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Nutritional characteristics of horticultural crop residues as ruminant feeds

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ABSTRACT

Various horticultural crop residues including vegetable (16) and fruit (9) crops consumed by the ruminants in Tripura, were evaluated in terms of proximate composition, cell wall constituents (CWC's), *in vitro* dry matter and organic matter digestibility (IVDMD and IVOMD) metabolisable energy (ME) levels. Most of the residues contained high moisture levels (82.61±1.05%). The overall average values for OM, CP, EE, CF, NFE and total ash were 91.48±0.34, 11.87±0.54, 2.94±0.10, 17.13±0.69, 59.54±1.00 and 8.52±0.33% (DM basis), respectively. About 65% of these had CP levels above 10%. Vegetable residues were comparatively richer in CP content (14.05±0.50%) than fruit residues (7.99±0.75%) while a reverse trend was observed for NFE (57.43±0.95 vs. 63.28±2.30%). The average values for NDF, ADF, hemicellulose, cellulose and ADL were 37.39±1.59, 22.66±0.87, 14.73±0.85, 15.88±0.64 and 4.44±0.25, respectively. The IVDMD values ranged from 53.25 to 82.61 (66.92±1.08%) and IVOMD from 54.53 to 84.58% (68.47±1.09%). The ME concentration averaged 8.37±0.12 MJ/kg DM ranging from 6.85 to 10.88 MJ/kg DM. There were large variations among different residues with regard to all the nutritional parameters studied. While NFE and EE contents had significantly positive correlation with IVDMD, IVOMD and ME values, however, CF, NDF and ADL showed significantly negative correlations with these parameters. ME levels were found positively correlated with IVDMD and IVOMD values. Thus, the majority of the horticultural residues possessed IVDMD/IVOMD values above 60% and ME above 7.5 MJ/kg DM indicating that they are having sizable nutritional value, however, their high moisture content and palatability needs to be taken care of, if they are used for livestock feeding.

Key words: Horticultural crop residues, Ruminant feeds

There is a chronic shortage of feeds and fodders in India and more so in Tripura where cultivation of fodder crops is quite meagre. Horticultural crop residues have a good potential for use in ruminant rations so that the gap between demand and supply of feeds and fodders could be lessened. India is the second largest producer of vegetables and fruits, however, hardly 2% of these are processed (Anonymous 2002) and about 33% is wasted during harvesting, marketing and processing (Gangadhar *et al.* 1993). High moisture content of these residues creats difficulty in preserving and using them as animal feed particularly during scarcity. Among various methods employed for preserving the horticultural residues, viz. freezing, drying, heat treatment, radiation or chemical treatment (Polan *et al.* 1968, Barry and Fennesy 1971, Parker and Krawshew 1982, Thakur and Sharma 1995, Atreja and Khan 2002), chemical treatment and sun drying appear to be less expensive and maintain the nutritive value (Lopez *et al.* 2000). Agro industrial horticultural residues have been utilized in concentrate mixture in variable proportions (Nour *et al.* 1981, Porte *et al.* 1993, El-Ghani 1999, Khattab *et al.* 2000, Atreja and Khan 2002, Khorsardnia and Yazdani 2007) and these proved to be having high feed conversion in animals (Akinbamijo *et al.* 2003). Since there is no information on availability and nutritive value of residues of horticultural crops in Tripura, therefore, these were assessed in the present study for various nutritional attributes in terms of proximate principles, cell wall constituents, *in vitro* DM and OM digestibility and metabolisable energy.

MATERIALS AND METHODS

Different horticultural crop residues (25) comprising vegetables (16) and fruits (9) were collected from different places including the agriculture farm, local weekly markets etc. These were then dried in a hot air oven at 70°C for 24h, ground to pass through 1 mm sieve and analysed for proximate principles (AOAC 1995) and cell wall constituents

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(Goering and Van Soest 1970). Studies on *in vitro* dry matter and organic matter digestibility (IVDMD and IVOMD) were carried out using 2–stage technique (Tilley and Terry 1963). Three rumen fistulated adult male cattle (BW=332.6±18.6 kg) fed according to their nutrient requirements (NRC 2001) were used as source of inoculum (rumen liquor) for *in vitro* digestibility and gas production studies as well.

