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Nutritional evaluation of *Pleurotus florida* harvested spent wheat–rice straw based diets in goats

K KAUR[1], M WADHWA[2] and M P S BAKSHI[3]

Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, Punjab 141 004 India

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ABSTRACT

An experiment was conducted to evaluate the nutritional worth of spent wheat straw-rice straw (WS-RS) in 50: 50 ratio in the complete feed of goat kids. The cultivation of *Pleurotus florida* (edible mushroom) on WS-RS (50: 50) resulted in low in OM, hemicellulose and NDF but enriched the straw with microbial protein. The digestion kinetic parameters for DM and NDF revealed that insoluble but potentially degradable fraction was low in spent WS-RS as compared to ordinary WS-RS. The apparent extent of digestion was lower in spent WS-RS as compared to WS-RS, resulting in higher rumen fill value predicting low voluntary DM intake in spent WS-RS. The loss in OM and other nutrients during fungal cultivation resulted in low net gas production and low *in-vitro* OM and NDF digestibility in spent WS-RS. The *in-sacco* and *in-vitro* gas production studies revealed that the spent straw due to heavy OM loss during mushroom cultivation had lower nutritional worth as compared to WS-RS. The effect of incorporation of WS-RS or spent WS-RS in isocaloric and isonitrogenous complete feed on the performance of goat kids was assessed. The WS-RS or spent WS-RS along with concentrate in 60: 40 ratio for 90 days revealed that spent WS-RS diet was palatable as indicated by higher DM intake. The digestibility of nutrients (except that of cellulose which was depressed), blood profile (except total protein and globulin which were depressed), N-retention, apparent biological value and daily live weight gain were comparable in both the groups. It was concluded that though spent WS-RS had lower nutritional worth than WS-RS but could be incorporated in isonitrogenous and isocaloric complete feed without any adverse effect on the performance of kids.

Key words: Goat kids, Nutrition, *Pleurotus florida*, Spent wheat–rice straw

In the Northern region of India, especially in Punjab, rice straw is available in plenty, i.e. to the tune of 11 million tonnes/year, most of which is surplus because the livestock requirement is met by feeding wheat straw. More than 80% of rice straw is burnt causing environmental pollution. Different methods have been adapted to find the alternate use of rice straw either in card board/paper industry, as packing or bedding material, livestock feed or mushroom cultivation. The spent straw available after harvesting the edible mushrooms is used as soil conditioner. Earlier reports from this laboratory revealed that *Agaricus bisporus* harvested wheat straw (Bakshi and Langar 1985, 1991), *Pleurotus* harvested wheat straw (Bakshi *et al*. 1985) and *Volveriella diplacia* harvested rice straw (Langar and Bakshi 1986) could be used as livestock feed. However, no information is available on the cultivation of *Pleurotus florida* on wheat-rice straw mixture as a substrate. Therefore, an attempt was made to cultivate this fungus on WS-RS mixture (50: 50 ratio) and to evaluate the nutritional worth of spent straw mixture as feedstuff for goat kids.

Present address: [1]Research Associate, [2]Senior Biochemist, [3]Senior Nutritionist-cum-Head (e-mail: bakshimps@yahoo.com), Department of Animal Nutrition.

MATERIALS AND METHODS

Spent WS-RS, after harvesting *Pleurotus florida* (edible mushroom) was procured from Department of Microbiology, Punjab Agricultural University, Ludhiana. The finely ground samples of ordinary untreated and spent WS-RS samples were analyzed in duplicate for chemical constituents.

In-sacco *studies:* The digestion kinetic parameter for DM and NDF were assessed by *in-sacco* technique (Mehrez and Orskov 1977). Three adult rams fitted with permanent rumen fistulae were selected and maintained on concentrate mixture supplemented with green fodder and rice straw. The nylon bags (pore size of 50±10 µ) stitched with monofilament polyester thread containing 3 g sample were incubated in the rumen for 3, 6, 9, 12, 24, 36, 48, 60 and 72h in triplicate. After the stipulated period, bags were taken out, washed under tap water, until rinsing water from the bag became colourless and dried in a forced air oven at 60º C for 48h. The degradable fractions (McDonald 1981) and the rumen fill (Van Eys 1982) were calculated. The DM intake was predicted by using the equation of Orskov *et al.* (1988).

