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Nutritional evaluation of cannery and fruit wastes as livestock feed

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ABSTRACT

This study was taken up to assess the nutritional worth of cannery and fruit wastes for ruminants. Amongst the cannery wastes, pea pods (PP) had the highest CP content, sarsonsaag waste (SSW) had that of cell wall constituents (CWC). Carrot pulp (CARP) had the lowest CP, NDF, ADF and ADL contents. The water soluble sugars (WSS) were highest in CARP, while the true protein content and total phenolics were highest in citrus pulp without peels (CPWP).The *in-sacco*DM degradability revealed that CPWP had the highest effective degradability (ED) and low rumen fill values, which was responsible for higher DM intake potential and nutritive index value as compared to other cannery wastes. Amongst the fruit wastes, muskmelon peels (MMP) had the highest CP and CWC. The WSS were highest in MMP, the true protein in watermelon peels (WMP) and phenolics in banana peels (BP). WMP had the highest ED and the lowest rumen fill value, which was responsible for higher DM intake potential and nutritive index value. The relative proportion of albumin was highest, followed by that of glutelin, globulin and prolamin in all the cannery and fruit wastes. Most of these wastes could meet the daily requirements of macro and micro elements for ruminants, except Ca in SSW; Mg in MMP; Fe in CARP and BP; Cu in CARP, CPWP, BP and MMP; Zn in CARP and BP were higher than the maximum tolerance limit. None of the wastes contained the heavy metals above the maximum tolerance limit. It was concluded that most of the tested cannery and fruit wastes could serve as excellent alternate feed resource for ruminants.

Key words: Cannery and fruit wastes, *In sacco* degradability, Mineral profile, Protein fractions, Water soluble nutrients

India has 199 and 105 million cattle and buffaloes (ICAR 2012) producing 127 million tonnes of milk-highest in the world. Keeping in view 529.7 million livestock population, there is a shortage of 25, 159 and 117 million tonnes (mt) of concentrates, green forages and crop residues, constituting respectively a deficit of 32, 20 and 25% of the requirement (Ravi Kiran *et al*. 2012). To meet the nutrient requirements of livestock and to sustain their productivity under these conditions seems rather impossible; unless and until new non-conventional alternate feed resources are explored. In India the production of fruits has increased remarkably from 43.1 to 74.9 mt, while vegetables from 93.9 to 146.6 mt (NHB 2011) in the last decade (2000–2010) with a total production of 221.5 mt, second largest in the world (FAO 2012). At present, only 2.2% of fruits and vegetables produced in the country are processed (MOFPI 2007–08), thereby generating about 1.81 mt of fruit and vegetable wastes (Wadhwa and Bakshi 2013), posing a big problem for their disposal, which are dumped in the landfills/road sides, causing environmental hazards. But such non-conventional resources can act as excellent source of nutrients and can bridge the gap between demand and supply of nutrients for livestock to a great extent and can economize dairy farming. This study was therefore taken up to assess the nutritional value of a few fresh cannery and fruit wastes, to bridge the gap between demand and supply of nutrients for livestock.

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MATERIALS AND METHODS

The cannery wastes [empty pea pods (PP), carrot pulp (CARP), citrus pulp without peels (CPWP) and *sarson-saag* waste (SSW)] and fruit wastes [banana peels (BP), musk melon peels (MMP) and watermelon peels (WMP)] were procured free of cost, to assess their nutritional worth.

In-sacco degradability: For determination of *in-sacco* degradability and DM kinetic parameters, 3 male buffalo calves with permanent rumen fistulae maintained on 2 kg concentrate mixture supplemented with 4 kg green fodder and 6 kg wheat straw were used. The nylon bags (8 cm×17cm, 50±10mm) containing 5 g sample were incubated in the rumen for 2, 4, 6, 8, 10, 12, 24, 36, 48, 60 and 72h, in triplicate (Mehrez and Orskov 1977). The '0' h bags were not incubated in the rumen, but were washed in the same manner as incubated bags. The different digestion kinetic parameters like rapidly soluble fraction (a), insoluble but potentially degradable fraction (b), degradation rate (c), and effective degradability (ED) were calculated according to McDonald

(1981). The rumen fill was calculated according to Van Eys (1982). The DMI potential was calculated by using the equation of Orskov *et al.* (1988).