For gas production (Menke *et al.* 1979), dried sample (200 mg) was introduced in 100 ml glass syringe and kept in the incubator at 39°C overnight. The following day, rumen contents were collected from 3 rumen fistulated adult male cattle before feeding at 8.00 AM into a pre- warmed (39°C) thermos flask and brought to the laboratory for further use. The rumen contents were blended in a blender while passing CO_2 and strained through a 2–layered muslin cloth. One part of this liquor was mixed with 2 parts of a buffer medium consisting of (added in order): 400 ml H_2O, 0.1 ml solution A (13.2g $CaCl_2.H_2O$, 10.0g $MnCl_2$. $4H_2O$, 1.0g $CoCl_2.6H_2O$, 8.0 g $FeCl_3.6H_2O$ and made up to 100 ml with H_2O), 200 ml solution B (35g $NaHCO_3$ and 4.0g NH_4HCO_3 in 1.0 litre H_2O), 200 ml solution C (5.7g Na_2HPO_4, 6.2g KH_2PO_4, 0.6 $MgSO_4.7H_2O$ and made up to 1.0 litre with H_2O) 1.0 ml resazurine solution (0.1% w/v) and 40 ml freshly prepared reduction solution (4 ml 1N NaOH, 625 mg $Na_2S.7H_2O$ and 95 ml H_2O). The mixture was kept under CO_2 in a water bath at 39°C and stirred using a magnetic stirrer.

Rumen liquor-buffer solution (30 ml) was pipetted into each syringe pre-warmed at 39°C. Any gas bubbles in the syringe were removed and syringes were incubated at 39°C. Blank set was also run simultaneously. The syringes were swirled at 1 h intervals for few hours after incubation and gas production was measured at 0, 2, 4, 6, 8, 12 and 24 h after incubation. Metabolisable energy values of horticultural residues were determined using gas production and their chemical composition (CP and EE) data using the equation from Menke *et al.* (1979). All the determinations in the study

Table 1. Proximate composition of horticultural crop residues used as ruminant feedstuffs in Tripura

