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Chemical composition and *in vitro* dry matter degradability of combination of wheat and paddy straw for small ruminant feeding

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Abstract

Paddy and wheat generate multi-million tons of straw as residue. These two straws although similar in their nutrient content are quite different in microstructure and non- nutritive chemical composition. Paddy and wheat are both important cereal crops of Jammu and Kashmir. The scarcity of green fodder, pasture and quality hay has increased the onus over cereal crop residues, as their feeding to livestock offers no direct competition with human resources and requirements. Present study scrutinized the chemical composition and *in vitro* dry matter degrability (IVDMD) of these straws as a combination. The Percent OM, CF, NFE, NDF, ADF, calcium and phosphorus content were highest in W100P0 and lowest in W0P100, with progressively decline with the increasing concentration of paddy straw in the straw mixtures. Inverse trend was observed with respect to the CP, ether extract, total ash and acid insoluble ash content. The IVDMD declined progressively with an increase in percentage of paddy straw. The point of inflection, where this decline became significant at W50P50 combination. As paddy straw is a less preferred feedstuff as compared to wheat straw and is available at a significantly lower cost in most of the North-West parts of India, it was meaningful to select the maximum level of paddy straw in the combination (W60P40), that doesn't affect the degradability significantly, therefore, the straw combination of W60P40 was determined suitable for small ruminant feeding.

Keywords: *In vitro* dry matter degradability, paddy and wheat straw

Introduction

A major portion of the ration of ruminant livestock in South-east Asia including India is based on cereal crop residues. The scarcity of green fodder, pasture and quality hay has increased the onus over cereal crop residues, as their feeding to livestock offers no direct competition with human resources and requirements. Alternative mode of disposal of cereal straw by burning is a major source of land and air pollution [1, 2]. However, using it as a feedstuff for ruminant animals makes it an extremely important renewable resource [3]. Rice (Oryza sativa L.) - wheat (*Triticum aestivum* L.) (RW) cropping system has been developed through the introduction of rice in the traditional wheat-growing areas and vice versa in India [4] There is mean residue production of about 6.7 and 5.0 Metric Tonne/Ha for paddy and wheat, respectively due to their increased production [5].

Paddy and wheat are both important cereal crops of Jammu and Kashmir. Paddy is the main crop of Kashmir, followed by maize, oilseeds, pulses, vegetables, fodder and wheat. In Jammu region, wheat is the predominant crop followed by maize, paddy, pulses, oilseeds, fodder, vegetables and other crops [6]. About 290.99 thousand hectare of land in Jammu and Kashmir is under wheat cultivation, producing about 5819.5 thousand quintals of grain yield [6], concurrently producing roughly 1.5 times this weight as straw [5]. Simultaneously, about 265.88 thousand hectare of land in Jammu and Kashmir is under rice cultivation, producing about 4548 thousand quintals of grain yield [6], concurrently producing roughly more than twice this weight as straw [5]. Paddy straw has poor nutritive value [7]. It contains less lignin, but more silica and oxalic acid than other cereal straws [8, 9]. The slow and limited ruminal degradation of fibrous carbohydrates and the low content of nitrogen are the main limiting factors of rice straw, affecting its value as feed [10].

Wheat straw is generally low in crude protein and phosphorous, limited in calcium, and high in fiber and lignin [11]. As such, it typically causes a decrease in voluntary intake, slowing of passage rate, and a decrease in digestibility.

Straw intake and digestibility in ruminants are influenced by the characteristics of straw which include chemical composition, morphological and anatomical features, physical nature and palatability [12]. These two straws although similar in their nutrient content are quite different in microstructure and non- nutritive chemical composition. Further, they also differ in their relative acceptability by livestock keepers as a feedstuff, which is also reflected in their market price. With this background, the present study was envisaged to scrutinize the utilization of these straws if fed as a combination.

