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Evaluation of Degradation Characteristics to Develop Supplemental Strategy for Effective Utilization of Paddy Straw Fed with Groundnut Cake or Sesame Cake to Cattle

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Abstract: A study was undertaken to optimise feeding protein sources viz., groundnut (*Arachis hypogaea*) cake and sesame (*Sesamum indicum*) cake with paddy (*Oryza sativa*) straw for effective nutrient utilisation by assessing their degradability characteristics. The percent effective degradability of dry matter in paddy straw was 24.39; sesame cake had 76.94 that was significantly ($p<0.01$) higher than groundnut cake with 67.69. The percent soluble nitrogen of groundnut cake (0) was significantly ($p<0.01$) lower than sesame cake (66.06), while the insoluble nitrogen fraction for groundnut cake (96.71) was significantly ($p<0.01$) higher than sesame cake (31.79). The percent effective rumen degradable nitrogen and organic matter apparently digested in the rumen reveals that the potential for microbial nitrogen production is higher ($p<0.05$) in sesame cake (2.01) than groundnut cake (1.89). Paddy straw requires 0.60% nitrogen supplementation to satisfy its potency for microbial production. It is observed that 200 g of groundnut cake or 250 g of sesame cake is required to supplement with one kg of paddy straw for optimizing microbial synthesis.

Key words: *Arachis hypogaea*, degradation characteristics, oil cake, *Oryza sativa*, paddy straw, *Sesamum indicum*

INTRODUCTION

The role of bovine livestock in SAARC (South Asian Association for Regional Cooperation) nation's agriculture is to generate farm power and to produce some milk by feeding on crop residues. Crop residues, weeds/grasses from wasteland and fallow cropping land, foliage of trees and shrubs are the basal feed resources and oil cakes, milling by-products of cereals and pulses are the main concentrate feeds for ruminant livestock. It is usual practice for the farmers to feed their animals with crop residues as a roughage source and additionally bran or locally available oil cake at the rate of 1-2 kg/head/day (Anonymous, 2000). Supplementation of crop residues (straws) with oil cakes improves rumen function and thereby enhances the intake and digestibility of the ration (Prasad *et al*., 1995).

Use of feeding standards as practiced by developed nations is inappropriate to SAARC countries, as low input resulting in low output forms the economical farming practice. The low milk procurement cost by milk co-operatives/commercial establishments also prohibits the change in the feeding practice by the poor farmers. Hence researcher should focus their attention to maximise farm produce without increasing the input cost of the farm. Scope to alter the feeding pattern with the same feed ingredient or slightly modifying the feeding quantity of the same ingredient to increase the profitability are the avenues that should be thoroughly searched upon.

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The development of such feeding strategies requires the understanding of the relative roles and nutrient needs of the two-compartment system represented by the microorganisms in the rumen and the host animal. Though attempts have been made on the improvement of crop residues, emphasis has not been laid on the effective utilisation of nutrients without altering the traditional feeding pattern.

Hence the present study was undertaken to optimise feeding protein sources with paddy straw for effective nutrient utilisation by assessing the degradability characteristics of commonly fed protein sources in SAARC countries.

MATERIALS AND METHODS

Paddy (*Oryza sativa*) straw and two oil cakes (expeller) viz., groundnut (*Arachis hypogaea*) cake and sesame (*Sesamum indicum*) cake were collected from six different areas, where paddy straw (as sole fodder) is supplemented with any one of the oil cake. The samples in duplicate were analysed for total dry matter, crude protein and total ash as per the method of AOAC (1995). Crude protein was estimated using Kjeltec system (Model No. 1002 Tecator, Sweden). The estimated values were expressed as percentage on dry matter basis.

The *in vitro* degradability characteristics of paddy straw and two different oil cakes i.e., groundnut cake and sesame cake were studied by Rumen Simulation Technique (RUSITEC) as described by Czerkawski and Brackenridge (1977).

