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Nutritional Evaluation and Chemical Compositions of Feedstuffs for Ruminant Using *in vitro* Gas Production Technique

Uddin[1,2*] Md Jasim, Khandaker[2] Zahirul Haque, Khan[2] Md Jasimuddin and Islam[2] Md Nurul

ABSTRACT

Common feed resources were evaluated by chemically and *in vitro* gas production method. The rumen mixed microbe inoculums source was taken from fistulated native steers. The cumulative gas volume 24h after incubation was highly significant (p<0.01) and estimated Metabolizable Energy (ME) ranged 6 to11, 4 to 11 and 9 to 11 mega jule (MJ) kg^{-1} dry matter (DM) for legume, non-legume and concentrate feedstuffs respectively. Oil cake and whole grain maize and khasari possessed significantly higher (P<0.01) ME than bran. Crop residue, rice straw contained very low ME reflecting high acid detergent fiber (ADF). The non-legume grasses exhibited moderate gas volume and estimated comparatively medium ME. Similarly legume grasses exposed the greatest gas production and estimated highest (6-12 MJ kg^{-1}). Concentrates showed the great potentiality for crude protein (CP), digestible energy (DE) content and organic matter digestibility (OMD). The lowest ME value (3.8 MJ kg^{-1} DM) was found in rice bran among concentrates. Non legume grasses contained 38-48 % ADF, 52-54% neutral detergent fiber (NDF), 6-7.5 MJ kg^{-1} DM. The jamboo grass showed higher OMD, contained significantly higher ME (MJ kg^{-1}) followed by napier grass while maize and oat contained lower ME. All non-legume fodder contained 7-9.5% CP which was the highest CP (9.51%). Albeit, legume contained less ADF (30-46%) and NDF (34-55%) but higher CP (9.51%). The dhaincha was rich in CP content (26%) than bean or French bean and the ipilipil contained the lowest CP (16.71%). Concentrate feed stuffs maize, mustard oil cake, khasari and anchor husk had higher ME values (11.41, 11.54 and 10.92 $MJkg^{-1}$ DM respectively). The difference of ME of various feedstuffs reflected different contents of fermentable carbohydrates and available nitrogen in cereals and protein supplements. The CP contents were 7 to 9.5, 17 to 26 and 11 to 35.5 % for non-legume roughage, legume roughage and concentrate feedstuffs respectively. The khasari bran, jamboo fodder, alfalfa had the highest NDF and ADF values. The OMD ranged from 52 to 83 % for concentrate except rice bran; 46-56% for non-legume roughage, 50-80% for legume roughage. Results of the present study suggest that a wide nutritional variation are existing among feed sources and potential sources might be considered prior to feeding ruminants.

Key words: Feedstuffs, nutritive value, *in vitro* technique.

INTRODUCTION

The use of conventional feedstuffs and agricultural byproducts in animal feeding is a very common practice in developing countries like Bangladesh. Evaluating the nutritive value of these available feed resources are important as these could make an important contribution to the nutrition of livestock (Taphizadeh et al., 2008).The nutritive evaluation of feedstuffs are determined by the extent of digestion in rumen and the concentration of chemical compositions. Methods *in vivo* and *in sacco* are usually used to determine the rate and extent of digestibility that are expensive, laborious and need large quantities of feed, thereby make them unsuitable for routine feed evaluation. *In vitro* gas production is an alternative technique used to determine the nutritive value of feedstuffs, since rate and extent of degradation and rumen fermentation can be easily determined by measurement of cumulative gas production (Khazaal et al., 1995; Dhanoa et al., 2000; Sommart et al., 2000; Chumpawadee et al., 2007). Therefore, the gas production technique is considered for nutritive evaluation as it is economical, highly reproducible and an easy method, at the same time more samples can be analyzed (Herrero et al., 1996). The *in vitro* gas production system helps to better quantify nutrient utilization and its accuracy in describing digestibility in animals that had been validated in numerous experiments (Taphizadeh et al., 2008).

There is a relationship between a feed's gas production profile and in dry matter

* Corresponding author: jasimsau@gmail.com
[1]Department of Animal Nutrition, Sylhet Agricultural University, [2]Department of Animal Nutrition, Bangladesh Agricultural University, Mymensingh, Bangladesh.

digestibility (Sommart et al., 2000) and feed intake (Blummel and Ørskov, 1993; Blummel and Becker, 1997). Energy and protein content of ruminant feed sources are the important factors to take into consideration due to feed ration composes of energy and crude protein content approximately seventy and fifteen percent (Chumpawadee, 2002). When planning diet formulation, cost, chemical composition and digestibility of an energy feed source should be fully taken into account. Numerous varieties of feedstuffs are available in four agro-ecological zones of Bangladesh. However, there are insufficient information available regarding nutrients concentration for feeding the ruminant and formation of nutritional index of feedstuffs. Therefore, the aim of this study was to evaluate the feed stuffs for data library using the *in vitro* gas production technique.