Analytical methods: The finely ground samples of different cannery and fruit wastes (in triplicate) were analyzed for CP and total ash (AOAC 1995), cellulose (Crampton and Maynard 1938), NDF, ADF and ADL (Robertson and Van Soest 1981). Hemicellulose was the difference between NDF and ADF. Water extract of fresh samples of vegetable waste was prepared by blending the test sample and distilled water in a 1:9 ratio and the filtrate was used for estimation of the water-soluble nutrients. Proteins in water extract were precipitated with equal volume of 60% TCA (kept at 4°C overnight). The precipitates were dissolved in 0.2 N NaOH and used for protein assay (Lowry *et al*. 1951). Supernatant was used for the estimation of total sugars (Dubois *et al*. 1956), reducing sugars (Nelson 1944) and phenolics (Swain and Hills 1963). The non-reducing sugars were calculated by difference between total and reducing sugars. The samples were defatted by using Soxhlet apparatus (AOAC 1995) and were fractionated into 4 protein fractions based on solubility (Monteiro*et al*.1982); water soluble (albumin), sodium chloride soluble (globulin), ethanol soluble (prolamin) and sodium hydroxide soluble (glutelins).

For the estimation of trace elements, the samples were digested (AOAC 1980) in triplicate with tri-acid mixture (HNO_3: H_2SO_4: $HClO_4$ in 15:2:4 ratio) initially at 120°C for one and a half hours and at 270°C for another 2 hours. The extractable aliquots were used for the estimation of Zn, Fe, Cu, Mn, Co, rare and heavy metals by atomic absorption spectrophotometer, calcium by AOAC (1995) and phosphorus by colorimetric method (Jackson 1987). The data of cannery and fruit wastes analyzed separately by completely randomized design (Snedecor and Cochran 1994) by using the software package SPSS (2007) version 16 and differences in mean were assessed by using Tukey's b test.

RESULTS AND DISCUSSION

The chemical analysis revealed that amongst the cannery wastes, the PP had the highest (P<0.05) CP content, lowest EE and ADL contents, CPWP had the highest OM, EE, lowest (P<0.05) hemicellulose and cellulose contents, while SSW had the highest (P<0.05) cell wall constituents (Table 1). The CARP had the lowest (P<0.05) CP, NDF, ADF and ADL contents. The lowest NDF content in CARP indicated higher DMI potential as compared to other cannery wastes. Amongst the fruit wastes, the BP had the highest (P<0.05) CP and lowest (P<0.05) EE contents, while the MMP had the highest (P<0.05) cell wall constituents, except cellulose, which was highest (P<0.05) in WMP.

Amongst the cannery wastes, the total sugars, reducing and non-reducing sugars content was highest (P<0.05) in CARP followed by CPWP, PP and lowest (P<0.05) in SSW (Table 2). However, the true protein content and total phenolics were highest (P<0.05) in CPWP followed by PP, CARP and lowest (P<0.05) in SSW. Amongst the fruit wastes, the total sugars, reducing and non-reducing sugars content was highest (P<0.05) in MMP followed by WMP and lowest (P<0.05) in BP, except that reducing sugars content was comparable between MMP and BP. However, the true protein content was highest (P<0.05) in WMP followed by BP and lowest (P<0.05) in MMP. BP had the highest (P<0.05) phenolics content followed by WMP and lowest (P<0.05) in MMP.

The fractionation of the true proteins, amongst the cannery wastes revealed that SSW had the highest (P<0.05) proportion of water soluble fraction (albumin), which was statistically comparable with that of CARP and PP, but higher than WMP (Table 3). PP had the highest (P<0.05) concentration of salt soluble (globulins) fraction, followed by CPWP and CARP, while SSW had the lowest globulin content. The alcohol soluble (prolamin) fraction was statistically comparable in PP, CARP and SSW, but lower