Name	Botanical name	DM (%)	Per cent composition (DM basis)					
			OM	CP	EE	CF	NFE	Ash
Vegetable crop residues								
Cabbage waste	*Brassica oleracea capitata*	11.09	87.60	10.12	2.91	13.82	60.75	12.40
Cauliflower waste	*Brassica oleracea botrytis*	25.99	89.62	18.12	4.92	14.50	52.08	10.38
Pea pod waste	*Pisum sativum*	18.66	92.80	15.20	4.45	21.27	51.88	7.20
Dioscorea leaves	*Dioscorea alata*	30.04	93.59	7.82	2.62	15.12	68.03	6.41
Radish leaves	*Raphanus sativus*	9.22	85.70	12.80	2.10	9.98	60.82	14.30
Radish peels	*Raphanus sativus*	6.15	92.60	12.37	2.01	21.17	57.05	7.40
Bottle gourd peels	*Lagenaria siceraria*	5.28	94.54	8.62	3.40	15.49	67.03	5.46
Bottle gourd vine	*Lagenaria siceraria*	13.81	92.41	16.05	2.55	15.69	58.12	7.59
Pumpkin waste	*Cucurbita maxima*	18.23	94.58	15.12	3.98	14.79	60.69	5.42
Cucumber peels	*Cucumis sativus*	7.88	90.30	14.26	2.98	18.09	54.97	9.70
Sweet potato leaves	*Ipomoea batatas*	14.91	92.18	15.08	2.98	11.63	62.49	7.82
Brinjal waste	*Solanum melongena*	14.12	91.74	17.42	3.10	22.55	48.67	8.26
Ash gourd peels	*Benincase hispida*	8.57	93.13	11.64	3.35	20.91	57.23	6.87
Tapioca leaves	*Manihot esculenta*	26.71	91.25	16.43	2.54	22.88	49.40	8.75
Potato skin	*Solanum tuberosum*	14.28	90.33	12.75	3.40	9.34	64.84	9.67
Data plant	*Amaranthus hybridus*	16.50	87.26	20.95	2.54	18.98	44.79	12.74
Mean±SE		15.09	91.23	14.05	3.11	16.64	57.43	8.77
		±1.06	±0.39	±0.50	±0.12	±0.63	±0.95	±0.39
Fruit crop residues								
Banana leaves	*Musa paradiasca*	18.00	89.84	8.50	2.78	24.30	54.26	10.16
Banana peels	*Musa paradiasca*	9.77	85.25	6.45	3.23	10.09	65.48	14.75
Papaya leaves	*Carica papaya*	23.48	93.25	16.05	1.82	21.83	53.55	6.75
Jack fruit waste	*Artocarpus heterophyllus*	15.30	92.01	8.41	3.27	16.90	63.43	7.99
Jack fruit seeds	*Artocarpus heterophyllus*	45.85	91.50	12.17	4.01	17.81	57.51	9.50
Orange peels	*Citrus sinensis*	25.87	96.08	6.89	3.65	31.22	54.32	3.92
Pine apple waste	*Ananas comosus*	16.87	93.83	3.90	1.45	8.66	79.82	6.17
Pine apple crown	*Ananas comosus*	12.88	92.12	5.99	1.95	24.68	59.50	7.88
Mango peels	*Mangifera indica*	25.35	93.56	3.57	1.59	6.71	81.69	6.44
Mean ±SE		21.48	91.94	7.99	2.64	18.03	63.28	8.06
		±2.02	±0.59	±0.75	±0.18	±1.63	±2.30	±0.59
Overall mean ±SE		17.39	91.48	11.87	2.94	17.13	59.54	8.52
		±1.05	±0.34	±0.54	±0.10	±0.69	±1.00	±0.33

were carried out in triplicates.

RESULTS AND DISCUSSION

The information regarding common names, botanical names and proximate composition of the residues of the horticultural crops including vegetables and fruits used for ruminants feeding has been furnished in Table 1. The average DM content of these residues ranged from 5.28 (bottle gourd peels) to 45.85% (jackfruit seeds). Most of the residues contained DM below 20% indicating that these are high moisture feedstuffs and need proper conservation to avoid putrefaction and mould growth that could affect their nutritive value adversely. The CP concentration ranged from 3.90% in pineapple waste to 20.95% in *Amaranthus* plant with an overall average of 11.87±0.54%. In general, vegetable residues had higher CP (14.05±0.50%) as compared to fruit residues (7.99±0.75%). Further, it was also observed that about 65% of these feedstuffs contained more than 10% of CP. The highest level of EE was in cauliflower waste (4.92%) and the lowest in pine apple waste (1.45%) and the average value across all the residues was 2.94±0.10%. The CF content varied from 6.71% (mango peels) to 31.22% (orange peels) averaging 17.13±0.69%. Such values are lower compared with cultivated fodders and other agricultural crop residues. The mean value for NFE was 59.54±1.00% ranging from 44.79% (data plant) to 81.69% (mango peels). Generally, fruit residues were richer in NFE as compared to vegetable crop residues (63.28±2.30 vs. 57.43±0.95%). It could be seen that about 90% of the samples contained more than 50% of NFE indicating that they are very good sources of soluble carbohydrates. The proximate composition of these residues was consistent with the usual range for tropical feeds (Kearl 1982, Richard *et al.* 1989, Pond *et al.* 1995). Though many of the horticultural residues have not been analysed earlier elsewhere but the values of proximate principles in the feeds which are in common with other studies fell in the range (FAO 1975, Thakur and Bhatia 1985, Gupta *et al.* 1985, Chakraborti *et al.* 1988, Gupta *et al.* 1993, Khan and Atreja

