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Nutritional evaluation of some ruminant feedstuffs by *in vitro* gas production technique

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ABSTRACT

The study was conducted to assess nutritional characteristics of some ruminant feedstuffs by using *in vitro* gas production technique. The commonly available feed samples of concentrates (n,18), dry (n,9) and green (n,28) roughages were collected from different parts of Gujarat. All the ground feed and fodder samples were analyzed for crude protein, ether extract, crude fiber, neutral detergent fiber, acid detergent fiber, total ash and acid insoluble ash. Metabolizable energy (ME) and total digestible nutrients (TDN) were estimated by incubating 200 mg of each of the samples with rumen mixed microbe inoculums for 24 h period, taken from fistulated buffaloes. Amongst concentrate feeds, safflower meal had lowest ME (7.21 MJ/kg DM) and TDN (48.80%) values, whereas, maize grain had highest ME (14.11 MJ/kg DM) and TDN (85.82%) values. Similarly, in dry roughages, rice husk had lowest and groundnut straw has highest ME (4.48 vs 8.93 MJ/kg DM) and TDN (22.23 vs 58.62%) values. The values of ME and TDN ranged from 5.05 to 9.15 MJ/kg DM and 37.23 to 59.24% in green roughages, with lowest in bamboo leaves and highest in mustard Chinese cabbage. Chemical composition and energy values reported for various feed and fodders in this communication could be used for formulating ration of field animals and under farm conditions for better utilization of these commonly available feed resources.

Key words: Feedstuffs, *In vitro* gas production, Metabolizable energy, Total digestible nutrients

Database on nutritive values, access and use of such information will have a significant impact on improved animal performance and productivity (Devendra and Leng 2011). The diversity in the nutritive value of different feedstuffs needs some easy and efficient method of their nutritional evaluation; therefore, some alternative laboratory methods are required. Recently the *in vitro* gas production technique has been proposed in use for determining fermentation kinetics of ruminant feed (Menke *et al.* 1979, Menke and Steingass 1988, Blummel and rskov 1993, Tessema and Baars 2004, Bohra *et al.* 2008). Datt *et al*. (2009) also used the *in vitro* gas production technique to evaluate nutritive values of leguminous and non-leguminous crops. With respect to concentrates, dry and green roughage feed resources available in Gujarat, limited information is available on the chemical composition and nutritive value. Due to the development of new plant varieties and change in cultivation and processing methods, there is need for estimating M E and TDN values of various feed ingredients, from time to time. Keeping these points in view, present study was designed to evaluate nutritive values of concentrates, dry and green roughage feed sources for ruminants using the *in vitro* gas production technique.

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MATERIALS AND METHODS

Sample collection: The commonly available feed samples of concentrates, dry and green roughages were collected from different parts of Gujarat. In concentrates maize (*Zea mays*), *jowar* (*Sorghum bicolor*), *bajra* (*Pennisetum glaucum*), broken rice (*Oryza sativa*), wheat bran (*Triticum spp.*), deoiled rice bran (*Oryza sativa*), rapeseed meal (*Brassica napus*), groundnut meal (*Arachis hypogaea*), soybean meal (*Glycine max*), cottonseed meal (*Gossypium spp.*), sunflower meal (*Helianthus annus*), guar korma (*Cyamopsis tetragonoloba*), mustard oil cake (*Brassica spp.*), safflower meal (*Carthamus tinctorius*), maize bran (*Zea mays*), soybean flakes (*Glycine max*), *Isabgol Lali* (*Plantago ovata*) and Isabgol Jeeraru were collected. Paddy straw (*Oryza sativa*), wheat straw (*Triticum spp.*), jowar straw (*Sorghum bicolor*), *bajra* straw (*Pennisetum glaucum*), maize straw (*Zea mays*),