The RUSITEC was equipped with six fermenters, each of 850 mL capacity. Inoculum was obtained from three cattle maintained on grazing alone. Ruminal fluid was filtered through 4 layers of cheesecloth upon collection. At the beginning of the experiment, the fermenters were filled with 500 mL of strained rumen liquor and 200 mL of artificial saliva, as prepared by McDougall (1948). Eighty grams of solid digesta (solid inoculum) and 10 g of test feed (dry matter basis) were placed in nylon bag which inturn was placed in the perforated cage. The perforated cage was then placed in the vessel and the remaining space was filled with distilled water and closed. To create anaerobic conditions carbon dioxide was passed through the gas valve for a minimum of 5 min. Two vessels were randomly allotted to test each of paddy straw, groundnut cake and sesame cake. Three runs were made and thus six measurements were made for each parameter studied. The pore size of nylon bag was 100 μ as suggested by Carro *et al.* (1995). The digesta bag was replaced by a feed bag after 24 h.

Artificial saliva was infused continuously into the fermenters at a dilution rate of 0.55 mL min^{-1}. Ten days of adaptation period was followed by collection period. The bags were incubated for 2, 4, 6, 8, 12, 18, 24, 36, 48 and 72 h in the fermenters of the RUSITEC. During the change of bags the fermenters were flushed with carbon dioxide to maintain anaerobic condition.

On removal the bags were washed in a washing machine for about 10 min and were then oven dried at 60°C for 48 h. After drying, the bags were stored in a dessicator until weighment.

In vitro Dry Matter Degradability Studies

The disappearance of dry matter was calculated at 12, 18, 24, 36, 48 and 72 h for paddy straw and 2, 4, 6, 8, 12, 18, 24, 36 and 48 h for groundnut and sesame cake. The percent *in vitro* degradability of samples were calculated by the following formula:

$$\textit{In vitro}\ \text{digestibility} \frac{\text{Weight of nylon bag with sample before incubation} - \text{weight of nylon bag with sample after incubation}}{\text{Weight of sample}} \times 100$$

The results of dry matter degraded at various time intervals were fitted to the exponential equation of McDonald (1981) using Neway, 1992 software.

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

Where,

P = The effective degradability after t hours of incubation

a, b, c = Constant in exponential equation

a + b = Potential degradability

c = Rate of degradability

In vitro Nitrogen Degradability Studies

The nitrogen degradability was measured at 2, 4, 6, 8, 12, 18 and 24 h of incubation. 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 the nylon bag under similar condition and making appropriate correction prior to calculating effective degradability (Negi *et al*., 1988). Neway, 1992 software was used to calculate the degradation rate/hour, soluble degradable dry matter/nitrogen, Insoluble degradable dry matter/nitrogen and effective dry matter/nitrogen degradability.

Scope for Synchronized Supply of Nutrients to Optimize Rumen Microbial Production

Maximizing the microbial nitrogen production was considered as key factor in enhancing the nutritive value of poor quality cereal roughage like paddy straw. The quantity of organic matter apparently digested in the rumen was calculated from the degradability characteristics and the ability of the organic matter apparently digested in the rumen to support microbial nitrogen production was assessed (AFRC, 1992) in paddy straw. As paddy straw is poor source of nitrogen, supplementary strategy from oil cake was worked out considering the quantity of their surplus nitrogen. The surplus nitrogen in the oil cakes were determined based on the quantity of organic matter apparently digested in the rumen from the oil cakes and their ability to support microbial nitrogen production. The quantity of nitrogen over and above the requirement to support this microbial nitrogen production was considered as surplus nitrogen. Thus the proportion of oil cake required per unit of paddy straw for optimum microbial production was determined to recommend feeding strategy.

In this context, the Effective Rumen Degradable Dietary Nitrogen (ERDN) was calculated as follows,

$$\text{ERDN} = 0.8\,[\text{soluble nitrogen}] + \frac{\text{Insoluble nitrogen} \times \text{Rate of degradation}}{\text{Rate of degradation} + \text{Outflow rate of degradation}}$$

The percent organic matter apparently digested was calculated by subtracting total ash content of feed ingredients from its dry matter and multiplying with the per cent effective degradability. The per cent potential microbial nitrogen production was derived by dividing the per cent organic matter apparently digested by 33.3 (AFRC, 1992). The per cent difference in nitrogen between potential microbial nitrogen and ERDN was calculated by subtracting the former from later and this difference was considered as the nitrogen supplementation required (AFRC, 1992) to enhance the nutrient utilization from paddy straw. The proportion of oilcake required to one kg of paddy straw for optimizing microbial synthesis (kg) was derived by dividing per cent nitrogen supplementation required for paddy straw to meet potential microbial nitrogen production by excess ERDN (surplus nitrogen) than it's potential for microbial nitrogen production. The data obtained in different parameters was subjected to statistical analysis as per the procedure of Snedecor and Cochran (1967).

