In-sacco Degradability of Dietary Combinations Formulated with Naturally Fermented Wheat Straw as Sole Roughage

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ABSTRACT : Twelve dietary combinations were prepared using 70 parts of fermented wheat straw (FWS) as the sole roughage supplemented with 30 parts of either the low protein concentrate mixture (Conc.-I), high protein concentrate mixture (conc.-II), maize grains (M), solvent extracted mustard cake (DMC), deoiled rice bran (DRB), uromol bran mixture (UBM), deep stacked poultry litter (DSPL), dried poultry droppings (DPD), M-DMC mixture (50:50), M-UBM mixture (50:50), M-DPD mixture (50:50) or M-UBM-DPD mixture (50:25:25) and evaluated by *in-sacco* technique. The above dietary combinations were also evaluated by changing the roughage to concentrate ratio to 60:40. The digestion kinetics for DM and CP revealed that FWS:DPD had the highest, whereas, the FWS:M-DMC had the lowest rapidly soluble fraction. The potentially degradable fraction was found to be maximum in FWS:M and minimum in FWS:DPD dietary combinations. The higher degradation rate of FWS:DRB and FWS:UBM combinations was responsible for their significantly ($p<0.05$) higher effective degradability as compared to other combinations. The highest undegradable fraction noted in FWS:M-UBM-DPD followed by FWS:DMC was responsible for high rumen fill values. The FWS:DRB, FWS:UBM and FWS:DPD combinations had higher potential for DM intake. The dietary combination with higher concentrate level (60:40) was responsible for higher potentially degradable fraction, which was degraded at a faster rate resulting in significantly higher effective degradability as compared to the corresponding dietary combination with low concentrate level (70:30). The low undegradable fraction in the high concentrate diet was responsible for low rumen fill values, which predicted of high potential for DM intake. Out of 24 dietary combinations, FWS with either of UBM, DRB, DMC, Maize, M-DMC or DPD in 70:30 ratio supplemented with minerals and vitamin A in comparison to conventional feeding practice (roughage and concentrate mixture) could be exploited as complete feed for different categories of ruminants. ***(Asian-Aust. J. Anim. Sci. 2002. Vol 15, No. 9 : 1307-1311)***

Key Words : Fermented Wheat Straw, Urea, Conventional/Non-conventional Protein, Energy Supplements, *In-sacco* Degradability

INTRODUCTION

The nutritive value of poor quality crop residues could be improved considerably by natural fermentation with urea (Bakshi and Langar, 1994). Such straw preparations supplemented with minerals and vitamin A could meet the energy and protein requirement for maintenance of adult ruminant (Bakshi et al., 1986) as well as could partly meet the growth requirements of young calves (Bakshi and Langar, 1990). Queries have been raised at various forums if the nutrient requirements of different categories of ruminants could be met by supplementing FWS with either energy, protein or combination of energy and protein supplements rather than conventional concentrate mixtures. The information available so far indicated that FWS supplemented with only cotton seed cake (Dahiya et al., 1991) or with low protein concentrate mixture (Lamba et al., 2002) could meet the nutrient requirements of lactating buffaloes. Therefore, this study was conducted to evaluate and to work out the digestion kinetic parameters for such dietary combinations in order to develop complete feed for different categories of ruminants.

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MATERIALS AND METHODS

Processing of feedstuffs

Preparation of naturally fermented wheat straw (FWS) : Urea and wheat straw (3.5:96.5) was moistened to 40 percent and stacked for 9 d natural fermentation. In a batch, 14 kg urea was dissolved in 200l water, uniformly sprinkled on 386 kg wheat straw, mixed and stacked for 9 days (Bakshi et al., 1987) before use.

Preparation of uromol bran mixture (UBM) : Urea and molasses (1:3) were boiled for 30 min on slow heat and thereafter mixed with equal parts of deoiled rice bran, while the mixture was still hot.

Dried poultry droppings (DPD) : Poultry droppings collected on polyethylene sheet kept under the cages of laying birds were dried in a forced air oven at 60°C for 48 h and ground.

Deep stacked poultry litter (DSPL) : Rice husk based poultry litter collected from the shed of laying White Leghorn pullets was mixed and deep stacked in a shed for 28 days (Bakshi et al., 1995) before use. For the first 9 days, the stack temperature was recorded at 24 h interval, thereafter at 72 h interval for the next 19 days.