Table 1. Chemical composition of cannery and fruit wastes,% DM basis

Constituents	Cannery wastes				Pooled	Fruit wastes			Pooled
	PP	CARP	CPWP	SSW	SE	BP	MMP	WMP	SE
Total ash	8.04^{b}	7.5^{b}	4.5^{a}	6.9^{b}	0.27	11.1^{B}	14.9^{C}	7.9^{A}	0.24
OM	91.96^{a}	92.5^{a}	95.5^{b}	93.1^{a}	0.27	88.9^{B}	85.1^{A}	92.1^{C}	0.24
CP	19.80^{d}	7.2^{a}	10.5^{b}	15.01^{c}	0.10	8.1^{A}	9.5^{B}	7.9^{A}	0.14
EE	0.95^{a}	1.75^{b}	5.82^{c}	0.97^{a}	0.08	6.2^{B}	5.78^{B}	1.78^{A}	0.07
NDF	48.05^{c}	24.0^{a}	26.5^{b}	63.32^{d}	0.12	35.8^{A}	59.3^{B}	33.8^{A}	0.11
ADF	35.38^{c}	20.0^{a}	24.5^{b}	45.60^{d}	0.63	25.3^{A}	35.7^{C}	33.7^{B}	0.09
Hemicellulose	12.67^{b}	4.0^{a}	2.0^{a}	17.72^{c}	0.67	10.5^{B}	23.6^{C}	0.1^{A}	0.10
Cellulose	23.98^{c}	15.3^{b}	12.8^{a}	34.82^{d}	0.16	18.2^{B}	14.8^{A}	26.4^{C}	0.10
ADL	3.9^{a}	3.8^{a}	5.9^{b}	7.22^{c}	0.10	-	-	-	-

PP, Pea pods; CARP, carrot pulp; CPWP, citrus pulp without peels; SSW, *sarson-saag* waste; BP, banana peels; MMP, musk melon peels; WMP, watermelon peels; figures with different superscripts^{a,b,c,d} for different cannery wastes and superscripts^{A,B,C} for fruit wastes with in a row differ significantly, P<0.05.

Table 2. Water soluble nutrients in cannery and fruit wastes,%

Constituents	Cannery wastes				Pooled	Fruit wastes			Pooled
	PP	CARP	CPWP	SSW	SE	BP	MMP	WMP	SE
Total sugars	35.8^{b}	64.3^{d}	53.6^{c}	6.0^{a}	1.28	13.8^{A}	24.5^{C}	19.3^{B}	0.14
Reducing sugars	3.2^{b}	6.2^{d}	5.8^{c}	0.2^{a}	0.03	5.9^{B}	6.8^{B}	3.5^{A}	0.21
Non-reducing sugars	32.6^{b}	58.1^{d}	47.8^{c}	5.8^{a}	1.30	7.9^{A}	17.7^{B}	15.8^{C}	0.22
True protein	12.8^{c}	10.2^{b}	19.8^{d}	7.0^{a}	0.14	11.5^{B}	8.7^{A}	20.4^{C}	0.33
Phenolics	9.4^{c}	4.3^{b}	10.3^{d}	0.4^{a}	0.15	4.8^{C}	0.7^{A}	1.4^{B}	0.02

PP, Pea pods; CARP, carrot pulp; CPWP, citrus pulp without peels; SSW, *sarson-saag* waste; BP, banana peels; MMP, musk melon peels; WMP, watermelon peels; figures with different superscripts^{a,b,c,d} for different cannery wastes and superscripts^{A,B,C} for fruit wastes with in a row differ significantly (P<0.05).

Table 3. Different protein fractions in cannery and fruit wastes,%

Constituents	Cannery wastes				Pooled	Fruit wastes			Pooled
	PP	CARP	CPWP	SSW	SE	BP	MMP	WMP	SE
Albumin	59.34^{b}	61.30^{b}	38.42^{a}	63.84^{b}	1.35	78.14^{B}	67.84^{A}	64.42^{A}	0.80
Globulin	15.58^{c}	11.89^{b}	12.38^{b}	8.29^{a}	0.74	12.32^{B}	6.41^{A}	8.14^{A}	0.80
Prolamin	7.31^{a}	7.92^{a}	14.02^{b}	8.24^{a}	0.33	2.52^{A}	8.46^{C}	4.80^{B}	0.16
Glutelin	17.78^{a}	18.88^{a}	35.18^{c}	21.03^{b}	0.52	7.02^{A}	17.04^{B}	22.81^{C}	0.39

PP, Pea pods; CARP, carrot pulp; CPWP, citrus pulp without peels; SSW, *sarson-saag* waste; BP, banana peels; MMP, musk melon peels; WMP, watermelon peels; figures with different superscripts^{a,b,c,d} for different cannery wastes and superscripts^{A,B,C} for fruit wastes with in a row differ significantly (P<0.05).