Material and methods

Locally cultivated wheat straw and paddy straw were procured from local farmers. Paddy and paddy straw was chaffed using power operated chaffer. A representative sample of the procured wheat and paddy straw were oven dried to a constant weight, and then ground in a laboratory grinder (Wiley mill) using 1-2mm sieve for further analysis. The ground samples of two straws were combined together in different proportions to prepare composite ration sample as shown in the table1. Proximate analysis of composite ration of wheat and paddy straw was done as per AOAC (1995) and fiber fractions [Neutral detergent fiber (NDF) and Acid detergent fiber (ADF)] were analyzed as per the method of Van Soest [13].

A 200 mg sample of each combination was taken as the substrate per replicate for *in vitro* dry matter degradability estimation. *In vitro* gas production technique was employed to estimate the *in vitro* DM degradability of composite ration comprising of variable straw combinations as per details mentioned below [14, 15]. Rumen liquor of caprine origin and was pooled in an insulated flask, plugged tightly, and brought to the laboratory for immediate processing. Rumen liquor was filtered through a four-layered muslin cloth. Carbon dioxide gas was passed through the rumen liquor for 60 seconds and maintained anaerobically at 39±1 °C temperature for further use. The incubations were carried out in 100 ml calibrated glass syringes [14, 15]. The substrate (200 mg; composite ration samples as per table 2) was weighed on a plastic boat with removable stem and placed into the bottom of the glass syringe without sticking to the sides of the syringes. The piston was lubricated with petroleum jelly and pushed inside the syringe. The incubation medium (solution I) was prepared by mixing different components in the proportion and order as mentioned in table 2 and were kept in the incubator at 39±0.5 °C till filling. Solution II (reduction solution) was prepared just before starting the filling of syringes. The syringes were also kept in an incubator at 39±0.5 °C prior to filling.

Reduction solution was added to the incubation medium and bubbled with CO2. After medium became colorless, the required amount of strained rumen liquor was added. The ratio of medium to rumen liquor was 2:1. Then 30 ml of incubation medium was injected to each syringe using auto pipette. The syringes were shaken gently and residual air or air bubble, if any, was removed and the outlet was closed. The level of piston was recorded (initial reading) and the syringes were placed in the water bath pre-adjusted at 39±0.5 °C. The syringes were shaken every 30 minutes for the first 2 h from the start of the incubation and thereafter every 2 h up to 6 h of incubation. Total incubation period of 24 h was given.

The contents of the syringes were transferred to 500 ml spoutless beakers by repeated washings with neutral detergent solution without sodium sulphite [16, 17]. The contents were then refluxed for 1 h to extract the microbial matter from the undegraded feed and the residue was recovered in pre-weighed filter crucibles [18]. After drying the crucibles (with residue) at 105 °C to constant weight, ashing was done at 400 °C to 500 °C for 2 hours.

Result and discussion

The proximate composition, fiber fractions and calcium phosphorus content (Percent DM) of different straw combinations are presented in Table 3. The straw combination varied significantly ($P<0.01$) from each other for all the analysed parameters. The Percent OM, CF, NFE, NDF, ADF, calcium and phosphorus content were highest in W100P0 (92.87, 37.80, 49.39, 78.04, 53.51, 0.53 and 0.20, respectively) and lowest in W0P100 (85.31, 31.40, 47.72, 72.09, 50.12, 0.32 and 0.10, respectively), with progressively decline with the increasing concentration of paddy straw in the straw mixtures. Inverse trend was observed with respect to the crude protein, ether extract, total ash and acid insoluble ash content, with highest values for W0P100 (4.76, 1.43, 14.69 and 10.29, respectively) and lowest values for W100P0 (4.35, 1.34, 7.13 and 5.35, respectively) and progressive decline with increasing concentration of wheat straw in straw mixtures. *In vitro* degradability pattern of tested straw combinations are presented in Table 4. The Percent degradability of straw combination ranged from 35.25 (W0P100) to 39.69 (W100P0). The IVDMD declined progressively with an increase in percentage of paddy straw. Highest degradability values were observed for W100P0, which were comparable to W90P10 and W80P20 combinations. These were in turn similar to W70P30 and W60P40. On the other hand, similar degradability values were observed for W50P50, W40P60, W30P70, W20P80 and W10P90 combinations, which were significantly ($P<0.01$) with all other combinations having higher wheat straw proportion. Significantly ($P<0.01$) lower degradability values were observed for plain paddy straw (W0P100).