Table 2. Cell wall composition, *in vitro* digestibility and metabolisable energy values of various horticultural crop residues used as ruminant feeds in Tripura

Name	Cell wall composition (% on DM basis)					*In vitro* digestibility (%)		ME (MJ/kg DM)
	NDF	ADF	HC	Cellulose	ADL	DM	OM	
Vegetable crop residues								
Cabbage waste	33.14	20.82	12.32	14.04	4.49	79.54	80.78	8.25
Cauliflower waste	31.22	23.45	7.77	18.88	3.56	82.35	84.33	9.60
Pea pod waste	55.97	34.74	21.23	25.55	5.68	66.20	67.54	8.01
Dioscorea leaves	33.19	21.16	12.03	14.08	4.87	55.28	56.82	7.66
Radish leaves	34.85	22.94	11.93	18.10	2.92	55.46	56.55	7.25
Radish peels	31.85	23.54	8.31	15.85	4.61	53.25	54.73	7.19
Bottle gourd peels	36.08	22.92	13.16	16.71	4.21	76.66	78.79	9.90
Bottle gourd vine	44.62	28.47	16.15	19.77	7.00	63.60	65.10	8.98
Pumpkin waste	26.00	19.64	6.36	10.81	6.83	73.29	74.93	8.80
Cucumber peels	37.02	23.00	14.02	17.83	3.17	71.30	72.59	8.65
Sweet potato leaves	49.05	31.42	17.63	21.18	7.42	59.44	61.32	7.38
Brinjal waste	47.70	22.08	25.62	14.04	6.24	61.59	63.75	7.63
Ash gourd peels	36.77	24.11	12.66	17.22	3.88	78.60	80.27	9.73
Tapioca leaves	36.52	16.94	19.58	12.47	3.46	59.25	61.00	7.85
Potato skin	23.51	12.06	11.45	6.22	2.32	65.20	66.35	7.35
Data plant	36.52	16.94	19.58	12.47	3.46	68.91	67.21	8.87
Mean±SE	37.13±1.35	22.77±0.78	14.36±0.75	15.45±0.65	5.63±0.23	66.74±1.33	68.25±1.34	8.32 ±0.14
Fruit crop residues								
Banana leaves	75.23	39.48	35.75	27.16	8.37	56.21	57.87	7.24
Banana peels	39.53	25.17	14.36	14.77	7.93	65.19	66.41	8.27
Papaya leaves	18.52	13.50	5.02	10.44	1.85	60.89	62.77	7.82
Jack fruit waste	43.44	35.37	8.07	23.07	7.29	72.15	73.89	9.56
Jack fruit seeds	39.56	20.75	18.81	16.20	1.35	82.61	84.58	10.88
Orange peels	14.61	9.98	4.63	6.21	2.38	63.74	64.84	7.67
Pineapple waste	30.95	18.57	12.38	15.01	2.02	74.76	76.65	9.16
Pineapple crown	57.86	29.48	28.38	22.30	4.18	53.40	54.60	6.85
Mango peels	21.09	10.06	11.03	6.51	1.61	76.25	78.11	9.28
Mean ±SE	37.87±3.40	22.48±2.02	15.39±2.00	15.74±1.39	4.11±0.55	67.22±1.87	68.86±1.91	8.46±0.24
Overall mean ±SE	37.39±1.57	22.66±0.87	14.73±0.85	15.88±0.64	4.44±0.25	66.92±1.08	68.47±1.09	8.37±0.12

001, Mekasha *et al.* 2002, Nouala *et al.* 2004, Gupta *et al.* 004a, Gupta *et al.* 2004b).