Dietary combinations

Twenty-four dietary combinations were prepared by using FWS as sole roughage with different conventional or non-

conventional energy, protein or energy and protein supplements mixed in 70:30 and 60:40 ratio (Table 1).

Chemical analysis

The different dietary combinations were analysed for total ash, crude protein (AOAC, 1984), cellulose (Crampton and Maynard, 1938) and neutral detergent fibre (Robertson and VanSoest, 1981).

***In sacco* evaluation**

The *in sacco* degradability was assessed by nylon bag (8×17 cm; 50±10 μm pore size) technique (Mehrez and Orskov, 1977). The bags containing 3 g ground test sample in triplicate were incubated in the ventral sac of the rumen of 3 adult rumen fistulated male buffaloes (live weight 332±17 kg). The animals were maintained on 2.0 kg concentrate mixture (maize 15, wheat 15, solvent extracted mustard cake 20, solvent extracted groundnut cake 10, rice bran 10, solvent extracted rice bran 27, mineral mixture 2 and salt 1 part each), 5 kg wheat straw and 2 kg green fodder (*Trifolium alexandrium*) so as to meet their nutrient requirements (NRC, 1989). The bags taken out at 3, 6, 9, 12, 24, 36, 48 and 60 h after incubation were washed under tap water till the rinsing water became colourless. The bags after squeezing gently were dried at 55°C for 48 h in a forced air oven. The disappearance of DM was calculated from the amount incubated and left in the bag at each incubation period. The residue was also analyzed for N for determining its rate and extent of degradation in the rumen. The different digestion kinetic parameters for DM and CP were worked out (Orskov et al., 1988; McDonald, 1981; Van Eys, 1982). The data was analysed statistically by following 12x2 factorial design (Snedecor and Cochran, 1968).

RESULTS AND DISCUSSION

Chemical composition of dietary combinations

The high ($p<0.05$) total ash content in FWS:DSPL and FWS:DPD combinations (Table 2) was mainly because of high inorganic matter in DSPL (33.18%) and DPD (15.02%). The high total ash content was responsible for low ($p<0.05$) OM content in diets containing poultry excreta. The lowest ($p<0.05$) total ash content in FWS:M combination comparable with FWS:M-DMC was responsible for the highest OM content. The CP content in FWS:UBM combination was significantly ($p<0.05$) higher than all other combinations. The FWS:DMC and FWS:M-UBM combination followed the similar trend. The FWS:M diet had the lowest ($p<0.05$) CP content which was comparable with that of FWS:DSPL and FWS:M-DPD dietary combinations. As most of the feed ingredients used were solvent extracted, therefore, the EE content was found to be very low. But among the various dietary combinations, those containing maize had the highest ($p<0.05$) EE content (1.04 to 1.89%) followed by those containing either DRB or concentrate mixture. The dietary combinations containing DSPL had the lowest EE content. The FWS:UBM combination had the lowest ($p<0.05$), whereas, the FWS:DSPL combination had the highest ($p<0.05$) NDF content as compared to other dietary combinations. The total ash and CP content were significantly higher ($p<0.05$) when roughage to concentrate ratio was narrow (60:40) as compared to wider roughage to concentrate ratio (70:30). Reverse trend was observed in case of OM and cell wall constituents (Table 3). The roughage to concentrate ratio did not have any significant ($p<0.05$) effect on the EE content.

Digestion kinetics of dietary combinations

Dry matter : The FWS:DPD combination had the highest rapidly soluble fraction. The rapidly soluble fraction among FWS:DSPL, FWS:Conc-II, FWS:Conc-I, FWS:DMC and FWS:M-UBM combinations was statistically comparable, but significantly ($p<0.05$) higher than that of FWS:M, FWS:DRB, FWS:M-DMC and FWS:M-DPD combinations (Table 4).

The insoluble but potentially degradable fraction was

Table 1. Fermented wheat straw (FWS) used with different feedstuffs in 70:30 and 60:40 ratio.

1.	Concentrate mixture-I;	Maize 20, wheat 10, mustard cake* 18, rice bran* 44, molasses 5, mineral mixture 2, salt 1 part each.
2.	Concentrate mixture-II;	Maize 20, wheat 10, groundnut cake* 15, mustard cake* 20, rice bran* 27, molasses 5, mineral mixture 2, salt 1 part each
3.	Maize grain (M)	
4.	Deoiled mustard cake (DMC)	
5.	Deoiled rice bran (DRB)	
6.	Uromol bran mixture (UBM)	
7.	Deep stacked poultry litter (DSPL)	
8.	Dried poultry droppings (DPD)	
9.	M-DMC (50:50)	
10.	M-UBM (50:50)	
11.	M-DPD (50:50)	
12.	M-UBM-DPD (50:25:25)	

* Solvent extracted.