The straw combination varied significantly ($P<0.01$) from each other for all the analysed parameters (Table 3). The wheat straw is relatively rich in OM, CF, NFE, NDF, ADF, calcium and phosphorus content, whereas paddy straw contains a relatively higher concentration of crude protein, ether extract, total ash and acid insoluble ash content. All the combinations of these straws analysed are therefore diluted with respect to respective compositional parameters. The chemical composition of wheat straw offered as basal feed was comparable with the values reported earlier by many workers [19-28]. Chemical composition of the paddy straw analyzed in the present study was similar to that reported in previous reports pertaining to paddy straw from different locations and varieties [29-38]. *In vitro* degradability pattern of tested straw combinations is presented in Table 4. The Percent degradability of straw combination ranged from 35.25 (W0P100) to 39.69 (W100P0). The IVDMD declined progressively with increase in percentage of paddy straw. Highest degradability values were observed for W100P0, which were comparable to W90P10 and W80P20 combinations. These were in turn similar to W70P30 and W60P40. On the other hand, similar degradability values were observed for W50P50, W40P60, W30P70, W20P80 and W10P90 combinations, which were significantly ($P<0.01$) with all other combinations having higher wheat straw proportion. Significantly ($P<0.01$) lower degradability values were observed for plain paddy straw (W0P100). The IVDMD (%) values for both straws are in accordance to the values reported by other authors [39-42]. however, higher IVDMD (%) observed for wheat straw as compared to paddy straw values is in contradiction to the values reported by these previous workers, although, none of them evaluated both straw simultaneously.

It has been reported that in case of wheat and paddy straw, digestibility of cellulose and hemicellulose in the internodes decline at similar rates, but the final digestibility of hemicelluloses was somewhat higher than that of NDF and cellulose in wheat [43]. Further, it has been suggested that the morphological location of silica in the plant causes differences in the *in vitro* gas production of paddy straw as for each unit of silica present in the sample [44, 45], a decrease of three units in the digestibility occurs [46], which is related to its role as a physical barrier [47, 48] or as an inhibitor of enzymatic hydrolysis in the rumen [49]. It has been reported that there is a high correlation between neutral detergent solubles % and IVOMD%. Higher cell soluble content (100-NDF%) of wheat straw observed in the present study may be attributed to its relatively higher degradability *in vitro* [50]. Chemical composition, especially the lignin and silica content has been reported to affect the ruminal degradability of paddy straw [10, 7]. With considerable difference seen in chemical composition of the straw combinations analyzed in the present study, significantly ($P<0.05$) different *in vitro* degradability among the tested combinations was on the line of expected observation. Critical evaluation of IVDMD percentage data, indicates that although there is a progressive decline in degradability values with increasing concentration of paddy straw in the combinations, the point of inflection, where this decline becomes significant is at W50P50 combination (Fig 1). As paddy straw is a less preferred feedstuff as compared to wheat straw and is available at a significantly lower cost in most of the North-West parts of India [51], it was meaningful to select the maximum level of paddy straw in the combination (W60P40), that doesn't affect the degradability significantly for small ruminant feeding.