RESULTS

Chemical Composition

As expected paddy straw has significantly ($p<0.05$) low level of nitrogen than oil cakes. Groundnut cake had the lowest ($p<0.05$) total ash resulting in highest ($p<0.05$) organic matter (Table 1).

In vitro Dry Matter Degradability

Statistical comparison in the dry matter degradability was carried out only between the oil cake as the objective of this study, is to identify the quantum of oil cakes required to optimize microbial production (Table 2).

A poor dry matter degradability of 51.07% was recorded for paddy straw at 72 h of incubation with 24.39% of effective degradability. The dry matter degradability of sesame cake was significantly very high ($p<0.01$) at 6 and 8 h of incubation and there after it was higher ($p<0.05$) for the remaining incubation hours, compared to groundnut cake. The dry matter degradation rate of groundnut cake and sesame cake was similar. The soluble degradable dry matter of sesame cake was significantly higher ($p<0.01$) than groundnut cake and the insoluble degradable dry matter as well as undegradable dry matter of groundnut cake was higher ($p<0.05$) than sesame cake. The effective degradability of dry matter was significantly ($p<0.01$) higher in sesame cake compared to groundnut cake.

In vitro Nitrogen Degradability

Paddy straw was not subjected to nitrogen degradability studies, as it does not contribute significant quantity of nitrogen. The nitrogen degradability of groundnut cake and sesame cake at different hours of incubation upto 24 h are given in Table 3.

Table 1: Percent chemical composition of paddy straw, groundnut cake and sesame cake used in this study. (Mean±Standard deviation)

Feed ingredients	Paddy straw	Groundnut cake	Sesame cake
Total nitrogen	0.67 ± 0.07^{a}	6.36 ± 0.59^{b}	5.70 ± 0.66^{b}
Total ash	17.83 ± 0.96^{c}	6.87 ± 0.51^{a}	12.80 ± 1.86^{b}
Total organic matter	82.17 ± 5.12^{a}	93.13 ± 6.24^{c}	87.20 ± 6.45^{b}

Mean of six observations; *Means bearing different superscript within row differ significantly ($p<0.05$) between oil cakes

Table 2: Percent dry matter degradability of paddy straw, groundnut cake and sesame cake in Rumen Simulation Technique at different hours of incubation along with their dry matter degradation characteristics. (Mean±SD)

		Oilcake	
Hours	Paddy straw	Groundnut	Sesame
2*	-	35.82 ± 2.33^{a}	50.18 ± 9.04^{b}
4*	-	43.25 ± 4.07^{a}	57.21 ± 8.92^{b}
6**	8.680 ± 3.23	51.48 ± 5.02^{a}	67.37 ± 8.38^{b}
8**	-	65.95 ± 4.68^{a}	74.74 ± 2.47^{b}
12*	20.360 ± 3.72	75.89 ± 1.69^{a}	81.80 ± 3.72^{b}
18*	26.500 ± 5.71	80.77 ± 5.29^{a}	87.70 ± 3.08^{b}
24*	30.760 ± 7.13	80.35 ± 3.50^{a}	88.43 ± 6.95^{b}
36*	41.990 ± 2.13	84.74 ± 3.82^{a}	94.18 ± 2.42^{b}
48*	45.280 ± 2.08	88.80 ± 1.47^{a}	93.22 ± 3.23^{b}
72	51.070 ± 2.89	-	-
Degradation rate/hour dry matter^{NS}	0.042 ± 0.33	0.14 ± 0.22	0.14 ± 0.07
Soluble degradable dry matter** (%)	0.00	16.72 ± 5.02^{a}	32.89 ± 7.18^{b}
Insoluble degradable dry matter* (%)	54.810 ± 5.90	69.80 ± 6.66^{b}	59.90 ± 3.18^{a}
Undegradable dry matter *	45.190 ± 5.93	13.42 ± 3.74^{b}	7.22 ± 4.82^{a}
Effective degradability of dry matter**	24.390 ± 3.25	67.69 ± 0.76^{a}	76.94 ± 3.33^{b}