sugarcane tops (*Saccharum officinarum*), groundnut straw (*Arachis hypogaea*), masoor straw (*Lens culinaris*) and rice husk (*Oryza sativa*) were collected as a dry roughages. Whereas, in green roughages bamboo leaves (*Filgueirasia arenicola*), rice bean (*Vigna umbellata*), hedge lucerne (*Desmanthus virgatus*), butterfly pea (*Centrosema molle*), stylo (*Stylosanthes guianensis*), *nandi* grass (*Setaria splendida*), siratro (*Macroptilium atropurpureum*), green panic grass (*Panicum maximum*), guinea grass (*Megathyrsus maximus*), rhodes grass (*Chloris gayana*), para grass (*Brachiaria mutica*), congo signal grass (*Brachiaria ruziziensis*), *dhaman* grass (*Cenchrus setigerus*), blue panic grass (*Panicum antidotale*), Hybrid Napier bajra CO3, Hybrid Napier bajra CO1, Hybrid Napier bajra PBN233, Hybrid Napier bajra PBN83, Hybrid Napier bajra PBN2, Hybrid Napier bajra PBN231, Hybrid Napier bajra RBC2, cowpea EC 4216, Hybrid Napier bajra CO4, guinea grass CO2, Hybrid sorghum (*Sorghum bicolor*×*Sorghum sudanense*), sugar beet (*Beeta vulgaris*), mustard-Chinese cabbage and mustard (*Brassica spp.*) were collected. All the feeds and fodder samples were ground to pass through 1 mm screen and analyzed in triplicate for dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF) and ash contents as per the methods of AOAC (1995). The cell wall constituents were estimated by the methods of Goering and Van Soest (1991).

In vitro *gas production technique:* For *in vitro* studies, rumen liquor was collected from two rumen cannulated adult male buffaloes (body weight = 589.6 ± 18.6 kg), strained through a 4–layered muslin cloth and pooled together which was used as inoculum source. The donor animals were fed 60% wheat straw and 40% concentrate according to their requirements (Kearl 1982). About 200 mg of feed sample was taken in a glass syringe and 30 ml of mixed buffered rumen liquor was added and incubated for 24 h, in a water bath at 39°C**.** Gas measurements were carried out at 0, 2, 4, 6, 8, 10, 12 and 24 h after incubation. Incubations were stopped at 24 h by dipping the syringes in cold water. All the determinations were carried out in triplicate. ME value of concentrates and roughages were calculated by using the prediction equations of Menke and Steingass (1988), whereas, TDN was calculated from ME value as per the equation of NRC (1989).

The prediction equations for concentrate feeds are:

ME (MJ/kg DM) = 1.06 + 0.1570×gas produced (ml/200mg DM) + 0.0084×CP (g/kg DM) + 0.022 × EE (g/kg DM) - 0.0081 × Ash (g/ kg DM)

For roughages:

ME (MJ/kg DM) = 2.20 + 0.13570 × gas produced (ml/200mg DM) + 0.0057×CP (g/kg DM)+0.00286 × $(EE)^2$ (g/kg DM)

ME (MCal/kg DM) = ME (MJ/kg DM)/4.184

TDN was calculated from ME value as per the following equation (NRC 1989).

TDN (%) = [ME (MCal/kg DM) +0.45]/ 0.0445309

RESULTS AND DISCUSSION

Composition of feeds and fodders: The chemical composition of different feeds and fodders are presented in Table 1. Generally, wide variations existed in the chemical composition of the investigated feedstuffs. Amongst concentrate feeds, CP content ranged from 8.10% for *jowar* grain to 45.37% for *guar korma*. EE content ranged from 0.06% for safflower meal to 11.76% for Isabgol Lali. Lowest neutral detergent fiber (NDF) and acid detergent fiber (ADF) were observed in maize grain whereas, highest in soybean flakes. Total ash content ranged from 1.00% for broken rice to 13.21% for deoiled rice bran. The chemical composition of concentrate feeds observed is in accordance with that of NRC (2001) and Mandal *et al.* (2003). CP content ranged from 2.85% for wheat straw to 12.00% for groundnut straw in dry roughages. EE content ranged from 1.02% for wheat straw to 2.32% for groundnut straw. Wheat straw contained highest NDF and ADF values whereas, *masoor* straw contained lowest NDF and ADF values. Total ash content ranged from 6.99% for groundnut straw to 19.45% for paddy straw. These results of chemical composition of straws corroborate the earlier reports of NRC (1982), Ranjhan (1998), Mandal *et al.* (2003) and Kumarmath *et al*. (2004).