MATERIALS AND METHODS

Chemical composition and nutritive values of available feed stuffs of four agro-ecological zones (high land, medium high land, plain land and plain but saline) of Bangladesh were studied and regarding this, feed ingredients were collected and analyzed. Besides, *in vitro* digestibility was done for nutritive evaluation of feedstuffs.

Feed samples and analysis

Standard questionnaire was prepared considering, availability of animals, categories of farmers and their practices to feed the animals, availability of feedstuffs, fodder cultivation practices and preservation techniques. Feed samples were collected during dry and wet season from two Upazillas of each two districts of high land, medium high land, plain land and plain but saline land of Bangladesh that are usually used by the countrymen for feeding their animals. The fresh green feed samples were collected, tagged and were carried to the Animal Nutrition laboratory, Bangladesh Agricultural University. Collected samples were firstly dried under the sun and were allowed for hot air oven dry at 65^0C up to constant weight. Samples were grinded and passed through a 1 mm sieve and stored in polythene bags at room temperature. These samples were analyzed chemically, as well as by *in vitro* gas method (Menke and Steingass, 1988).Grinded samples were labeled and stored for chemical analysis following AOAC (2006) method. Partitioning of ADF and NDF as well as Gross energy and nutritive values were measured allowing the procedure of Vansoest (1993) and Menke et al. (1997) procedure.

Gas production technique: The medium preparation was as described by Makkar et al. (1995). Mixed rumen fluid inoculums were obtained from native steer (weighed 200±10 kg). The animals were offered rice straw and green grass with concentrate mixture @ 1% of BW. A mixture of rumen fluid and particulate matter was collected into pre-warmed CO_2 filled beaker, transferred to the laboratory, homogenized in a laboratory blender and filtered through cheese cloth. All laboratory handling of rumen fluid was carried out under continuous flushing with CO_2. Feed samples (200 mg) were weighed in a small polypropylene weighing spoon, the spoon containing feed sample was fixed to a glass rod with a rubber adapter and finally the samples were transferred quantitatively to the closed end of the syringe. Each sample was taken in triplicate. With every batch of incubation, three syringes were taken as blank, 3syringes for concentrate reference standard and 3 for roughage reference standard. The syringes were kept in an incubator set at 39°C. Media was prepared and kept in water bath at 39°C and bubbled with CO_2 slowly for15 to 20 minutes. A total of 30 ml media consisting of10 ml rumen fluid and 20 ml of a bicarbonate-mineral distilled water mixture was injected into the syringes through the silicon tube. The gas bubbles were pushed out and the silicon tube was closed with the clamps. The gas produced was recorded at 12 and 24 hours of incubation.

Using chemical composition and net gas produced (GP, corrected for blank and the appropriate reference standard), at 24 hours incubation, metabolizable energy (ME, MJ kg^{-1}DM) and digestibility of organic matter (DOM) were calculated by using the following mathematical equations adopted from Menke et al. (1979) and Menke and Steingass (1988). For compound feed (grass, cereals and byproducts):

DOM (%) = 9 + 0.9991 GP + 0.0595 CP + 0.0181 ash

ME (MJ/Kg) = 1.06 + 0.1570 GP + 0.0084 CP

For roughages (forages and straws):