(P<0.05) than CPWP. Similarly the alkali soluble fraction (glutelins) was the highest (P<0.05) in CPWP, followed by SSW and lowest in PP and CARP which were comparable. Amongst the fruit wastes, BP had the highest (P<0.05) proportion of albumin and globulins as compared to MMP and WMP, in which these protein fractions were statistically comparable. The prolamin fraction was highest (P<0.05) in MMP followed by WMP and lowest (P<0.05) in BP. The glutelin fraction was highest (P<0.05) in WMP, followed by MMP and lowest (P<0.05) in BP. Wadhwa *et al.* (2010) revealed that irrespective of protein supplements, the rumen degradability of globulin was highest, followed by albumin, glutelin and prolamin, reflecting theavailability of bypass protein in a particular cannery or fruit waste.

The mineral assay revealed that amongst cannery wastes SSW had the highest (P<0.05) concentration of Ca, statistically comparable with PP, while CARP had the lowest (P<0.05) content (Table 4). The P and Mg content was highest (P<0.05) in PP and lowest (P<0.05) in CPWP, whereas Na content was highest in CARP as compared to the rest of the cannery wastes, which were statistically comparable. Amongst the fruit wastes, MMP had the highest concentration of all the macro-elements, except that of K which was lowest. The P and Mg content were comparable with that of WMP. The highest concentration of K was observed in BP, followed by that in WMP and lowest in BP. Most of the cannery and fruit wastes could meet the daily requirements of macro-and micro-elements (NRC 2001) except a few like BP could not meet that of Ca, P and Na;CPWP of P; PP and CPWP could not meet the requirement of Na. ButCa in SSW and Mg in MMP were higher than the maximum tolerance limit (NRC 2001).

The micro-mineral assay revealed that amongst all the tested cannery wastes, CARP had the highest (P<0.05) concentration of Fe, Cu, Zn and Mn, while PP had the lowest (P<0.05) except that Mn concentration was lowest (P<0.05) in CPWP (Table 4). The Mo content in PP was comparable with that of CARP and SSW, but higher (P<0.05) than that in CPWP. The Co concentration was highest (P<0.05) in CPWP, followed by that in PP which was comparable with SSW, and lowest (P<0.05) in CARP. Amongst the tested fruit wastes, BP was the richest (P<0.05) source of all the trace elements, while WMP had the lowest (P<0.05) concentration. Most of the cannery and fruit wastes were very rich in trace elements and could meet their daily requirements (NRC 2001). However, the concentration of Fe in CARP and BP; Cu in CARP, CPWP, BP and MMP; Zn in CARP and BP were higher than the maximum tolerance limit (NRC 2001), suggesting that these should not be fed *ad lib*, rather should be supplemented in the ration of ruminants as source of organic nutrients.

Amongst all the tested cannery wastes, the CPWP had the highest concentration of Al, Ni and Pb, while CARP had that of Cr and Cd; PP had the highest concentration of As. Amongst the tested fruit wastes, BP had the highest concentration of Al, As, Cr, Cd and that of Cd, while WMP