Amongst green roughages, CP content ranged from 5.84% for *nandi* grass to 30.98% for mustard. EE content ranged from 1.07% for stylo to 4.89% for mustard. Total ash content ranged from 4.99% for stylo to 20.47% for mustard Chinese cabbage. Among all the feed and fodder samples, highest CP content was observed in *guar korma* (45.37%) followed by soybean meal (45.00%) and cottonseed meal (38.50%). Highest EE content was observed in Isabgol *lali* (11.76%) followed by cottonseed meal (9.30%) and mustard oilcake (9.17%). Highest NDF and ADF contents were observed in bamboo leaves and lowest in sugarbeet. The chemical composition and cell wall constituents of green roughages were in the range reported earlier by other workers (Ranjhan 1998, Kumarmath *et al.* 2004, Datt *et al.* 2009).

Energy values: Amongst concentrate feeds, safflower meal had lowest ME and TDN values, whereas, maize had highest ME and TDN values (Table 2). *Jowar*, *guar korma* and Isabgol *Lali* also had higher ME value in concentrates. Our results are in agreement with that of Ranjhan (1998) and Khanum *et al.* (2007). Amongst dry roughages, rice husk had lowest ME and TDN value, whereas, groundnut straw had highest ME and TDN value (Table 2). Ranjhan (1998) and Mandal *et al.* (2003) also reported similar ME and TDN values of straws as observed in present study.

Similarly, amongst green roughages, bamboo leaves had less ME and TDN values whereas, mustard Chinese cabbage had highest ME (9.15 MJ/kg DM) and TDN (59.24%) value (Table 2). The ME and TDN values of green roughages observed in present study are in agreement with that of Aka and Kamalu (2004),Jadhav *et al.* (2007) and Datt *et al.* (2009).

Table 1. Chemical composition of concentrates, dry and green roughages (% on DM basis)