DOM (%) = 16.49 + 0.9042 GP + 0.0492 CP + 0.0387ash

ME (MJ/Kg) = 2.20 + 0.1357 GP + 0.0057 CP +0.0002859 EE

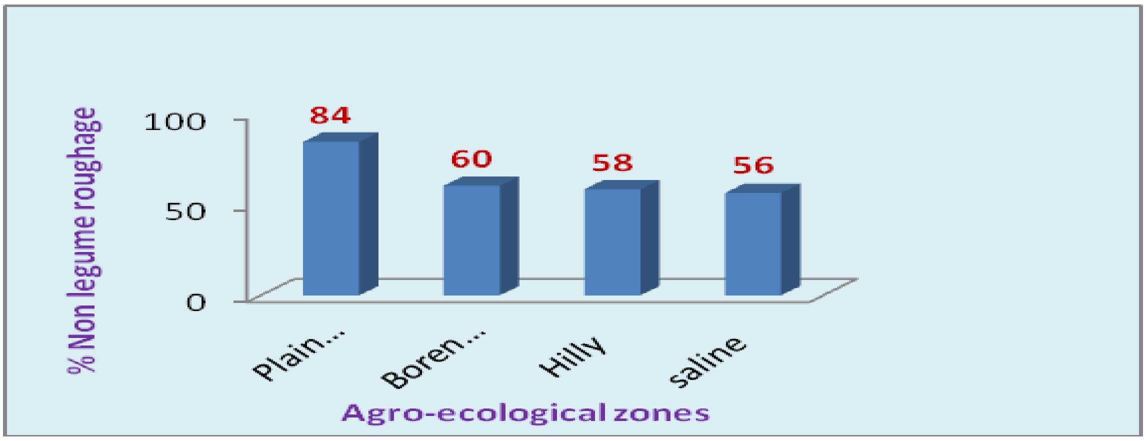
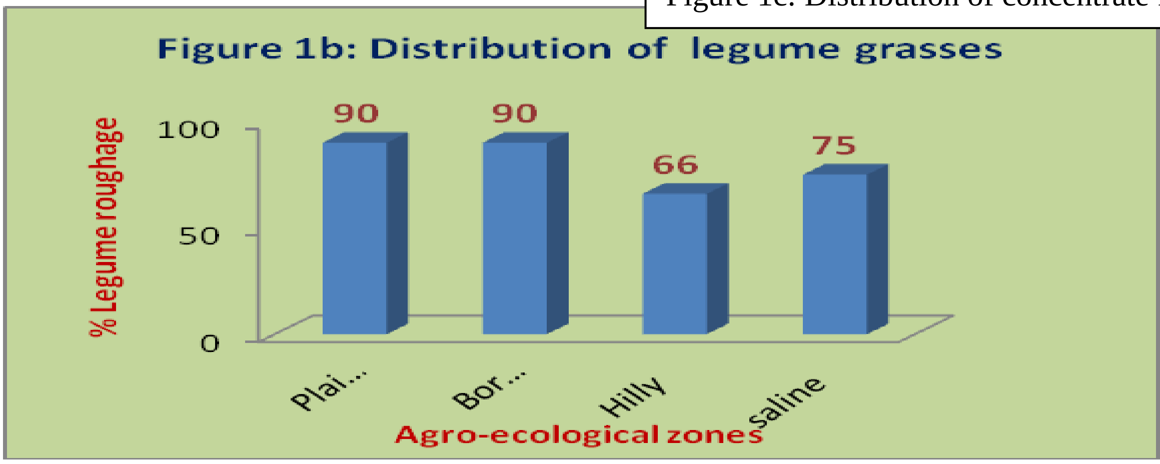


Figure 1a: Distribution of non legume grasses

Figure 1c: Distribution of concentrate feed ingredients



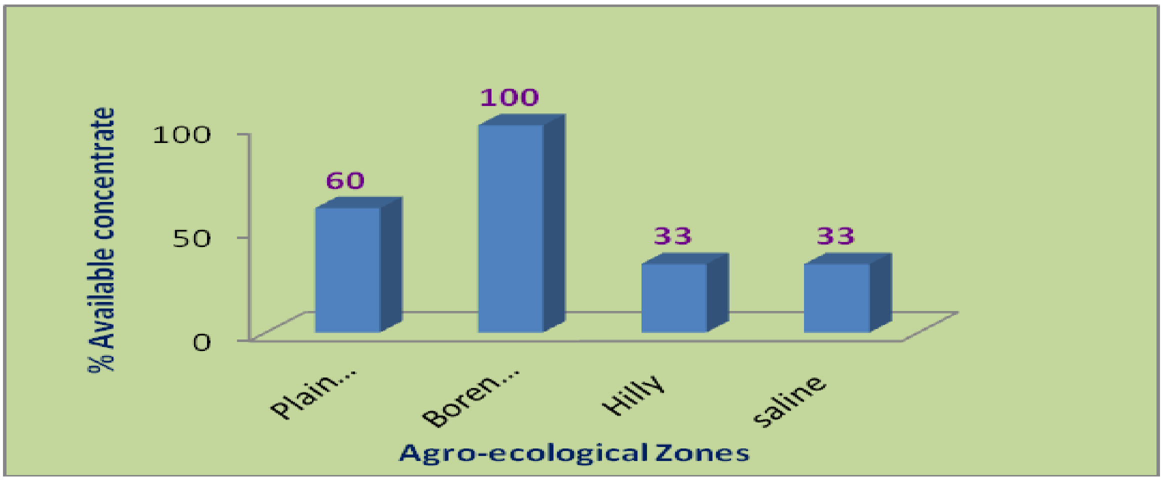
The rumen liquor was collected into the thermo flask that had been pre warmed to a temperature of 39^{0}C from the steer before they were offered the morning feed. Incubation procedure was as reported by Menke and Steingass (1988) using 120 ml calibrated transparent plastic syringes with fitted silicon tube. The sample weighing 200 [illegible] efully dropped into [illegible] er, 30 ml inoculums containing cheese cloth strained rumen liquor and buffer(gm L^{-1}) of 9.8 $NaHCO_3$ + 2.77 Na_2HPO_4 + 0.57KCl + 0.47 NaCl + 2.16 MgSO3 $7H_2O$ + 16 $CaCl_2.2H_2O$) (1:4 v/v) under continuous flushing with CO_2 was dispensed using another 50 ml plastic calibrated syringe. The syringe was tapped and pushed upward by the piston in order to completely eliminate air in the inoculums. Incubation was carried out at 39±1^{0}C and the volume of gas production was measured at 12 and 24 h interval.