Table 2. Chemical composition of different dietary combinations irrespective of roughage to concentrate ratio (% DM basis).

Dietary combination	Ash	OM	CP	EE	Cellulose	NDF
FWS:Conc-I	9.46^{bc}	90.54^{bc}	10.47^{bc}	0.83^{bc}	28.95^{abc}	65.50^{abc}
FWS:Conc-II	9.36^{bc}	90.64^{bc}	11.52^{c}	0.85^{bcd}	30.00^{c}	65.05^{ab}
FWS:M	6.56^{a}	93.44^{d}	7.16^{a}	1.89^{g}	27.85^{ab}	65.60^{abc}
FWS:DMC	9.61^{c}	90.39^{b}	18.27^{d}	0.78^{b}	29.58^{bc}	67.80^{abc}
FWS:DRB	9.65^{c}	90.35^{b}	11.11^{bc}	0.88^{bcd}	29.28^{bc}	70.75^{bc}
FWS:UBM	9.18^{bc}	90.82^{bc}	28.68^{e}	0.72^{b}	27.95^{ab}	62.75^{a}
FWS:DSPL	17.00^{d}	83.00^{a}	8.96^{ab}	0.50^{a}	33.90^{d}	71.25^{c}
FWS:DPD	15.16^{d}	84.84^{a}	10.76^{bc}	0.77^{b}	29.78^{c}	69.70^{bc}
FWS:M-DMC	7.60^{ab}	92.40^{cd}	12.28^{c}	1.24^{ef}	28.30^{abc}	67.65^{abc}
FWS:M-UBM	8.92^{bc}	91.08^{bc}	15.94^{d}	1.37^{f}	27.30^{a}	67.50^{abc}
FWS:M-DPD	10.02^{c}	89.98^{b}	8.72^{ab}	1.05^{de}	29.95^{c}	69.80^{bc}
FWS:M-UBM-DPD	8.34^{abc}	91.66^{bcd}	12.68^{c}	1.04^{cde}	30.00^{c}	70.20^{bc}
Pooled SE	0.67	0.66	0.87	0.08	0.62	2.14

Mean values with different superscripts in the same column differ significantly ($P<0.05$).

Table 3. Effect of roughage to concentrate ratio irrespective of dietary combination on chemical composition (%, DM basis).

Component	Roughage:Concentrate		Pooled SE
	70:30	60:40	
Ash	9.49^{a}	10.66^{b}	0.27
OM	90.51^{b}	89.34^{a}	0.27
CP	11.46^{a}	14.63^{b}	0.36
EE	1.00	0.99	0.31
Cellulose	31.10^{b}	22.70^{a}	0.25
NDF	69.85^{b}	65.74^{a}	0.87

Mean value with different superscripts in the same row differ significantly ($p<0.05$).

observed to be maximum in FWS:M (70.5%) and minimum in FWS:DPD (28.36%) combination. The quality of FWS:DPD was improved significantly when maize was incorporated in such dietary combinations, mainly because of the increased availability of potential degradable fraction from 28.36 to 69.4% and the undegradable fraction decreased from 36.06 to 26.69%. However, the supplementation of maize in FWS:DPD dietary combination did not have any significant impact on the effective degradability may be because the degradation rate was comparable. When maize was supplemented with FWS:UBM dietary combination it improved its rapidly soluble fraction (8.85 to 17.40%). But decreased the insoluble but potentially degradable fraction from 70.25 to 52.70% as well as its degradation rate was considerably depressed (0.07 to 0.05). The total degradable fractions were comparable in the dietary combination in which the FWS was supplemented with either maize, DRB or UBM. The significantly ($p<0.05$) higher degradation rate of potentially degradable fraction was inturn responsible for significantly ($p<0.05$) higher effective degradability in FWS:UBM, FWS:DRB, FWS:M-DPD and FWS:Conc-II combinations as compared to rest of the dietary combinations.