Parameter	DM	CP	EE	CF	NDF	ADF	Total ash	AIA
Concentrates								
Maize (*Zea mays*)	92.10	9.39	3.66	8.60	13.55	3.57	1.28	0.89
Jowar (*Sorghum bicolor*)	92.09	8.10	2.53	11.09	16.55	5.95	2.67	1.03
Bajra (*Pennisetum glaucum*)	92.00	11.20	3.50	10.45	17.20	4.55	4.90	1.21
Broken rice (*Oryza sativa*)	87.60	8.80	1.70	0.90	22.60	10.95	1.00	0.54
Wheat bran (*Triticum* spp.)	94.16	17.06	3.47	15.12	63.50	15.50	5.91	1.98
Deoiled rice bran (*Oryza sativa*)	92.20	15.10	0.56	18.00	51.54	23.06	13.21	2.96
Rapeseed meal (*Brassica napus*)	93.49	37.62	0.84	8.51	22.50	17.55	8.89	1.02
Groundnut meal (*Arachis hypogaea*)	92.00	43.30	1.20	13.27	14.68	6.50	6.50	1.04
Soybean meal (*Glycine max*)	90.00	45.00	1.60	8.54	13.64	8.80	8.50	0.89
Cottonseed meal (*Gossypium* spp.)	92.00	38.50	9.30	7.47	28.50	20.00	8.10	0.80
Sunflower meal (*Helianthus annus*)	92.00	26.85	6.84	25.45	40.00	26.55	10.5	1.04
Guar korma (*Cyamopsis tetragonoloba*)	93.30	45.37	4.52	12.54	31.22	17.77	5.60	1.06
Mustard oil cake (*Brassica* spp.)	93.92	36.40	9.17	14.05	24.34	13.87	7.95	0.95
Safflower meal (*Carthamus tinctorius*)	81.25	35.24	0.06	10.40	44.85	32.08	6.66	1.12
Maize bran (*Zea mays*)	88.90	9.60	3.04	8.05	17.50	10.01	2.40	0.42
Soybean flakes (*Glycine max*)	93.88	13.38	5.04	27.07	67.20	50.00	4.93	1.05
Isabgol lali (*Plantago ovata*)	93.31	31.61	11.76	11.37	53.20	30.33	6.20	1.04
Isabgol jeeraru	92.08	17.19	2.62	32.10	56.95	31.62	2.21	0.54
Dry roughages								
Paddy straw (*Oryza sativa*)	90.85	3.54	1.65	42.58	69.80	46.30	19.45	2.54
Wheat straw (*Triticum* spp.)	92.87	2.85	1.02	35.47	79.12	54.92	10.48	1.02
Jowar straw (*Sorghum bicolor*)	91.58	3.94	1.84	34.58	77.46	49.57	12.41	2.08
Bajra straw (*Pennisetum glaucum*)	92.45	3.54	1.24	35.24	73.36	50.08	10.58	1.54
Maize straw (*Zea mays*)	91.24	3.68	1.84	33.24	71.20	42.50	11.24	0.87
Sugarcane tops (*Saccharum officinarum*)	93.36	5.73	1.32	32.00	69.53	43.53	8.50	3.80
Groundnut straw (*Arachis hypogaea*)	85.47	12.00	2.32	32.99	64.32	42.13	6.99	0.87
Masoor straw (*Lens culinaris*)	93.98	5.51	1.99	36.87	62.52	41.51	8.25	1.04
Rice husk (*Oryza sativa*)	89.78	2.94	1.15	28.01	68.70	42.01	15.38	12.20
Green roughages								
Bamboo leaves (*Filgueirasia arenicola*)	93.99	15.47	1.48	27.48	73.05	41.65	13.88	3.42
Rice bean (*Vigna umbellata*)	18.84	16.43	2.04	26.95	54.61	39.24	10.48	1.74
Hedge lucerne (*Desmanthus virgatus*)	28.22	18.75	2.79	22.42	42.45	31.84	6.27	0.48
Butterfly pea (*Centrosema molle*)	37.44	18.69	2.27	26.64	43.68	38.45	5.99	0.71
Stylo (*Stylosanthes guianensis*)	30.41	14.46	1.07	26.24	51.34	29.87	4.99	0.17
Nandi grass (*Setaria splendida*)	21.67	5.84	1.83	25.26	67.21	39.20	8.80	2.86
Siratro (*Macroptilium atropurpureum*)	24.80	13.06	1.61	23.29	55.60	41.55	8.11	1.72
Green panic grass (*Panicum maximum*)	18.77	10.54	1.51	25.30	63.81	35.62	11.11	4.24
Guinea grass (*Megathyrsus maximus*)	22.04	6.02	1.54	27.97	69.65	40.64	12.72	3.22
Rhodes grass (*Chloris gayana*)	33.68	8.85	2.12	25.99	53.74	31.47	11.18	4.51
Para grass (*Brachiaria mutica*)	16.23	22.97	3.14	16.30	71.57	41.15	13.28	2.19
Congo signal grass (*Brachiaria ruziziensis*)	61.37	13.29	2.30	21.09	64.19	36.18	12.55	3.43
Dhaman grass (*Cenchrus setigerus*)	29.04	10.49	2.05	23.85	63.29	40.07	10.29	9.12
Blue panic grass (*Panicum antidotale*)	19.25	10.90	1.71	20.95	62.45	36.73	11.21	4.06
Hybrid Napier bajra CO3	25.30	6.23	1.84	23.11	69.09	39.60	13.54	3.28
Hybrid Napier bajra CO1	20.83	9.93	2.91	23.40	66.37	39.22	13.33	3.57
Hybrid Napier bajra PBN233	18.06	14.71	3.19	20.77	67.53	36.80	13.44	2.97
Hybrid Napier bajra PBN83	25.34	19.65	2.81	24.19	68.44	39.34	10.28	2.61
Hybrid Napier bajra PBN2	23.54	13.36	2.90	20.79	70.05	40.13	12.11	2.81
Hybrid Napier bajra PBN231	22.12	10.38	2.19	26.60	69.95	39.54	9.62	2.31
Hybrid Napier bajra RBC 2	21.24	12.20	2.11	26.56	66.88	38.08	9.88	1.62
Hybrid Napier bajra CO4	22.34	13.37	3.29	25.64	67.81	37.80	12.82	3.10
Cowpea EC 4216	21.35	23.80	2.59	16.46	52.64	33.63	9.52	1.29
Guinea grass CO2	18.65	10.87	3.43	24.79	66.78	39.85	13.45	2.95
Hybrid sorghum (*Sorghum bicolor*× *Sorghum sudanense*)	24.57	14.30	2.42	25.69	71.31	41.34	10.57	2.32
Sugar beet (*Beeta vulgaris*)	20.14	23.59	4.64	6.94	16.90	7.98	15.63	2.06
Mustard-Chinese cabbage	54.84	28.55	2.66	7.39	28.38	17.34	20.47	5.05
Mustard (*Brassica* spp.)	24.15	30.98	4.89	7.53	33.48	18.98	12.90	1.80