ne grasses

Statistical analyses: All data obtained from the trials were subjected to the analysis of variance procedure of statistical analysis system (SAS, 2007) according to randomize completely block design. Means were separated by Duncan Multiple Range Test. The level of significance was determined at $p<0.05$.

RESULTS

Availability of roughage feed (Non-legume) was prevalent a plenty (84%) in plain area while other three experimental zones were around 60% (Figure 1a). On the other hand, figure 1b showed the feature of legume roughages that were usually consumed by the animals of selected zones. It is clear that plain and moderately high (Barandra) land zones were occupied alike and highest in amount (90%) followed by saline zone (75%) but hilly area had only 66%. Figure 1c



represents the status of concentrate feedstuffs fed to the animals among selected areas during experimental period. Farmers of Barandra area usually practiced all sorts (100%) of concentrate feed ingredients followed by plain land (60%). Farmers of hilly and saline region are comparatively less accustomed to use concentrate (33%) for feeding their animals.

Three types of concentrate of agricultural by products were found in feeding practice of animal, namely cereal brans (legume and non-legume), cereals (legume and non-legume) and oil cakes. Moreover, cereal crop residue, the basal feed of ruminants contributes more than 90% of bulkiness of ruminant feeding in Bangladesh.

The neutral detergent fiber (NDF), the index of bulk, was found having the lowest values for crushed khasari (25%) followed by lentil bran (42.63%), black gram bran (47.75%) and mung bran (47.81) as shown in Table 1. ADF had the negative reflection on organic matter digestibility (OMD). The low ADF remained the high digestibility. The crushed khasari contained the lowest ADF (13.44%) showed better digestibility (83.43% OMD). However, anchor bran showed rather better fiber (51.48%ADF, 57.8% NDF) with improved OMD value (75%) than other brans. Among the bran groups, anchor and khasari contained the highest portion of undigestible fiber part (cellulose and lignin) 51.48 and 50.99%ADF. Mung and black gram contained more or less the similar ADF around 31% while lentil bran constituted with a bit higher part of ADF (38%). In case of enzymatic degdradability of bran, anchor was the best (75%) followed by khasari (60%). Meanwhile, other brans were remained below 60%. On the contrary, for gross energy (GE) value, khasari, black gram

Table 1: Fiber content and nutritive values of concentrates and rice straw available in four agro-ecological zones