The low total degradable fraction especially with slow degradation rate in FWS:M-UBM-DPD and FWS:DMC combinations were responsible for highest undegradable fraction resulting in maximum rumen fill values, respectively in the two dietary combinations. The rumen fill has been reported to be a good indicator for the prediction of voluntary dry matter intake of a feedstuff. The significantly low rumen fill values of FWS:DRB, FWS:UBM and FWS:M-DPD dietary combinations were responsible for their higher ($p<0.05$) potential intake. The FWS:DMC combination exhibited the minimum potential for DMI.

The narrow roughage to concentrate ratio (60:40) irrespective of dietary combination had higher potentially degradable fraction which was degraded at a faster rate resulting in significantly ($p<0.05$) higher effective degradability (Table 5). The low undegradable fraction in high concentrate dietary combination was responsible for low rumen fill value which inturn predicted higher potential for DM intake.

Crude protein : The FWS:UBM combination had the highest ($p<0.05$) rapidly soluble protein fraction mainly because of the nature of ingredients used in the preparation of UBM (Table 6). This dietary combination had the lowest potentially degradable protein fraction which was degraded at the highest rate. However, when maize was supplemented alone or in combination with DPD in FWS:UBM combination, it reduced the rapidly soluble fraction, improved the potential degradable fraction which was degraded slowly in the rumen, ultimately leading to low effective degradability of crude protein.

The FWS:M had the highest ($p<0.05$) insoluble but potentially degradable protein fraction which was degraded at the slowest rate ($p<0.05$) mainly because of the higher concentration of insoluble protein fractions (prolamins and glutelins) present in the maize grain, which are degraded slowly in the rumen (Wadhwa et al., 1998). That is why when maize was added with either DMC, UBM or DPD it led to increase in their undegradable protein fraction. Among the non-conventional feedstuffs the FWS:DSPL combination had the highest undegradable protein mainly because of the heat generated (67°C) during deep stacking of poultry litter.

Table 4. Effect of dietary combinations irrespective of roughage to concentrate ratio on the digestion kinetic parameters of DM (%)

Dietary combination	Rapidly soluble fraction	Potentially degradable fraction	Degradation rate	Undegradable fraction	Effective degradability	Rumen fill	Predicted intake (kg)
FWS:Conc-I	18.10^{ab}	54.80^{ab}	0.030^{a}	27.10^{ab}	48.24^{b}	24.30^{de}	5.87^{abc}
FWS:Conc-II	20.85^{ab}	50.00^{ab}	0.035^{ab}	29.12^{abc}	49.73^{bcd}	23.94^{cde}	5.88^{abc}
FWS:M	7.78^{a}	70.25^{b}	0.035^{ab}	21.97^{a}	49.23^{bc}	21.97^{abcd}	6.01^{abcd}
FWS:DMC	17.85^{ab}	42.60^{ab}	0.035^{ab}	39.55^{de}	43.33^{a}	25.74^{e}	5.22^{a}
FWS:DRB	8.50^{a}	59.50^{b}	0.070^{c}	32.01^{bcde}	52.18^{cd}	20.30^{ab}	7.07^{cd}
FWS:UBM	8.85^{ab}	60.25^{b}	0.070^{c}	30.88^{bcd}	53.27^{d}	19.78^{a}	7.26^{d}
FWS:DSPL	21.85^{ab}	43.30^{ab}	0.045^{abc}	34.79^{bcde}	49.23^{bc}	23.71^{bcde}	5.84^{abc}
FWS:DPD	35.55^{b}	28.36^{a}	0.060^{bc}	36.06^{cdef}	47.46^{b}	21.94^{abcd}	6.54^{bcd}
FWS:M-DMC	0.05^{a}	63.60^{b}	0.040^{ab}	37.94^{def}	42.98^{a}	23.42^{bcde}	5.96^{abc}
FWS:M-UBM	17.40^{ab}	52.70^{ab}	0.050^{abc}	29.89^{bc}	47.84^{b}	23.92^{cde}	5.84^{abc}
FWS:M-DPD	0.90^{a}	69.40^{b}	0.060^{bc}	26.69^{abc}	50.16^{bcd}	20.58^{abc}	6.95^{cd}
FWS:M-UBM-DPD	11.55^{ab}	44.80^{ab}	0.050^{abc}	43.67^{e}	40.74^{a}	25.45^{de}	5.38^{ab}
Pooled SE	8.58	9.78	0.009	2.49	1.24	1.13	0.41

Mean values with different superscripts in the same column differ significantly ($p<0.05$).