Table 4. Mineral profile of cannery and fruit wastes

Constituents	Cannery wastes				Pooled	Fruit wastes			Pooled	Requirement	MTL
	PP	CARP	CPWP	SSW	SE	BP	MMP	WMP	SE		
Macro-elements,%											
Calcium	0.85^{ab}	0.42^{a}	0.49^{a}	1.42^{b}	0.20	0.29^{A}	0.62^{C}	0.47^{B}	0.01	0.44–0.80	1.00
Phosphorus	0.38^{b}	0.23^{ab}	0.14^{a}	0.22^{ab}	0.04	0.18^{A}	0.44^{B}	0.43^{B}	0.02	0.22–0.44	1.00
Magnesium	0.38^{b}	0.17^{a}	0.11^{a}	0.18^{a}	0.05	0.30^{A}	0.43^{B}	0.36^{AB}	0.02	0.11–0.29	0.40
Sodium	0.03^{a}	1.00^{b}	0.02^{a}	0.14^{a}	0.08	0.01^{A}	0.49^{C}	0.21^{B}	0.03	0.10–0.34	1.6
Potassium	0.63^{b}	0.45^{a}	0.66^{b}	0.64^{b}	0.04	1.11^{C}	0.44^{A}	0.74^{B}	0.03	0.5–1.24	3.00
Sulphure	0.21	0.22	0.14	0.29	0.04	0.27	0.29	0.18	0.03	0.2	0.4
Micro-elements, ppm											
Iron	237^{a}	1816^{d}	893^{c}	389^{b}	9.94	2947.0^{C}	226.0^{B}	185^{A}	6.06	12–28	1000
Copper	7.56^{a}	228.2^{c}	138.6^{b}	11.39^{a}	5.63	386.0^{C}	54.43^{B}	4.85^{A}	1.27	10–18	40
Zinc	27.25^{a}	710.0^{c}	430.0^{b}	35.97^{a}	9.03	1138.0^{B}	40.03^{A}	39.31^{A}	1.83	21–73	540
Manganese	23.16^{b}	292.77^{c}	0.02^{a}	25.96^{b}	2.51	522.0^{C}	20.40^{B}	14.36^{A}	1.31	13–24	1000
Molybdenum	3.32^{b}	2.39^{b}	0.52^{a}	2.39^{b}	0.31	3.32^{B}	2.49^{B}	0.83^{A}	0.31	-	10
Cobalt	6.38^{b}	3.36^{a}	27.3^{c}	6.17^{b}	0.22	6.03^{B}	5.98^{B}	3.85^{A}	0.20	0.11	10
Heavy elements, ppm											
Aluminium	218.0^{b}	297.0^{c}	833.0^{d}	139.0^{a}	8.03	180.0^{B}	143.0^{A}	137.0^{A}	3.42	-	1000
Arsenic	3.14^{b}	2.09^{a}	1.39^{a}	1.74^{a}	0.20	3.84^{B}	2.44^{AB}	1.05^{A}	0.34	-	50
Chromium	0.93^{a}	10.38^{c}	6.36^{b}	1.68^{a}	0.40	17.37^{B}	1.34^{A}	1.03^{A}	0.41	-	1000
Nickel	9.52^{b}	7.55^{a}	13.07^{c}	8.51^{ab}	0.45	12.67	12.15	12.92	0.50	-	50
Cadmium	0.17^{a}	0.42^{c}	0.22^{ab}	0.35^{bc}	0.04	0.57^{B}	0.38^{AB}	0.25^{A}	0.06	-	0.50
Lead	5.28^{a}	5.33^{a}	7.66^{b}	5.95^{ab}	0.44	7.24^{B}	4.50^{A}	3.78^{A}	0.43	-	30.0

PP, Pea pods; CARP, carrot pulp; CPWP, citrus pulp without peels; SSW, *sarson-saag* waste; BP, banana peels; MMP, muskmelon peels; WMP, watermelon peels; figures with different superscripts^{a,b,c,d} for different cannery wastes and superscripts^{A,B,C} for fruit wastes with in a row differ significantly P<0.05.

Table 5. Digestion kinetic parameters for DM in cannery and fruit wastes,%

Parameters	Cannery wastes				Pooled	Fruit wastes			Pooled
	PP	CARP	CPWP	SSW	SE	BP	MMP	WMP	SE
Rapidly soluble fraction (a)	36.58^{bc}	29.51^{b}	46.13^{c}	8.66^{a}	2.95	26.14	33.00	24.04	5.44
Potential degradable fraction (b)	45.75^{a}	68.22^{b}	49.80^{a}	66.60^{b}	2.82	63.42^{AB}	47.77^{A}	68.53^{B}	5.17
Degradation rate (c)	0.06^{a}	0.09^{b}	0.12^{c}	0.06^{a}	0.01	0.10	0.09	0.11	0.01
Undegradable fraction (UDF)	17.67^{b}	2.27^{a}	4.07^{a}	24.73^{c}	0.69	10.44^{B}	18.23^{C}	7.43^{A}	0.47
Effective degradability (ED)	68.12^{b}	84.01^{c}	87.59^{d}	55.42^{a}	0.61	77.02^{B}	71.95^{A}	80.09^{C}	0.41
True degradability (TD)	68.93^{a}	79.65^{b}	83.20^{c}	69.91^{a}	2.08	79.98	79.94	81.06	2.34
Rumen fill	17.56^{b}	9.06^{a}	8.23^{b}	19.20^{b}	0.62	11.54^{AB}	14.75^{B}	10.17^{A}	0.98
Potential DM intake (kg/d)	9.25^{a}	12.20^{b}	13.05^{b}	8.89^{a}	0.30	11.68	10.98	12.40	0.59
Nutritive index value,%	66.06^{b}	76.81^{c}	90.87^{d}	47.30^{a}	0.54	71.95^{A}	72.37^{AB}	74.31^{B}	0.65