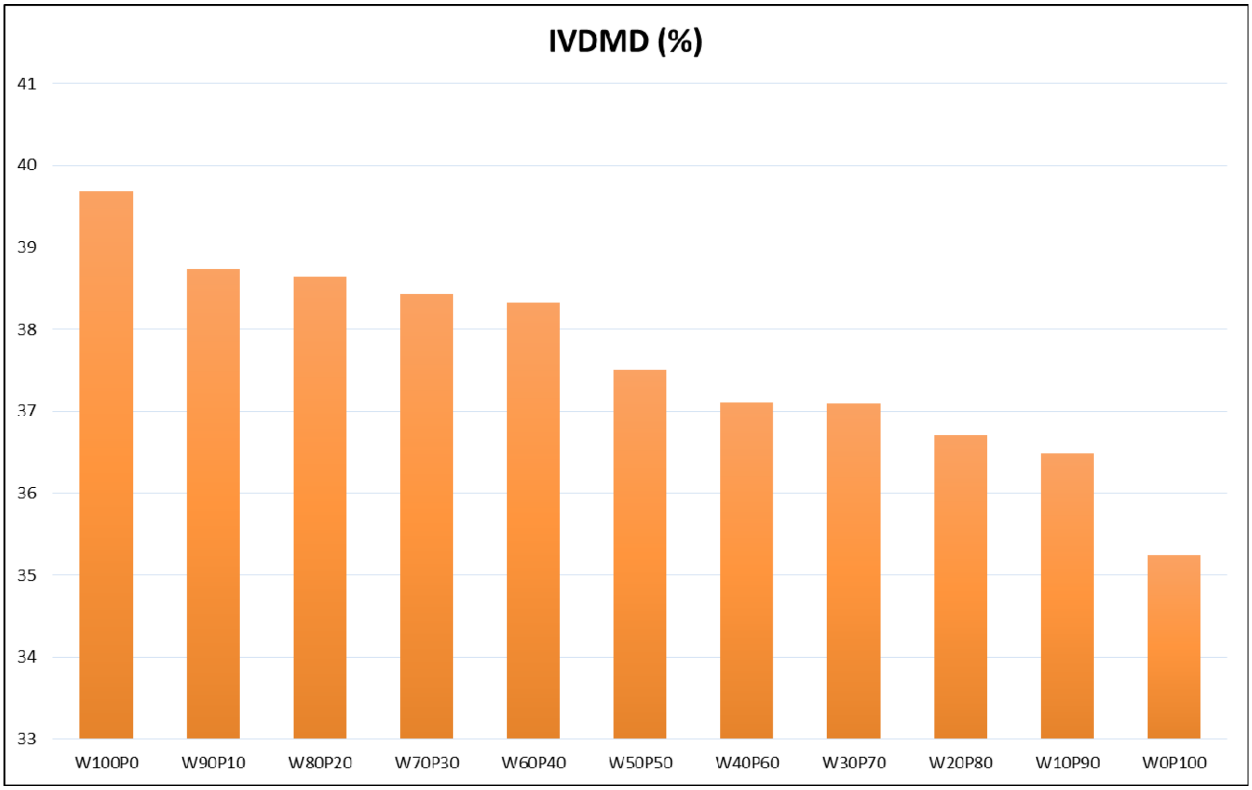

Fig 1: *In vitro* dry matter degradability of straw combinations

Table 1: Straw proportions (%) in composite ration samples

S. No.	Ration	Wheat straw	Paddy straw
1	W100P0	100	0
2	W90P10	90	10
3	W80P20	80	20
4	W70P30	70	30
5	W60P40	60	40
6	W50P50	50	50
7	W40P60	40	60
8	W30P70	30	70
9	W20P80	20	80
10	W10P90	10	90
11	W0P100	0	100

Table 2: Details of solutions and the order in which they were added prior to the filling in syringes for *in vitro* degradability trial

Solution: I	
Distilled water	365 ml
Micromineral solution	0.10 ml
Rumen buffer solution	183 ml
Macromineral solution	183 ml
Resazurine solution	0.95 ml
Solution: II (Reduction solution)	
1N NaOH	2 ml
$Na_2S.7H_2O$	285 mg
Distilled water	47.5ml
Solution: III	
Strained rumen liquor	330 ml