In-vitro *studies:* The nutritional value of WS-RS mixed in 50: 50 ratio and spent WS-RS were evaluated by *in vitro* gas production technique (Menke *et al*. 1979, Menke and Steingass 1988). About 375 mg of WS-RS or spent WS-RS was incubated at 39°C for 24 hr in triplicate in 100 ml calibrated glass syringes (Haberle Labortechnik, Germany) with buffered rumen fluid. The solution, containing 960 ml distilled water, 0.16 ml micro-mineral solution, 660 ml bicarbonate buffer, 330 ml macro-mineral solution and 1.6 ml resazurine (0.1%), was mixed in a 3 l Woulff flask kept in a water bath at 39° C, followed by addition of 50ml freshly prepared reducing solution and flushing of CO_2. Then strained rumen liquor (SRL) was added to the buffer media in 1: 2 ratios. The flushing of CO_2 was continued till the last syringe was filled. 30 ml buffered SRL was pumped in each syringe. The contents in all the syringes were swirled at 60 min interval for first 8 hr of incubation. After 24 h, volume of gas produced in each syringe was recorded and the contents of syringes were transferred to spout-less beaker, boiled with neutral detergent solution (which dissolves microbial biomass) for assessing the true OM and NDF digestibility.

In-vivo *studies:* Beetal male goat kids (Body weight 31.0±0.82 kg) divided into 2 equal groups were offered iso-nitrogenous and iso-caloric complete feed containing either WS-RS or spent WS-RS once a day at 9 hr for 90 days followed by a 7-day metabolism trial. The concentrate to roughage ratio in both the groups was maintained at 40: 60. The roughage portion was made up of WS-RS or spent WS-RS and available green fodder in 85: 15 ratio. Fresh water was offered twice a day. During the trial, the animals were kept in individual metabolic cages. Urine was collected in plastic cans (kept underneath the metabolic cages) over 100 ml of 20% sulphuric acid to maintain the pH below 3. Urine samples were kept in a deep freezer, till analyzed for N. Blood samples were collected (in heparin and sodium floride-oxalate vials) by puncturing the jugular vein at 4 h-post feeding. Record of feed intake, orts, faeces and urine voided was maintained. The serum was separated and stored at 0°C till analysed. The animals were weighed every fortnight for 3 consecutive days and the feeding schedule was adjusted accordingly (NRC 1981).

Analytical methods: The finely ground samples of feedstuffs, orts and faeces were analyzed for DM, CP and total ash (AOAC 1995), cellulose (Crampton and Maynard 1938) and other cell wall constituents like NDF, acid detergent fiber (ADF) and acid detergent lignin (Robertson and VanSoest 1981). Hemicellulose was the difference between NDF and ADF. The urine samples were analyzed for total-N (AOAC 1995). Blood samples were analysed for protein (Doumas *et al.* 1971), albumin (Doumas *et al.* 1971), glucose (Trinder 1969), urea (Evans 1968), creatinine (Folin and Wu 1919) and uric acid (Trivedi *et al.* 1978). The data were analyzed by simple ANOVA (Snedecor and Cochran 1994) by using SPSS (1996) version 12.0 and the means were tested for the significant difference by using Tukey's b.

RESULTS AND DISCUSSION

The chemical composition of WS-RS and spent WS-RS revealed that WS-RS as compared to spent WS-RS had higher OM (88.9 vs. 80.8%) and lower total ash content (11.1 vs. 19.2%), indicating that *Pleurotus* sp. consumed considerable nutrients while proliferating in the WS-RS, but enriched the straw with mycelial protein as indicated by higher crude protein in spent WS-RS as compared to WS-RS (6.47 vs. 3.72%). The spent WS-RS as compared to WS-RS had lower NDF (61.1 vs. 77.7%), hemicellulose (14.1 vs. 24.7%) and cellulose (25.0 vs. 38.5%) contents as these were also used for the proliferation of fungal mycelia, confirming the earlier reports indicating higher nutrient losses in spent straws (Bakshi and Langar 1985 and 1991, Bakshi *et al.* 1985; Langar and Bakshi 1986). The production of fruiting bodies and CO_2 resulted in about 50% loss in DM, which was well with in the range (45 to 70%) reported earlier (Gupta and Langar 1988, Kakkar *et al.* 1990)