Mean of six observations; **: Means bearing different superscript within row differ significantly ($p<0.01$) between oil cakes; *: Means bearing different superscript within row differ significantly ($p<0.05$) between oil cakes; ^{NS}: Do not differ significantly between oil cakes

Table 3: Percent nitrogen degradability of groundnut cake and sesame cake in Rumen Simulation Technique at different incubation periods along with its nitrogen degradation characteristics. (Mean±Standard deviation)

Hours of incubation	Groundnut cake	Sesame cake
2**	15.68±4.61[a]	77.15±6.760[b]
4**	36.20±4.75[a]	82.34±5.730[b]
6**	55.60±8.69[a]	88.23±4.630[b]
8**	75.73±4.14[a]	91.98±1.940[b]
12**	86.78±3.43[a]	94.98±0.780[b]
18**	90.43±1.62[a]	97.18±0.980[b]
24*	95.45±1.39[a]	97.95±1.030[b]
Degradation rate/hour nitrogen[NS]	0.20±0.02	0.20±0.050
Soluble** degradable dry matter (%)	0.00[a]	66.06±11.66[b]
Insoluble* degradable dry matter (%)	96.71±1.62[b]	31.79±11.34[a]
Undegradable nitrogen[NS]	3.29±1.62	2.16±1.780
Effective degradability of nitrogen[NS]	76.94±1.13	78.31±1.390

Mean of six observations; **: Means bearing different superscript within row differ significantly ($p<0.01$); *: Means bearing different superscript within row differ significantly ($p<0.05$); [NS]: Do not differ significantly

Table 4: Scope for supplementation of groundnut cake and sesame cake to enhance the utilisation of nutrients of paddy straw, (Mean±Standard deviation)

Feed ingredients	Paddy straw	Groundnut cake	Sesame cake
Total nitrogen	0.67±0.07	6.36±0.59	5.70±0.66
Total ash	17.83±0.96	6.87±0.51	12.80±1.86
Organic matter apparently digested in the rumen *	20.04±1.03[a]	63.04±0.71[b]	67.09±2.89[c]
Potential for microbial production *	0.60±0.09[a]	1.89±0.07[b]	2.01±0.09[b]
ERDN **	-	4.90±0.03[b]	4.46±0.07[a]
Difference in nitrogen between potential microbial for nitrogen and ERDN ** (%)	-0.60±0.09	3.01±0.12[a]	2.45±0.17[b]
Nitrogen supplementation required (%)	-0.60±0.09	Nil	Nil
Proportion of oilcake required to one kg of paddy straw for optimizing microbial synthesis (kg)	Nil	0.199 (Rounded to 200 g)	0.245 (Rounded to 250 g)

Mean of six observations each; **: Means bearing different superscript within row differ significantly ($p<0.01$); *: Means bearing different superscript within row differ significantly ($p<0.05$); [NS]: Do not differ significantly

The nitrogen degradability at 2 h of incubation in groundnut cake was 15.68% and it degraded upto 95.45% in 24 h while for sesame cake it was 77.15 and 97.95%, respectively. The sesame cake had significantly ($p<0.01$) higher nitrogen disappearance in all incubation periods upto 18 and at 24 h, dry matter degradability was higher ($p<0.05$) in sesame cake over groundnut cake.

Similar to dry matter, the degradation rate of groundnut cake and sesame cake was same and the soluble nitrogen of groundnut cake was significantly ($p<0.01$) lower in sesame cake, while the insoluble nitrogen fraction for groundnut cake was significantly ($p<0.01$) higher than sesame cake. However, there was no difference in the portion of undegradble nitrogen as well as in the effective degradability of nitrogen.