Table 3: Percent chemical composition (DM basis) of straw combinations*

Attributes*/Straw Combinations	Organic matter	Crude protein	Ether extract	Crude Fibre	Nitrogen Free Extract	Total ash	Neutral detergent fibre	Acid detergent fibre	Acid insoluble ash	Calcium	Phosphorus
W100P0	92.87^{k}±0.012	4.35^{a}±0.009	1.34^{a}±0.003	37.80^{h}±0.058	49.39^{k}±0.081	7.13^{a}±0.012	78.04^{k}±0.030	53.51^{k}±0.020	5.35^{a}±1.005	0.53^{k}±0.002	0.20^{k}±0.003
W90P10	91.73^{j}±0.319	4.43^{b}±0.037	1.36^{ab}±0.007	37.13^{g}±0.071	49.22^{j}±0.067	8.27^{b}±0.319	77.64^{j}±0.185	53.12^{j}±0.062	6.76^{b}±0.008	0.51^{j}±0.002	0.19^{j}±0.003
W80P20	91.35^{i}±0.032	4.44^{b}±0.006	1.36^{b}±0.010	36.37^{f}±0.184	49.05^{i}±0.053	8.65^{c}±0.032	76.92^{i}±0.044	52.88^{i}±0.062	7.20^{b}±0.052	0.49^{i}±0.002	0.18^{i}±0.003
W70P30	90.47^{h}±0.123	4.49^{b}±0.020	1.37^{bc}±0.004	35.60^{e}±0.300	48.89^{h}±0.039	9.53^{d}±0.123	76.19^{h}±0.097	52.54^{h}±0.032	7.54^{bc}±0.003	0.47^{h}±0.002	0.17^{h}±0.003
W60P40	89.81^{g}±0.058	4.50^{b}±0.016	1.38^{bc}±0.003	35.17^{e}±0.084	48.72^{g}±0.026	10.19^{e}±0.058	75.76^{g}±0.124	52.11^{g}±0.059	7.58^{bc}±0.617	0.45^{g}±0.002	0.16^{g}±0.003
W50P50	89.01^{f}±0.035	4.58^{c}±0.013	1.39^{cd}±0.012	34.40^{d}±0.200	48.55^{f}±0.014	10.99^{f}±0.035	75.13^{f}±0.097	51.88^{f}±0.065	7.83^{bcd}±0.510	0.43^{f}±0.002	0.15^{f}±0.003
W40P60	88.34^{e}±0.029	4.63^{cd}±0.042	1.39^{cd}±0.007	33.97^{d}±0.018	48.39^{e}±0.011	11.66^{g}±0.029	74.34^{e}±0.171	51.54^{e}±0.089	8.75^{cde}±0.027	0.41^{e}±0.002	0.14^{e}±0.003
W30P70	87.60^{d}±0.030	4.65^{d}±0.008	1.40^{de}±0.008	33.12^{c}±0.120	48.22^{d}±0.022	12.40^{h}±0.030	73.95^{d}±0.031	51.10^{d}±0.053	8.84^{de}±0.327	0.38^{d}±0.002	0.13^{d}±0.003
W20P80	86.92^{c}±0.060	4.70^{de}±0.025	1.41^{def}±0.008	32.47^{b}±0.237	48.05^{c}±0.035	13.08^{i}±0.060	73.22^{c}±0.109	50.85^{c}±0.076	9.52^{ef}±0.018	0.36^{c}±0.002	0.12^{c}±0.003
W10P90	85.98^{b}±0.049	4.73^{e}±0.023	1.42^{ef}±0.006	31.72^{a}±0.361	47.89^{b}±0.048	14.02^{j}±0.049	72.82^{b}±0.090	50.50^{b}±0.069	9.90^{ef}±0.003	0.34^{b}±0.002	0.11^{b}±0.003
W0P100	85.31^{a}±0.020	4.76^{e}±0.026	1.43^{f}±0.009	31.40^{a}±0.058	47.72^{a}±0.062	14.69^{k}±0.020	72.09^{a}±0.048	50.12^{a}±0.023	10.29^{f}±0.009	0.32^{a}±0.002	0.10^{a}±0.003

^{Abcdefghijk}Means bearing different superscripts within a column differ significantly ($P<0.01$)

*Each value is a mean of three observations (analysis in triplicate)

Table 4: *In vitro* dry matter degradability of straw combinations*

Straw Combinations	IVDMD (%)
W100P0	39.69^{e}±0.213
W90P10	38.74^{de}±0.315
W80P20	38.64^{de}±0.251
W70P30	38.43^{d}±0.163
W60P40	38.32^{d}±0.465
W50P50	37.50^{bc}±0.191
W40P60	37.11^{bc}±0.586
W30P70	37.09^{bc}±0.106
W20P80	36.71^{b}±0.088
W10P90	36.49^{b}±0.630
W0P100	35.25^{a}±0.125

^{abcde}Mean values bearing different superscripts differ significantly ($P<0.01$)

*Each value is a mean of nine observations (observation in triplicatex three trials)

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