The digestion kinetic parameters for DM worked out from *in sacco* studies revealed that the spent WS-RS as compared to WS-RS had higher (P<0.01) rapidly soluble fraction and

Table 1. *In-sacco* degradability of WS-RS and spent WS-RS

Parameters	WS-RS	Spent WS-RS	Pooled SE
Digestion kinetic parameters for DM, %			
a**	14.14[a]	26.39[b]	2.74
b**	45.63[b]	29.94[a]	3.66
c**hr^{-1}	0.04[b]	0.02[a]	-
UDF	40.22	43.67	1.26
ED	40.66	41.47	0.77
TD**	58.01[b]	50.34[a]	1.80
PED**	56.58[b]	49.10[a]	1.75
AED*	35.60[b]	29.08[a]	1.69
RF*	26.37[a]	28.94[b]	0.66
Digestion kinetic parameters for NDF, %			
a	2.78	2.78	0.92
b**	54.88[b]	42.13[a]	3.04
C, hr^{-1}	0.04	0.04	-
UDF**	42.34[a]	55.09[b]	3.04
ED**	35.70[b]	29.93[a]	1.30
TD	60.11	64.33	1.68
PED	58.63	62.74	1.64
AED**	35.40[b]	29.63[a]	1.33
RF**	26.42[a]	28.60[b]	0.51

**P<0.01; *P<0.05.

a, Rapidly soluble fraction; b, potentially degradable fraction, c, degradation rate; UDF, undegradable fraction; ED, effective degradability; TD, true degradability; PED, potential extent of digestion; AED, apparent extent of digestion; RF, rumen fill; Figures with different superscript in a row differ significantly.

Table 2. *In- vitro* gas production and digestibility of nutrients in WS-RS and spent WS-RS

Parameters	WS-RS	Spent WS-RS	Pooled SE
NGP, ml/g	128.50[b]	74.82[a]	12.24
NDFD, %	33.76	19.32	4.46
TOMD, %	50.32	44.54	2.57
PF	2.74[a]	3.99[b]	0.36
Ammonical N, %	17.95	18.24	0.19

$P<0.01$. NGP, Net gas production; NDFD, neutral detergent fiber digestibility; TOMD, true organic matter digestibility; PF, partitioning factor; Figures with different superscript in a row differ significantly.

lower ($P<0.01$) insoluble but potentially degradable fraction (Table 1). The potentially degradable fraction of spent WS-RS was degraded at a faster rate ($P<0.01$) as compared to WS-RS. The undegradable fraction was comparable. The apparent and potential extent of digestion and true degradability of DM was higher ($P<0.01$) in WS-RS as compared to spent WS-RS. However, effective degradability of DM was not affected. The significantly ($P<0.01$) higher rumen fill value of spent WS-RS as compared to WS-RS predicted of lower voluntary intake of DM in spent WS-RS.

The digestion kinetic parameters for NDF revealed that the rapidly soluble fraction was comparable but potentially degradable fraction was higher ($P<0.01$) in WS-RS as compared to spent WS-RS (Table 1). But the rate of degradation of potentially degradable fraction was comparable in both the groups. The undegradable fraction was higher ($P<0.01$) in spent WS-RS. The effective degradability and apparant extent of digestion of NDF were higher ($P<0.01$) in WS-RS as compared to spent WS-RS, resulting in higher ($P<0.01$) rumen fill value in spent WS-RS.

The *in-vitro* gas production studies revealed that the net gas production was lower ($P<0.01$) in spent WS-RS as compared to WS-RS (Table 2). The digestibility of OM and NDF though low in spent WS-RS as compared to ordinary WS-RS but the differences were statistically non-significant. The ammonical-N was also comparable in both the groups. However, the partitioning factor was higher ($P<0.01$) in spent WS-RS as compared to WS-RS. The *in-sacco* and *in-vitro* gas production studies conclusively revealed that the spent straw due to heavy OM loss during mushroom cultivation had low nutritional worth as compared to WS-RS.

To make the rations isonitrogenous and isocaloric, 2 types of concentrate mixtures were prepared, i.e. high protein (Conc-I) and low protein (Conc-II) for supplementing to WS-RS and spent WS-RS respectively (Table 3). As obvious, the Conc-I had higher CP than Conc-II, but the OM content was comparable in the 2 concentrate mixtures. The higher NDF and hemicellulose content in Conc-II as compared to Conc-I was mainly due to higher level of rice bran (23.5 vs 15.0%) in Conc-II. The conventional non leguminous green fodder offered to animal of both the groups contained 8.8% CP, 81.6% OM, 74.1% NDF and 33.0% cellulose.