Scope for Synchronized Supply of Nutrients to Optimize Rumen Microbial Production

The ERDN of groundnut cake was significantly ($p<0.01$) higher than sesame cake, which indicates that relatively more nitrogen is available in the rumen from groundnut cake than sesame cake (Table 4). However, the organic matter apparently digested in the rumen was higher ($p<0.05$) in sesame cake than groundnut cake and hence the potential for microbial nitrogen production is also higher ($p<0.05$) in sesame cake than groundnut cake. Thus the dependence on organic matter supplementation becomes lesser in sesame cake than groundnut cake. Paddy straw has a significantly ($p<0.01$) lowest potential for microbial nitrogen production compared to groundnut and sesame cake. The difference in nitrogen between potential for microbial production and ERDN was significantly ($p<0.01$) higher in groundnut cake over sesame cake (Table 4). Paddy straw requires 0.60% nitrogen supplementation to satisfy its potency for microbial production. It is observed that 200 g of groundnut cake or 250 g of sesame cake is required to supplement with one kg of paddy straw for optimizing microbial synthesis.

DISCUSSION

Chemical Composition

The chemical composition recorded in this study viz., Total nitrogen, total ash and total organic matter of paddy straw, groundnut cake and sesame cake were in agreement to the values reported by Sohane and Singh (2000).

In vitro Dry Matter Degradability of Paddy Straw

The percent dry matter degradability of paddy straw was recorded as 45.28% at 48 h in the present study, whereas Reddy and Sivaiah (2001) reported that the mean *in vitro* dry matter degradability of semi dwarf and medium varieties of paddy straw as 28.03 and 29.26%, respectively at 48 h of incubation. The variation in degradability of paddy straw may be attributed to variation existing in chemical composition and digestibility among whole straw of different rice cultivars as well as between leaf and stem fractions (Sohane and Singh, 2000).

Reddy and Sivaiah (2001) worked out the *in vitro* dry matter degradability of different paddy straw varieties and reported that the readily soluble fraction, insoluble but degradable fraction ranged from 9.39 to 14.06 and 51.75 to 56.97, respectively. The rate of degradation was reported to be 0.035 to 0.04 in the different varieties. However, these values concur with the results of the present study.

In vitro Dry Matter Degradability of Oil Cake

The values recorded for dry matter degradability, the degradation rate, soluble nitrogen, insoluble nitrogen and effective protein degradation of groundnut cake and sesame cake concurred with Walli *et al*. (2000), Haldar and Rai (2002) but differed from Walli *et al*. (1999). The variable results were attributed to the animal factors like rumen environment, retention time and flow rate. In addition, the groundnut cake used in the current study was expeller variety and it is quite possible that the reported values could be for solvent extracted groundnut cake as there was no mention in those articles.

Scope for Synchronized Supply of Nutrients to Optimize Rumen Microbial Production

The quantum organic matter that is apparently digested in the rumen and the ERDN determines the proportion of oilcake to be supplemented to poor quality cereal straw like paddy straw. As the quantum of organic matter apparently digested reflects the potential for microbial production, a higher quantum of organic matter apparently digested, means a relatively higher proportion of ERDN in the oil cake will be useful towards fulfilling the need for achieving the potential for microbial production. Thus relatively lower amount of ERDN would be available to support microbial production for the organic matter digested from other feed/fodder. Hence, the nitrogen fraction of oil cake that can be spared to promote the nutrient utilization (organic matter apparently digested) of paddy straw will be relatively lower. On the other hand, a lower organic matter apparently digested means a relatively higher proportion of ERDN available to support microbial production for the organic matter digested from other feed/fodder. Consequent to the level of ERDN available in oil cake to support microbial production for the organic matter digested from paddy straw, the proportion of oil cake to be fed with paddy straw is determined to maximize the nutrient utilization wherever only oil cake are fed along with paddy straw (as sole fodder).

Thus groundnut cake with higher ERDN, lower organic matter apparently digested in the rumen and lower potential for microbial nitrogen production than sesame cake resulted in 200 g as optimal level to enhance the nutrient utilization from 1 kg of paddy straw through maximizing microbial production, as against 250 g of sesame cake.

CONCLUSION

This study concludes that 200 g of groundnut cake or 250 g of sesame cake is required to supplement with every one kg of paddy straw for optimizing microbial synthesis.

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