Feed ingredients	**ADF (%)**	**NDF (%)**	**DOM (%)**	**CP (%)**	**Energy (MJ/kg DM)**		
					GE	**DE**	**ME**
			Legume				
Lentil bran *Lenseulinaris*	$38.34^{c}\pm0.02$	$42.63^{d}\pm0.6$	$52.65^{e}\pm0.07$	$16.64^{c}\pm0.04$	$15.76^{ab}\pm0.5$	$8.84^{e}\pm0.2$	$6.309^{f}\pm0.02$
Mung bran *Phaseolusaureus*	$30.76^{e}\pm0.02$	$47.81^{c}\pm0.6$	$58.19^{d}\pm0.07$	$17.85^{b}\pm0.04$	$16.25^{ab}\pm0.5$	$9.95^{cd}\pm0.2$	$7.422^{d}\pm0.02$
Black gram bran *Phaseolusradiatus*	$30.87^{d}\pm0.02$	$47.75^{c}\pm0.6$	$57.87^{d}\pm0.07$	$17.9^{b}\pm0.04$	$16.37^{b}\pm0.5$	$9.85^{d}\pm0.2$	$6.993^{e}\pm0.02$
Khasari bran *Lathyrussativus*	$50.99^{b}\pm0.02$	$56.15^{b}\pm0.6$	$59.43^{c}\pm0.07$	$14.84^{d}\pm0.04$	$16.57^{ab}\pm0.5$	$10.07^{c}\pm0.2$	$7.749^{c}\pm0.02$
Khasari *Lathyrussativus*	$13.44^{f}\pm0.02$	$20.0^{e}\pm0.6$	$83.43^{a}\pm0.07$	$31.26^{a}\pm0.04$	$17.04^{a}\pm0.5$	$14.82^{a}\pm0.2$	$11.539^{a}\pm0.02$
Anchor husk *Cicerarietinum*	$51.48^{a}\pm0.02$	$57.80^{a}\pm0.6$	$75.08^{b}\pm0.07$	$10.66^{e}\pm0.04$	$15.99^{ab}\pm0.5$	$12.80^{b}\pm0.2$	$10.921^{b}\pm0.02$
SEM	2.40	2.28	2.00	1.16	0.07	0.38	0.36
LS				P<0.01			
			Non-legume				
Rice bran *Oryza sativa*	$51.08^{a}\pm0.04$	$62.10^{a}\pm0.11$	$32.97^{d}\pm0.04$	$8.95^{d}\pm0.05$	$15.56^{c}\pm0.06$	$5.68^{d}\pm0.05$	$3.8^{d}\pm0.06$
Rice polish *Oryza sativa*	$5.81^{c}\pm0.04$	$19.85^{b}\pm0.11$	$67.03^{c}\pm0.04$	$17.49^{a}\pm0.05$	$16.21^{b}\pm0.06$	$11.63^{c}\pm0.05$	$9.24^{c}\pm0.06$
Wheat bran *Triticumestivum*	$6.89^{b}\pm0.04$	$20^{b}\pm0.11$	$74.77^{b}\pm0.04$	$15.92^{b}\pm0.05$	$15.28^{d}\pm0.06$	$12.86^{b}\pm0.05$	$10.6^{b}\pm0.06$
Maize *Zea mays*	$4.14^{d}\pm0.04$	$13.74^{c}\pm0.11$	$77.29^{a}\pm0.04$	$9.66^{c}\pm0.05$	$16.48^{a}\pm0.06$	$13.19^{a}\pm0.05$	$11.41^{a}\pm0.06$
SEM	5.69	5.58	5.13	1.08	0.14	0.88	0.86
LS				P<0.01			
			Oil cake				
Mustard oil cake *Brassica campestris*	$20.14^{b}\pm0.1$	$23.87^{b}\pm0.01$	$76.69^{a}\pm0.03$	$35.66^{a}\pm0.03$	$19.38^{a}\pm0.06$	$14.43^{a}\pm0.02$	$11.11^{a}\pm0.03$
Til oil cake *Sesamumindicum*	$25.75^{a}\pm0.05$	$27.12^{a}\pm0.01$	$66.44^{b}\pm0.03$	$28.01^{b}\pm0.03$	16.26^{b}	$11.97^{b}\pm0.02$	$8.91^{b}\pm0.03$
SEM	1.98	1.15	3.62	2.70	1.10	0.87	0.78
LS				P<0.01			
			Crop residue				
Rice Straw *Oryza sativa*	53.41	6.95	**33.56**	4.41	14.50	5.17	3.380

and mung occupied a bit higher (16-16.5MJ) part than that of anchor or lentil (16MJkg^{-1}DM). In addition, value of digestible energy (DE) and metabolizable energy (ME), the anchor was also in topmost position (12.8 and 10.92 MJkg^{-1}DM) followed by khasari bran (10.7 and 7.75 MJkg^{-1}DM) while others were similar in trend for DE and ME (9-10 and 6-7.5 MJkg^{-1}DM).

Among energy rich brans, rice polish (RP) contained the less fiber (5.8% ADF and 19.85% NDF) but 67% DOM (Table 1). Whereas, wheat bran (WB) constituted with more fiber (6.89% ADF and 20% NDF) than RP showed the better digestibility (75%) while rice bran (RB) embraced high fiber and very poor digestibility (33%). For gross energy (GE) content, RP contained a bit more (16.21 MJkg^{-1}DM), none the less in case of digestibility RP showed the weakness (11.63 MJkg^{-1}DM) than WB (12.86 MJkg^{-1}DM) whilst RB remained in bottom of energy value providing half of DE value of WB and RP. WB also proved its effectiveness on ME (10.6 MJkg^{-1}DM) value than that of RP (9.24 MJkg^{-1}DM) while RB supplied only 3.8 MJkg^{-1}DM. In all cases, whole grain (maize) ascended the superior position beyond of brans. However, WB seized just below of maize in nutritive ranking. Sesame oil cake contained more fiber (25.27% ADF and 27.2% NDF) rather than mustard oil cake (20.14% ADF and 23.87 % NDF). So, mustard oil cake (77% DOM) was superior to til oil cake (65% DOM). Similarly, rich energy values (GE, DE and ME) also observed for mustard oil cake (19.38, 14.43 and 11.11 MJkg^{-1}DM) than sesame oil cake (16.26, 11.97 and 8.9 MJkg^{-1}DM). Straw rich in fiber (53.41% ADF, 56.95% NDF) content, had low digestible value (33%DOM) with poor DE (5.17 MJkg^{-1}DM) and ME (3.38 MJkg^{-1}DM). The protein rich feed mustard oil cake possessed less fiber (18.2% ADF and 22.2% NDF) but high OM digestibility (76.5%) and also energy nutrition (19.15, 14.34 and 11 MJ GE, DE and ME kg^{-1} DM) which were almost similar to maize grain (77.2% DOM, 17, 13.45 and 11.5 MJ GE, DE, ME kg^{-1}; 4.45% ADF and 13.85% NDF). The neutral detergent fiber (NDF), the index of bulk, was found the lowest values for crushed khasari (25%) followed by lentil bran (42.63%), black gram bran (47.75%) and mung bran (47.81). The crushed khasari contained the lowest ADF (13.44%) showed better digestibility (83.43% OMD). Anchor bran showed rather better fiber (51.48%ADF, 57.8% NDF) with improved OMD value (75%) than other brans. Among the bran groups, anchor and khasari contained the highest portion of ADF (51.48 and 50.99%). Mung and black gram contained more or less the similar ADF around 31% while lentil bran constituted with a bit higher part of ADF (38%). Anchor was found better OMD (75%) followed by khasari (60%) but other brans were remained below 60%. On the contrary khasari, black gram and mung occupied a bit higher GE (16-16.5MJ) than that of anchor or lentil (16MJ/kgDM). In addition, value of digestible energy (DE) and metabolizable