Table 5. Effect of roughage to concentrate ratio irrespective of dietary combination on digestion kinetic parameters of DM (%)

Digestion kinetic parameter	Roughage:Concentrate		Pooled SE
	70:30	60:40	
Rapidly soluble fraction	15.38	12.80	3.50
Potentially degradable fraction	51.47	55.12	3.99
Degradation rate	0.046	0.051	0.004
Undegradable fraction	33.14	32.31	1.02
Effective degradability	46.94^{a}	48.79^{b}	0.506
Rumen fill	23.16	22.69	0.46
Predicted intake (kg)	6.03	6.28	0.16

Mean values with different superscripts in the same row differ significantly ($p<0.05$).

Table 6. Effect of different dietary combinations irrespective of roughage to concentrate ratio on the digestion kinetic parameters of CP (%)

Dietary combination	Rapidly soluble fraction	Potentially degradable fraction	Degradation rate	Undegradable fraction	Effective degradability
FWS:Conc-I	40.00^{abc}	38.05^{cd}	0.02^{ab}	21.92^{cd}	58.23^{abc}
FWS:Conc-II	51.80^{cde}	27.00^{abcd}	0.025^{ab}	21.17^{bcd}	66.06^{cde}
FWS:M	35.70^{ab}	38.50^{d}	0.015^{a}	25.82^{cde}	51.36^{a}
FWS:DMC	41.65^{abc}	32.00^{bcd}	0.045^{bc}	26.31^{cde}	61.68^{bc}
FWS:DRB	42.80^{abcd}	33.50^{bcd}	0.055^{cd}	23.66^{cde}	65.74^{cd}
FWS:UBM	81.06^{g}	10.87^{a}	0.075^{d}	8.06^{a}	88.95^{e}
FWS:DSPL	48.85^{bcd}	21.70^{abc}	0.040^{abc}	29.48^{de}	62.78^{bc}
FWS:DPD	58.53^{de}	21.93^{abc}	0.055^{cd}	19.56^{bc}	74.02^{ef}
FWS:M-DMC	32.15^{a}	36.15^{cd}	0.040^{abc}	31.70^{e}	55.31^{ab}
FWS:M-UBM	76.50^{fg}	10.60^{a}	0.025^{ab}	12.90^{ab}	82.05^{fg}
FWS:M-DPD	55.75^{cde}	17.60^{ab}	0.035^{abc}	26.63^{cde}	65.90^{cd}
FWS:M-UBM-DPD	65.10^{ef}	15.55^{a}	0.020^{ab}	19.32^{bc}	71.62^{de}
Pooled SE	5.06	2.16	0.009	2.74	2.61

Mean values with different superscripts in the same column differ significantly ($p<0.05$).

It is always recommended to use both energy and protein supplements in the ration for better productive performance of livestock. In the present study, FWS used as a sole roughage, served as a good source of available ME, because of the breakdown of ligno-cellulose bond during fermentation which led to higher availability of free cellulose for microbial degradation in the rumen (Bakshi and Wadhwa, 1999). Therefore, when FWS was supplemented with any protein source like DMC, DRB or UBM it gave much better performance (as indicated by significantly higher ($p<0.05$) effective degradability) as compared to when FWS was supplemented with energy source like maize (Table 6).

The roughage to concentrate ratio irrespective of dietary combinations did not have any significant effect on the

Table 7. Effect of roughage to concentrate ratio irrespective of dietary combination on digestion kinetic parameters of CP (%)

Digestion kinetic parameter	Roughage:Concentrate		Pooled SE
	70:30	60:40	
Rapidly soluble fraction	50.49	54.49	2.07
Potentially degradable fraction	24.37	26.20	2.16
Degradation rate	0.039	0.036	0.004
Undegradable fraction	25.13^{b}	19.28^{a}	1.12
Effective degradability	64.66	69.22	1.06

Mean values with different superscripts in the same row differ significantly ($p<0.05$).

digestion kinetic parameters of crude protein (Table 7) except undegradable fraction which was 23% lower in high concentrate combination (60:40), may be because such diets had higher rapidly soluble fraction, potentially degradable fraction and effective degradability.

Keeping in view the above evaluation, the conventional protein sources (DMC or DRB), energy sources like maize and non-conventional feed resources (UBM or DPD) with FWS as sole roughage in comparison to conventional feeding practice (roughage and concentrate mixture) could be exploited as complete feed for production purposes.

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