Table 2. Energy values of concentrates, dry and green roughages predicted by using *in vitro* gas production technique

Name of feed*	ME (MJ/kg DM)		TDN (%)	
	Range	Mean ± SE	Range	Mean ± SE
Concentrates				
Maize (25)	13.40–14.62	14.11 ± 0.10	82.00–88.59	85.82 ± 0.52
Jowar (30)	12.66–14.08	13.76 ± 0.09	78.30–89.73	83.97 ± 0.50
Bajra (20)	12.20–13.30	12.61 ± 0.21	75.00–82.00	77.79 ± 1.12
Broken rice (12)	11.40–13.10	12.16 ± 0.20	71.30–81.10	75.39 ± 1.10
Wheat bran (25)	11.13–13.21	12.03 ± 0.18	69.83–81.01	74.65 ± 0.94
Deoiled rice bran (25)	7.60–8.40	8.03 ± 0.09	51.00–55.00	53.22 ± 0.51
Rapeseed meal (30)	9.37–11.70	10.62 ± 0.10	60.41–72.90	67.12 ± 0.55
Groundnut meal (11)	10.00–11.00	10.43 ± 0.09	64.00–69.00	66.07 ± 0.48
Soybean meal (13)	12.20–13.00	12.73 ± 0.06	76.00–80.00	78.41 ± 0.32
Cottonseed meal (30)	9.53–10.35	9.87 ± 0.04	61.25–65.67	63.08 ± 0.20
Sunflower meal (12)	8.50–09.20	8.80 ± 0.08	56.00–60.00	57.50 ± 0.41
Guar korma (18)	12.61–14.23	13.51 ± 0.13	77.77–86.48	82.63 ± 0.70
Mustard oil cake (30)	11.75–14.08	13.16 ± 0.11	73.15–85.70	80.76 ± 0.60
Safflower meal (12)	6.30–07.66	7.21 ± 0.13	45.31–51.20	48.80± 0.71
Maize bran (12)	8.03–09.48	8.50 ± 0.09	53.37–58.54	55.22± 1.08
Soybean flakes (12)	10.01–11.50	10.54 ± 0.11	64.45–68.14	66.71 ± 0.24
Isabgol lali (12)	12.50–14.04	13.22 ± 0.25	79.85–82.45	81.06 ± 0.47
Isabgol jeeraru (12)	10.45–12.47	11.72 ± 0.15	71.48–75.89	72.89 ± 1.42
Dry roughages				
Paddy straw (25)	5.31 – 6.40	6.01 ± 0.14	40.91 - 44.17	42.36 ± 0.38
Wheat straw (25)	5.40 – 6.90	6.25 ± 0.10	40.03 - 46.52	44.56 ± 0.54
Jowar straw (20)	7.03 – 8.48	8.14 ± 0.23	46.37 - 56.54	51.91 ± 1.08
Bajra straw (12)	5.70 – 7.10	6.31 ± 0.20	41.53 - 47.12	45.41 ± 1.10
Maize straw (12)	6.03 – 7.36	6.40 ± 0.19	45.45 - 49.01	47.44 ± 0.92
Sugarcane tops (12)	5.50 – 6.80	6.10 ± 0.14	44.13 - 45.99	43.61 ± 0.84
Groundnut straw (12)	7.56 – 9.01	8.93 ± 0.12	56.45 - 60.12	58.62 ± 0.88
Masoor straw (12)	5.43 – 6.92	6.29 ± 0.05	40.15 - 46.65	42.99 ± 0.70
Rice husk (15)	4.15 – 4.62	4.48 ± 0.15	18.85 - 25.13	22.23 ± 0.83
Green roughages				
Bamboo leaves (30)	4.38–5.95	5.05 ± 0.09	33.61–42.0	37.23 ± 0.47
Rice bean (9)	7.17–7.53	7.33 ± 0.04	46.47–50.09	47.92 ± 0.43
Hedge lucerne (9)	6.13–6.71	6.52 ± 0.03	41.50–45.69	43.86 ± 0.46