Table 2: Nutritive values and chemical composition of non-legume green fodder

Feed Ingredients	**%ADF**	**%NDF**	**%DOM**	**%CP**	**Energy (MJ kg^{-1} DM)**		
					GE	**DE**	**ME**
Napier (*Pennisetumpurpurium*)	45.28^{b}±0.02	53.12^{b}±0.5	53.63^{b}±0.3	7.34^{d}±0.9	16.99^{a}±0.6	9.11^{b}±0.07	7.24^{b}±0.1
Guma/Jamboo (*Sorghum bicolor* X *S. Sudanese)*	47.7^{a}±0.02	59.13^{a}±0.5	56.03^{a}±0.3	8.73^{b}±0.9	16.88^{a}±0.6	9.46^{a}±0.07	7.56^{a}±0.1
Maize fodder (Zea mays)	43.3^{c}±0.02	52.4^{c}±0.5	45.19^{d}±0.3	8.41^{c}±0.9	16.13^{c}±0.6	7.29^{d}±0.07	5.28^{d}±0.1
Oat fodder (*Avena sativa)*	38.3^{d}±0.02	51.7^{c}±0.5	46.87^{c}±0.3	9.51^{a}±0.9	16.39^{b}±0.6	7.68^{c}±0.07	5.64^{c}±0.1
SEM	0.998	0.853	1.305	0.225	0.102	0.265	0.284
LS				P<0.01			

^{a,b,c} means along the same column with different superscript are significantly varied (P<0.05), LS=Level of significance, SEM=Standard error of mean, ADF=Acid detergent fiber, NDF=Neutral detergent fiber, DOM=Digestible organic matter, CP=Crude protein, DM=Dry matter, MJ=Mega jule, GE=Gross energy, DE=Digestible energy, ME=Metabolizable energy.

Table 3: Nutritive values and chemical composition of legume green fodder

Feed Ingredients	%ADF	%NDF	%DOM	%CP	Energy (MJ/kg DM) GE	DE	ME
Mash kali (*Vigna mungo*)	$39.11^{b}\pm0.6$	$52.13^{c}\pm0.2$	$61.05^{c}\pm0.05$	$19.82^{d}\pm0.3$	$17.89^{a}\pm0.1$	$10.92^{b}\pm0.1$	$8^{c}\pm0.1$
Cowpea (*Vigna unguiculata*)	$33.0^{c}\pm0.6$	$51.2^{d}\pm0.2$	$59.15^{d}\pm0.05$	$18.2^{e}\pm0.3$	$17.41^{bcd}\pm0.1$	$10.3^{c}\pm0.1$	$7.82^{c}\pm0.1$
French bean (*Cyammopsis tetragonoloba*)	$32.46^{c}\pm0.6$	$39.7^{e}\pm0.2$	$61.9^{b}\pm0.05$	$22.26^{b}\pm0.3$	$17.55^{b}\pm0.1$	$10.88^{b}\pm0.1$	$8.31^{b}\pm0.1$
Khasary (*Lathyrussativus*)	$38.00^{b}\pm0.6$	$51.3^{d}\pm0.2$	$57.92^{e}\pm0.05$	$20.7^{c}\pm0.3$	$17.27^{d}\pm0.1$	$10^{d}\pm0.1$	$7.25^{d}\pm0.1$
Dhaincha (*Sesbaniaaculeate*)	$39.30^{b}\pm0.6$	$54.7^{b}\pm0.2$	$56.25^{f}\pm0.05$	$26^{a}\pm0.3$	$17.51^{b}\pm0.1$	$9.85^{d}\pm0.1$	$6.95^{e}\pm0.1$
Alfalfa (*Medicago sativa*)	$46.82^{a}\pm0.6$	$51^{d}\pm0.2$	$52.88^{g}\pm0.05$	$20.2^{cd}\pm0.3$	$17.34^{cd}\pm0.1$	$9.17^{e}\pm0.1$	$6.48^{f}\pm0.1$
Ipilipil (*Leucaena leucocephala*)	$39.01^{b}\pm0.6$	$55.75^{a}\pm0.2$	$80.35^{a}\pm0.05$	$16.7^{f}\pm0.3$	$17.97^{a}\pm0.1$	$14.44^{a}\pm0.1$	$11.76^{a}\pm0.1$
Bean (*Lablab purpureus*)	$30.13^{d}\pm0.6$	$34.54^{f}\pm0.2$	$50.18^{h}\pm0.05$	$22.61^{b}\pm0.3$	$17.48^{bc}\pm0.1$	$8.77^{f}\pm0.1$	$5.89^{g}\pm0.1$
SEM	0.66	0.94	1.14	0.36	0.03	0.22	0.22
LS				P<0.01			