PP, Pea pods; CARP, carrot pulp; CPWP, citrus pulp without peels; SSW, *sarson-saag* waste; BP, banana peels; MMP, muskmelon peels; WMP, watermelon peels; figures with different superscripts^{a,b,c,d} for different cannery wastes and superscripts^{A,B,C} for fruit wastes with in a row differ significantly P<0.05.

had the lowest concentration. None of the cannery and fruit wastes were found to contain the heavy metals above the maximum tolerance limit (NRC 2001).

The *in-sacco* DM degradability of cannery wastes revealed that CPWP had the highest (P<0.05) rapidly soluble fraction followed by PP, it was lowest in SSW (Table 5). The insoluble but potentially degradable fraction was highest (P<0.05) in CARP, comparable with that of SSW and CPWP, lowest in PP. The highest degradation rate of this fraction observed in CPWP, which was responsible for highest (P<0.05) effective degradability followed by that of CARP and lowest in SSW. SSW had the highest undegradable fraction, followed by PP, CPWP and lowest in CARP. The CPWP had the lowest rumen fill values, followed by that in CARP, while the highest rumen fill values were observed in SSW. The low rumen fill values in CPWP and CARP predicted higher DM intake potential and nutritive index value as compared to PP and SSW. The nutritive value of empty PP in goat bucks (Wadhwa *et al.*

2006) and SSW in male buffaloes (Bakshi *et al.* 2005) were comparable to conventional green oats (*Avina sativa*) fodder. Earlier studies also revealed that leaves of cauliflower, cabbage and raddish can be fed fresh (Wadhwa and Bakshi 2005) or after ensiling with wheat or rice straw in 70: 30 ratio (Bakshi *et al*. 2007).Citrus pulp is considered as a safer feed than cereals for animals fed high-concentrate, low-roughage diets as in high-yielding dairy cows (Crawshaw 2004). Dried citrus pulp can replace 20% concentrate in dairy cattle (Assis *et al.*2004) and up to 30% in lactating ewes (Fegeros *et al.*1995) without affecting DM intake, rumen metabolites, digestibility, milk yield or milk protein and fat contents.

Amongst different fruit wastes, the rapidly soluble fraction and degradation rates of fruit wastes were comparable. The insoluble but potentially degradable fraction was highest ($P<0.05$) in WMP, comparable with that of BP and lowest in MMP. The MMP had the highest undegradable fraction, followed by BP and lowest in WMP. The WMP had the highest ED followed by BP and lowest in MMP. The WMP had the lowest rumen fill values, followed by that in BP, while the highest rumen fill values were observed in MMP. The low rumen fill values in WMP and BP predicted higher DM intake potential. The nutritive index value was highest in WMP, comparable with MMP, while BP had the lowest NIV. It was concluded that most of the tested cannery and fruit wastes could serve as excellent alternate feed resources for ruminants.

REFERENCES

AOAC. 1995. *Official Methods of Analysis.* 16thedn. Association of Official Analytical Chemists, Arlington, Virginia, USA.

Assis A J, Campos J M S, Filho S, Queiroz A C, Lana R, Euclydes R F, Neto J M, Magalhaes A L R and Mendonca S. 2004. Citrus pulp in diets for milking cows. 1. Intake of nutrients, milk production and composition. *Revista Brasileira de Zootecnia* **33**: 242–50.

Bakshi M P S, Kaushal S and Wadhwa M. 2005. Potential of *sarson-saag* waste " A canneryw aste as ruminant feed. *Asian Australian Journal of Animal Sciences* **18**: 479–82.