The *in vivo* studies conducted on goat kids revealed that the daily DM intake was higher ($P<0.05$) in spent WS-RS

Table 3. Composition of feedstuffs offered to goat kids during growth trial

	Conc-I (HP)	Conc-II (LP)	Green fodder
Ingredient composition,%			
Maize	25.0	30.0	
Mustard-cake	28.0	13.5	
Rice bran	15.0.	23.5	
Deoiled rice bran	29.0	30.0	
Mineral mixture	02.0	02.0	
Common salt	01.0	01.0	
Chemical composition,%DM basis			
Total ash	6.86	7.25	8.38
Organic matter	93.14	92.75	91.62
Crude protein	19.74	16.18	8.74
NDF	42.25	55.50	74.10
ADF	15.50	14.75	42.25
Cellulose	8.50	7.50	33.00
Hemicellulose	26.75	40.75	31.85

HP, High protein; LP, low protein.

Table 4. Effect of complete feed containing WS-RS or spent WS-RS on dry matter intake, digestibility of nutrients, blood profile and nitrogen utilization in goat kids

Parameters	WS-RS	Spent WS-RS	Pooled SE
DMI, kg/d*	0.65[a]	0.80[b]	0.04
Digestibility of nutrients,%			
DM	61.08	54.84	2.35
OM	64.47	56.58	2.84
CP	74.92	65.00	
NDF	55.04	48.48	3.98
ADF	41.76	30.99	3.26
Cellulose*	59.88[b]	35.23a	6.30
Hemicellulose	70.69	66.99	5.59
Blood profile, mg/dl			
Glucose	47.97	45.17	2.78
Total protein**, g/dl	5.90[b]	4.50[a]	0.33
Albumin, g/dl	2.57	2.67	0.11
Globulin**, g/dl	3.30[b]	1.83[a]	0.33
A/G*	0.80[a]	1.47[b]	0.17
Urea	39.57	30.37	3.69
Uric acid	1.00	0.73	0.14
Nitrogen utilization, g/d			
N-intake	12.97	14.28	0.44
Fecal-N*	3.91[a]	5.81[b]	0.50
Urinary-N	4.19	3.11	0.43
N-retained	4.87	5.36	0.46
N-retained as % Intake	37.41	37.70	3.22
Apparent BV,%	53.43	63.08	5.12

Figures with different superscript in a row differ significantly, $^{**}P<0.01$; $^{*}P<0.05$.

group as compared to conventional control group (Table 4). The digestibility of nutrients was low in spent straw group, but the differences between the 2 groups were statistically non-significant except that of cellulose which was significantly ($P<0.05$) depressed in spent straw group. The blood profile of the animals revealed that feeding spent WS-RS to the kids did not have any effect on blood glucose or urea concentration. But serum total protein and globulin concentrations were depressed ($P<0.01$), while the A:G ratio was significantly ($P<0.01$) higher in spent WS-RS fed group as compared to control group. The level of all the blood parameters was within the physiological limits. The daily N-intake was comparable to both the groups. The fecal-N excretion was higher ($P<0.05$) in spent straw group as compared to control group, mainly because mycelial cell wall N is poorly digested (Dias De Silva and Sundstol 1986, Bakshi *et al*. 1986, Makhdoomi *et al*. 1996). But the N-absorbed was utilized efficiently as indicated by low urinary-N excretion in spent straw group, resulting in comparable N-retention in both the groups. The N-retained as per cent of N intake was statistically comparable. The apparent biological value of protein was numerically higher in spent straw fed group but the differences were statistically non significant. The average daily live weight gain in kids in control (WS-RS) and experimental (spent WS-RS) groups was statistically comparable, i.e. 55.5 vs. 62.8 g/d.

It was concluded that though spent WS-RS had lower nutritional worth than WS-RS but could be incorporated in the complete feed of ruminants provided it is compensated for OM without any adverse effect on the voluntary DM intake, palatability, digestibility of nutrients, blood profile and N-utilization. Above all the conventional protein supplements could be spared for other species.

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