The NDF, ADF and hemicellulose content of horticultural esidues averaged 37.39±1.57, 22.66±0.87 and 14.73±0.85% DM basis), respectively (Table 2). The highest values were ecorded in banana leaves (75.23, 39.48 and 35.75%, espectively) and the lowest in orange peels (14.61, 9.98 and .63%, respectively). The mean cellulose content was 5.88±0.64% ranging from 6.21 (orange peels) to 27.16% banana leaves) while ADL content averaged 4.44±0.25 arying from 1.35 to 8.37% (Table 2). Thus, it was evident 1at these horticultural residues are lower in CWC's than ther feedstuffs like cultivated fodders, agricultural crop esidues and other feed resources like agricultural weeds Ranjhan 1980, Wadhawa and Bakshi 2005, Chander Datt *et l.* 2005, Chander Datt *et al.* 2006). Very few horticultural esidues have been analysed for CWC's earlier and such tudies are scanty (Thakur and Bhatia 1985, Chakraborti *et l.* 1988, Wadhawa and Bakshi 2005). The variation in hemical composition among the studies is expected because f differences in agro-climatic conditions, stage of harvesting nd processing technique.

The overall mean values for IVDMD and IVOMD were 6.92±1.08 and 68.47±1.09%, respectively (Table 2). The ighest DM and OM digestibility was observed in jack fruit eeds (82.61 and 84.58%) followed by cauliflower waste 82.35 and 84.33%), cabbage waste (79.54 and 80.78%), ash ;ourd peels (78.60 and 80.27%) and mango peels (76.25 and '8.11%), whereas the lower values were recorded in radish eels (53.25 and 54.73%), pine apple crown (53.40 and i4.60%) and *Dioscorea* leaves (55.28 and 56.82%). The ligestibility values for various horticultural residues were imilar to those reported by other workers, however, such nformation is scanty. For example, Thakur and Bhatia (1985) eported *in sacco* DM/OM value of 79.56/79.47 and 81.92/ 32.45% for radish leaves and cauliflower residue, espectively. The IVDMD values for cabbage waste, orange eels and banana peels have been reported to be 80.4, 82.6 ınd 72.9%, respectively (Mekasha *et al.* 2002). Similar to he present observations, Foulkes and Preston (1978) reported 55% DMD of banana peels *in vivo*. Nouala *et al.* (2004) bserved a range of 65.2–76.4% for *in vitro* true DM ligestibility in horticultural residues (4 No.). *In sacco* DM ligestibility ranged from 75.1 to 84.9% in 8 vegetable esidues studied (Wadhawa and Bakshi 2005). Vegetable esidues like sugar beet pulp could replace barley as energy ource to the extent of 75% without affecting IVDMD and ME values (Khorsardnia and Yazdani 2007).

The ME concentration averaged 8.37±0.12 ranging from 5.85 (pineapple crown) to 10.88 MJ/kg DM (jackfruit seeds). Cauliflower waste, bottle gourd peels, ash gourd peels, ackfruit waste, pine apple waste and mango peels contained ME more than 9.0 MJ/kg DM. Wadhawa and Bakshi (2005) eported ME concentration of 6.1–9.2 MJ/kg DM among 8 vegetable wastes. It could be seen that the majority of the fresh horticultural residues (about 70%) possessed IVDMD/IVOMD values above 60%, and ME level above 7.5 MJ/kg DM indicating that they are nutritionally good and have a good potential for ruminant feeding, however, their palatability and method of conservation may be explored.

Table 3. Correlation among different nutritional parameters

Parameter	NFE	EE	CF	NDF	ADF	ADL	ME
DMD	0.22*	0.43*	–0.33**	–0.30**	–0.20*	–0.22**	0.83**
OMD	0.23*	0.43**	–0.33**	–0.29**	–0.19	–0.22**	0.85**
ME	0.18	0.35**	–0.26*	–0.22*	–0.14	–0.22	1.00

The NFE and EE contents had positive correlation with IVDMD, IVOMD and ME levels of the feedstuffs, however, CF, NDF and ADL showed negative correlations with these parameters (Table 3). It was also observed that ME levels were highly correlated with IVDMD and IVOMD values (r=0.83 and 0.85; P<0.01).

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