[a,b,c] means along the same column with different superscript are significantly varied (P<0.05), LS=Level of significance, SEM=Standard error of mean, ADF=Acid detergent fiber, NDF=Neutral detergent fiber, DOM=Digestible organic matter, CP=Crude protein, DM=Dry matter, MJ=Mega jule, GE=Gross energy, DE=Digestible energy, ME=Metabolizable energy.

energy (ME), the anchor was found also in topmost position (12.8 and 10.92 $MJkg^{-1}DM$) followed by khasari bran (10.7 and 7.75 $MJkg^{-1}DM$) while others were similar in trend for DE and ME (9-10 and 6-7.5 $MJkg^{-1}DM$).

Table 2 & 3 depict the overall fibrosity (NDF), index of digestibility (ADF), digestibility of organic matter and energy values of fibrous feedstuffs usually consumed by the ruminants of surveyed areas of our country.

In Table 2, Ration intake index, NDF was found highest in amount around 60% in Guma/Jambo grass followed by napier (53.12%), maize (52.40%) and oat (51.70%). The same trend was noticed in case of acid detergent fiber content (ADF) for napier, jambo, maize and oat fodder 45.28, 47.7, 43.30 and 38.30% respectively. On the other hand, in organic matter digestibility (DOM) jambo respond better (56%) than napier (53.63%) and others. Gross energy content focused more or less equilibrium (16-17MJ/kgDM) for all types. Moreover, digestible energy (DE) and metabolizable energy (ME) content per kg DM were higher for napier (9.11 and 7.24 $MJkg^{-1}DM$) and jambo (9.46 and 7.56 $MJkg^{-1}DM$) than that of maize (7.29 and 5.28 $MJkg^{-1}DM$) and oat (7.68 and 5.64 $MJkg^{-1}DM$).

Table 3 showes seven legume fodder species mash kali, cowpea, farash, khasary, dhaincha, lucern and ipilipil respectively. Ipilipil is perennial and legume tree fodder which showed the highest organic matter digestibility (80.35%),NDF content (55.75%) and also energy values 17.97, 14.44 and 11.76 $MJkg^{-1}DM$ for GE, DE and ME. Dhancha contained comparatively better NDF (54.7%) just after the ipilipil, however %DOM (56.25) and energy values were not satisfactory 9.85 and 6.95 $MJkg^{-1}DM$ respectively. The nutritive values of alfalfa fodder were more or less similar with dhaincha fodder. On the contrary, matikali, cowpea, farash and khasary legumes were in second highest quality feed in terms of energy nutrition. The contained more than 10 MJ DE $kg^{-1}DM$ 7.0 to 8.0 MJ ME $kg^{-1}DM$ and 58 to 62 % DOM as well. In case of fiber content, farash was in lowest position for NDF content around 40% while others were more than 50%. Meanwhile ADF was the resemble of NDF value.