Butterfly pea (9)	6.93–7.55	7.24 ± 0.04	45.47–50.25	47.52 ± 0.46
Stylo (9)	7.30–8.84	7.92 ± 0.10	49.29–54.71	51.99 ± 0.67
Nandi grass (9)	6.50–7.68	6.97± 0.07	45.01–51.31	47.49 ± 0.72
Siratro (9)	6.50–7.68	6.85 ± 0.06	46.45–50.06	47.99 ± 0.54
Green panic grass (9)	6.33–7.44	7.12 ± 0.03	46.75–50.06	48.31 ± 0.33
Guinea grass (9)	6.30–6.89	6.60 ± 0.04	43.93–47.07	45.54 ± 0.34
Rhodes grass (9)	5.92–7.22	6.44 ± 0.08	41.89–48.85	44.69 ± 0.81
Para grass (9)	7.92–8.60	8.20 ± 0.05	52.60–56.24	54.13 ± 0.52
Congo signal grass (9)	7.31–7.87	7.55± 0.04	49.35–52.33	50.62 ± 0.36
Dhaman grass (9)	8.13–8.67	8.40 ± 0.03	53.73–56.65	55.21 ± 0.28
Blue panic grass (9)	5.35–5.92	5.70 ± 0.03	38.84–41.88	40.72 ± 0.33
Hybrid Napier bajra CO3 (9)	6.72–7.45	7.13 ± 0.04	46.20–50.10	48.36 ± 0.43
Hybrid Napier bajra CO1 (9)	6.92–8.09	7.46 ± 0.08	47.27–53.50	50.13 ± 0.81
Hybrid Napier bajra PBN233 (9)	6.99–7.66	7.30 ± 0.04	47.61–51.23	49.30 ± 0.37
Hybrid Napier bajra PBN83 (9)	7.69–8.47	8.15 ± 0.33	51.37–55.55	53.83 ± 0.32
Hybrid Napier bajra PBN2 (9)	7.21–8.02	7.55 ± 0.08	48.79–53.15	50.61 ± 0.44
Hybrid Napier bajra PBN231 (9)	6.80–9.41	7.41 ± 0.26	46.62–60.61	49.90 ± 1.39
Hybrid Napier bajra RBC 2 (9)	7.03 – 8.08	7.53 ± 0.11	47.86–53.48	50.53 ± 0.59
Hybrid Napier bajra CO_4 (9)	7.90–8.87	8.40 ± 0.11	52.52–57.70	55.20± 0.59
Cowpea EC 4216 (9)	7.20–8.10	7.71 ± 0.12	48.76–53.59	51.48 ± 0.64
Guinea grass CO2 (9)	7.05–7.87	7.53± 0.08	47.92–52.36	50.53 ± 0.44
Hybrid sorghum (9)	7.19–8.69	8.02 ± 0.18	48.68–56.76	53.17 ± 0.98
Sugar beet (9)	7.14–8.92	8.24 ± 0.12	51.66–57.98	54.31 ± 0.66
Mustard-Chinese cabbage (9)	8.63–9.74	9.15 ± 0.13	56.42–62.38	59.24± 0.70
Mustard (9)	8.12–9.12	8.76 ± 0.13	53.68–59.03	57.10 ± 0.69

*Figures in parenthesis indicate number of samples.

It is concluded based on the present study that maize, groundnut straw and mustard Chinese cabbage had highest ME and TDN values in concentrate, dry and green roughages, respectively. The crude protein and energy values of various feed resources may be referred while formulating balanced ration for the animals, for a particular level of milk production and physiological status.

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