Bakshi M P S,Wadhwa M, Kaushal S and Ameir A A. 2007. *In vitro* evaluation of ensiledfruit and vegetable wastes. *Indian Journal of Animal Nutrition* **24**: 12–15.

Crawshaw R. 2004. *Co-product Feeds: Animal Feeds from the Food and Drinks Industries.* Nothingham University Press,

Crampton E W and Maynard L A. 1938. The relation of cellulose and lignin content to the nutritive value of animal feeds. *Journal of Nutrition***15**: 383–95.

Dubois M, Giles K A, Hamilton J K, Robert P A and Smith F. 1956. Colorimetric method for the determination of sugars and related substances. *Analytical Chemistry* **28**: 350–56.

FAO. 2012. *Food and Agriculture Organization Corporate Statistical Database (FAOSTAT).* Food and Agriculture Organization, Rome.

Fegeros K, Zervas G, Stamouli S and Apostolaki E. 1995. Nutritive value of dried citruspulp and its effect on milk yield and milk composition of lactating ewes. *Journal of Dairy Science* **78**: 1116–21.

Jackson M L. 1987. *Soil Chemical Analysis.* Prentice Hall of India, New Delhi.

Lowry O H, Rosebrough J N, Farr A L and Randall R J. 1951. Protein measurement with folin-phenol reagent. *Journal of Biological Chemistry* **193**: 265–90.

McDonald I. 1981 A revised model for the estimation of protein degradability in the rumen. *Journal of Agriculture Science* **96**: 251–52.

Mehrez A Z and Orskov E R. 1977. A study of artificial bag technique for determining the digestibility of feeds on the rumen. *Journal of Agriculture Science* **88**: 645–50.

MOFPI. 2007–08. *Annual Report.* Ministry of Food Processing Industries, Government of India. New Delhi.

NHB. 2011. *Indian Horticulture Database.* National Horticulture Board, Ministry of Agriculture, Government of India, New Delhi.

Nelson N. 1944. A photometric adaptation of the Somogyi method for determination of glucose. *Journal of Biological Chemistry* **153**: 375–80.

NRC. 2001. *Nutrient Requirements of Dairy Cattle.* 7th revised edn. National Research Council, National Academy of Sciences, Washington D C, USA.

Orskov E R, Reid G W and Kay M. 1988. Prediction of intake by cattle from degradation characteristics of roughages. *Animal Production* **46**: 29–34.

Ravi Kiran G, Suresh K P, Sampath K T, Giridhar K and Anandan S. 2012. *Modeling and forecasting livestock and fish feed resources: Requirements and Availability in India.* National Institute of Animal Nutrition and Physiology, Bengaluru.

Robertson J B and Van Soest P J. 1981. The detergent system of analysis and its application to human foods. *The Analysis of Dietary Fibre in Food.* (Eds) James W P T and Theander O. Pp. 123–58. Marcel Dekker Inc., New York, USA.

Snedecor G W and Cochran W G. 1994. *Statistical Methods.* Oxford and IBH Publications, New Delhi.

SPSS. 2007. *Statistical Packages for Social Sciences.* Version 16. SPSS Inc., Illinois, USA.

Swain T and Hills W E. 1963. The phenolic constituents of *Prunusdomesticus*. The quantitative analysis of phenolic constituents. *Journal Science and Food Agriculture* **10**: 63–68.

Van Eys J E. 1982. 'Ruminal digestion of tall fescue and fescue red clover herbage.' Ph D Dissertation, West Virginia University, Morgantown., USA.

Wadhwa M and Bakshi M P S. 2005. Vegetable wastes " A potential source of nutrients for ruminants. *Indian Journal of Animal Nutrition* **22**: 70–76.

Wadhwa M and Bakshi M P S. 2013. Utilization of fruit and vegetable wastes as livestock feed and assubstrates for generation of other value-added products. Food and Agriculture Organization, RAP Publication # 2013/04.

Wadhwa M, Kaur N and Bakshi M P S. 2010. Degradability of protein fractions of conventionaland non-conventional protein supplements. *Animal Nutrition and Feed Technology* **10**: 235–43.

Wadhwa M, Kaushal S and Bakshi M P S. 2006. Nutritive evaluation of vegetable wastes as complete feed for goat bucks. *Small Ruminant Research* **64**: 279–84.