in dry matter degradability during the initial incubation period indicates that processing of tapioca leaves favors degradability of soluble portion of nitrogen. The lower insoluble degradable dry matter with higher insoluble degradable nitrogen in unprocessed leaves indicates that majority of insoluble degradable dry matter consisting of nitrogenous substance in unprocessed leaves, whereas the insoluble degradable fraction in processed leaves contains mixture of nitrogenous and non-nitrogenous nutrients.

Partitioning of Total Nitrogen of Tapioca Leaves of White Rose (H226) and Mulluvaadi (Mvd-1))-Unprocessed, Hay and Silage

Reduction in nitrogen content of White Rose (H226) in haymaking as well as silage making is due to wilting of leaves in haymaking and loss of cell sap in silage making. Higher nitrogen content in haymaking of Mulluvaadi (MVD-1) is due the higher proportion of shoots in this verity that do not wither by haymaking. The non-significant difference in RDN between hay and unprocessed leaves of Mulluvaadi (MVD-1), inspite of apparent reduction in RDN was due to higher nitrogen content in hay. The effect of haymaking/silage making on RDN was evident when digestible RDN was considered as percentage of total nitrogen. Thus it is evident that both processing methods in both verities reduce RDN.

The significant reduction ($p<0.05$) in the effective degradability of dry matter in hay as well as in silage of both verities of tapioca leaves reflected in significant reduction ($p<0.05$) in organic matter apparently digested in the rumen as well as potential microbial nitrogen production. Similarly significant reduction ($p<0.05$) in the effective degradability of nitrogen in hay and silage of Mulluvaadi (MVD-1) reflected in significant increase ($p<0.05$) in UDN as well as DUN. However, non significant difference in absorbable nitrogen in both verities between processed and unprocessed tapioca leaves indicates processing of tapioca leaves of both the varieties do not influence the utilization of nitrogen. The availability of rumen degradable nitrogen (RDN) when compared to potential microbial nitrogen revealed that there is scope for further improvement in the microbial production through organic matter supplementation in all groups. Further this study revealed that the scope for organic matter supplementation was enhanced through hay making in both the varieties of tapioca leaves.

Higher pH, lower propionic acid and TVFA, higher ammonia nitrogen and lower microbial protein synthesis clearly tilt the favour against unprocessed tapioca leaves. The lower pH in processed leaves could be attributed to higher TVFA production in the processed tapioca leaves than in unprocessed tapioca leaves. The higher TVFA seems to be a result of better microbial fermentation as reflected by higher microbial protein synthesized in the processed tapioca leaves. It can be argued that even though there is no difference in the nitrogen utilization between processed and unprocessed tapioca leaves, a better microbial fermentation has occurred in the processed tapioca leaves inspite of higher effective dry matter degradability with higher soluble organic matter in the unprocessed tapioca leaves. Thus it appears that processing regulates the nutrient delivery in the rumen/RUSITEC, resulting in better microbial fermentation. The ammonia nitrogen further amplifies the regulated fermentation as seen from the lower level of ammonia nitrogen in processed tapioca leaves. A significantly ($p<0.05$) higher ammonia in nitrogen unprocessed tapioca leaves with lower efficacy in microbial fermentation indicates that the degraded nutrients are not fully exploited in unprocessed tapioca leaves. Thus it can be concluded that processing of White Rose (H226) or Mulluvaadi (MVD-1) tapioca leaves either as hay or silage is desirable over feeding unprocessed tapioca leaves of those varieties.

CONCLUSION

Degradability of studies in RUSITEC conducted to assess the effect of processing (hay or silage) tapioca leaves of both the varieties on their nutritive value indicated that unprocessed tapioca leaves contained high soluble degradable dry matter and high effective degradability compared to processed (hay and silage) tapioca leaves of both the varieties. Whereas processed tapioca leaves of both the varieties had higher soluble nitrogen resulting in alteration of RDN and UDN value between unprocessed and processed tapioca leaves. However, the total absorbable nitrogen of both the varieties remained similar (70.67 to 71.96%) between unprocessed and processed tapioca leaves. In order to assess the need for supplemental nutrient for unprocessed, hay or silage of tapioca leaves of both the varieties to examine the scope for further improvement in microbial production was studied. The results are suggestive of need to supplement digestible of organic matter to the extent of 10.99 to 21.31% along with tapioca leaves fed either processed or unprocessed to exploit the nutritive value of tapioca leaves. The rumen fermentation characteristics were studied to examine the effect of processing of tapioca leaves. The results of rumen fermentation characteristics, as affected by processed/unprocessed tapioca leaves suggest that processing of tapioca leaves of White Rose (H226) or Mulluvaadi (MVD-1) as hay or silage is desirable over unprocessed tapioca leaves.

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