DISCUSSION

The nutrient composition of many feed resources used in the present study is within the range of reported values in the literature for similar stuffs (Sayed et al., 1986). Dry matter and crude protein contents of different fodders showed wide variations. These variations could be a result of agronomic factors such as application of various levels of nitrogen fertilizers, time of harvest, ensiling, field drying and storage. Similar findings have been reported in Italian rye grass for its dry matter yield, which varied from 18.8 to 75.5% mainly due to different harvesting time (Bittante and Andrightto, 1982). Like DM and CP, other nutrients could also vary in different feeds due to agroclimatic conditions, cultural practices and post-harvest processing and storage conditions. In general, predicted metabolizeable energy values were very low in the feedstuffs having high fiber and low protein contents. These feedstuffs included various grasses, crop residues and some tree leaves. Lower metabolizeable energy values (3 and 5.5 MJ/kg) were found in straw that match with the findings of Chumpuwadee et al. (2007). These roughages are deficient in fermentable carbohydrates, reflected by relatively low organic matter digestibility (Jayasuriya, 2000). Chemical treatment of feedstuffs like crop residues increases their feeding potential. The difference of metabolizeable energy of various feedstuffs reflects different contents of fermentable carbohydrates and available nitrogen in cereals while fermentable carbohydrates increase gas production.

It has been reported that addition of degradable nitrogen compounds to fiber rich feeds decreased gas production due to better or improved capturing of nutrients and higher production of microbial protein. The carbon source is diverted from gas to microbial protein (Menke and Steingass, 1988). Although the predictive ME values were found within the range of reported values for a large number of feedstuffs (Sen et al., 1978; Krishnamurthy et al., 1995), yet some feedstuffs showed a significant variation in ME values resulted in ME values of 7.0-9.9 MJ/kg dry matter. A wide range in predicted ME among the different species may be due to different agronomic conditions at different farms. These variations may also be due to low quality of samples or different origins or areas, used in these studies. However, some of the differences in the predicted ME values are difficult to explain. Allow predicted ME for maize fodder in comparison to napier may be attributable to an early stage of harvest as the samples obtained were from fodder harvested before the formation of grain. The findings agree with the statement of Chumpuwadee et al. (2007), Akinfemi et al. (2012) and Babayemi (2006). Except a few feeds, the energy values and rate of organic matter fermentation calculated from *in vitro* gas method seems to be quite comparable with the values available in the literature for different feedstuffs.

The variation observed in the chemical composition of different feedstuffs could be due to many factors such as stage of growth, maturity, species or variety (Von Keyserlingk et al., 1996; Agbagla-Dohanni et al., 2001; Promkot and Wanapat, 2004), drying method, growth environment (Mupangwa et al., 1997) and soil types (Thu and Preston, 1997). These listed factors may partially explain the differences in chemical composition (Chumpuwadee et al., 2007) between this study and others. Additionally, legumes had high protein content. The protein fermentation does notlead to extensive gas production (Khazaal et al., 1995). The higher fermentation of the insoluble fraction were observed in wheat bran and maize, possibly influenced by the carbohydrate fraction readily available to the microbial population (Chumpuwadee et al., 2007).Deaville and Given (2001) reported that kinetics of gas production could be affected by carbohydrate fraction. The relatively low content of fibre can facilitate the colonization of the feed by the microbial rumen population, which in turn might induce higher fermentation rates, therefore improving digestibility (Van Soest, 1994). As the fermentation process is partially regulated by the fibrous content of the feeds concentrates ferment faster than coarse feed. Since gas production on incubation of feed is buffered rumen fluid is associated with feed fermentation and carbohydrate fraction (Sallam et al., 2008), so the higher gas production could be related to fiber fraction content. This is in agreement with De Boever et al. (2005), who reported that gas production was negatively related with NDF content and positively with starch. The negative effect of cell wall content on gas production in groundnut shell could be due to reduction in the microbial activity through increasing the adverse environmental condition as incubation time progresses.The present results consistent with the findings of Sallam et al. (2008). The estimated ME in this study were consistent with those obtained for the concentrate feedstuffs (Chumpuwadee et al., 2007; Babayemi, 2006).There was a positive correlation between ME calculated and from the in vitro gas production together with CP and fat content with metabolisable energy value of conventional feed measured in vivo (Menke and Steingass, 1988). High digestibility of organic matter (OMD) obtained in beans and maize was because the major carbohydrate of their feedstuffs is starch, which is fermented by amylolytic bacteria and protozoa (Kotarski et al., 1992). This result implies that the microbes in the rumen and animal have high nutrient uptake. Chemical composition of feedstuffs were affected may be owing to stage of growth maturity, species or variety (Von Keyserlingk et al., 1996; Agbagla-Dohnani et al., 2001; Promkot and Wanapat, 2004), drying method, growth environment (Mupangwa et al., 1997) and soil types (Thu and Preston, 1999). These factors may partially explain differences in chemical composition between our study and others.

CONCLUSION

The tropical grasses and agricultural by-products showed a great variation in chemical composition and nutritional value content. The results of this study demonstrate that gas production characteristics of the feedstuff differed widely. Based on this study, high fermentation potentials ought to be considered before feeding the animals.

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