The Relationship between the calculated (Cal. ME) and gas estimated (Est. ME) metabolizable energy for Ruminants of some Sudanese feedstuffs

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Summary

Seventeen samples of Sudanese feedstuffs (4 samples of protein rich feedstuffs "cakes", 3 samples of oilseeds, 3 samples of different browse trees fruits, 4 samples of forages "2 rich in protein and 2 of low protein value" and 3 of roughages "crop residues") were analyzed to assess DM, Ash, CP, EE, CF and NFE, DM and CP degradability and digested to estimate their energy content.

The results revealed significant differences in all chemical components within each feed group. The cakes showed the highest DM and CP degradability, while other groups approximately showed similar values. The results showed that the calculated energy (Cal.ME) was nearly similar within each group except in cakes and oilseeds. In general, caked and oilseeds showed the highest energetic values, while browse trees fruits, forages and roughages showed slight differences. The correlation coefficient between the estimated (Est. ME) and calculated (Cal. ME) metabolizable energy was moderately positive for oilseeds and browse trees fruits and very high for forages and roughages, while cakes showed high negative correlation. In general, the correlation showed moderate value overall feedstuffs. From these results we recommend to use gas production method to assess the energetic value of feeds for ruminants.

Introduction

Livestock production in Sudan is one of the national largest industries, livestock population increase over years. The main sources of animal feed are natural and irrigated pasture, crop residues and concentrates which fluctuate in DM production and nutritive value, this fluctuation continuously hamper livestock production. In general, feedstuffs vary greatly in efficiency and adequacy; moreover, rations even of equal values differ in them per unit cost. In general, gross energetic values of feedstuffs are based on Weende analysis Kellner (1917) and Rostock (MAFF, 1975) or calculated according to NRC (1958) assuming that carbohydrates, protein, ether extractives and nitrogen free extract yield 4.3, 5.6, 9.3 and 4.3 Kcal GE/gram respectively, or determined by combustion in a bomb calorimeter (GE, Crampton and Harris, 1969), where ME was considered to be 75% of GE. However, Menke *et al.* (1979) and Menke and Steingass (1988) used gas production technique to estimate the ME, using the chemical composition of feeds (CP, EE and NFE or CP, CF and EE) and the gases produced from fermentation processes. On the other hand, Blummel and Ørskov (1993) used the same technique, depending on the increment of gas production at a series of intervals.

Generally, the metabolizable energy of ruminant feed is affected by the chemical composition of feed and fermentation processes by rumen microflora, as well as by the digestibility of the feed. Moreover, the energetic value is largely affected by the method used for energy estimation. These variables however, admit the need to study the correlation between different methods used for energy estimation. This study aimed to assess the relationship between the energetic values assessed from the chemical composition and gases produced from fermentation process in the rumen.

Materials and Methods

Four groups of feedstuffs namely: Protein feedstuffs (Groundnut *"Arachis hypogaea"*, Gurum "*Citrullus lanatus* var. colocynthoid" chemically extracted and mechanically extracted "Assara" and cottonseed *"Gossipium spp."* Cake. Oilseeds (White cotton seed linted and delinted. And black cotton seed). Browse trees fruits (Khuraim *"Acacia albida"*, Mesquite *"Prospis glandulosa"* and Dign Elbasha *"Albiza lebeka"*), Forages (Lubia *"Dolicus lablab"*, Sweet potato *"Convolvulus batatas*", Sugarcane *"Saccarum officnarum"* tops and Banana "*Musa sapientum*" leaves) and roughages (Sunflower *"Helianthus annus"* residues, Lubia adasi *"Cajanus cajana"* residues and Maize *"Zea mays"* cobs) were collected. The samples were dried at 85°C for 48 hr, ground 2mm in size and stored in a plastic bags.

All samples were analyzed (5 replicates) according to A. O. A. C. (1980) to determine DM, Ash, CP, EE, CF and NFE, DM and CP contents.

Degradability was assessed according to Ørskov and McDonald (1979) and McDonald (1981), the exponential models $P = a + b (1 – e^{-ct})$ and $P_{effective} = a + bc (c + k)$ were fitted to the data. Rostock equation (MAFF, 1975) was used to calculate the metabolizable energy (Cal. ME),

ME (MJ/Kg DM) = 0.012 CP + 0.031 EE + 0.005 CF + 0.014 NFE.

While the estimated metabolizable energy (Est.ME) was determined by using the *in vitro* gas production technique of Menke and Steingass (1988) using the following equation: ME (MJ/Kg DM) = 0.139 GP + 0.007 XP + 0.0179 XL + 1.55

The correlation between the calculated and the estimated metabolizable energy was calculated according to Gomaz and Gomaz (1976). The relationship between the two attributes was studied, using regression analysis. Estimated and calculated values resulting from the relationship were also verified using relevant tests, (Draper and Smith, 1998).

Results and Discussion

Table 1. presents the chemical composition of feedstuffs. Cakes had the highest protein content (ranged between 175.0 and 315.0 g/Kg DM) and the lowest values of CF (80.0 – 100.0 g/Kg DM), except groundnut cake (241.6 g/Kg DM). The chemical composition of cakes differ according to their varieties, soil, climate and method of extraction, even within the same type. These findings are in line with Ishag (1986). The lowest CP content was found in browse trees fruits (except Khuraim, 123.4 g /Kg DM), forages and roughages (except Sunflower, 113.8 g/Kg DM), Tanner (1990) reported similar results. Groundnut cake, browse trees fruits, forages and roughages had shown the highest CF content, these findings are in line with those reported by Smith (1987). In general, significant differences were found within each group.

Table 1. Average chemical composition (g/Kg) of feedstuffs (mean ± SE):

Serial number		Feedstuff	DM g/Kg	Ash	EE	CF g/Kg DM	CP	NFE
(1)	Protein feedstuffs:							
	A	**Cakes:**						
	i	Groundnut	964.6[a] ± 1.0	95.0[a] ± 0.91	18.4[d] ± 0.71	241.6[a] ± 0.71	315.0[a] ± 0.59	330.0[b] ±1.11
	ii	Gurum	949.1[b] ± 0.61	44.7[b] ± 0.88	30.0[b] ± 0.4	100.0[b] ± 1.1	192.5[b] ± 0.5	631.0[b] ± 0.66
	iii	Gurum (Assara)	951.7[b] ± 0.5	46.7[b] ± 0.29	63.3[a] ± 0.64	96.7[c] ±1.2	185.3b[c] ± 0.98	608.0[c] ± 1.09
	iv	Cotton seed	940.0[c] ± 0.63	46.7[b] ± 1.34	23.3[c] ± 0.39	80.0[d] ± 0.56	175.0[c] ± 0.4	675.0[a] ± 0.44
	B	**Oilseeds:**						
	i	White cotton seed (lin)	959.1[b] ± 2.0	50.0[a] ± 3.02	183.3[c] ± 0.62	286.7[a] ± 0.92	138.5[a] ± 0.59	341.5[b] ± 0.61
	ii	White cotton seed (delin)	967.8[a] ± 0.6	50.3[a] ± 1.98	230.0[b] ± 1.0	270.3[b] ± 0.32	130.7[c] ± 0.87	318.7[c] ± 1.0
	iii	Black cotton seed	950.7[c] ± 1.2	36.5[b] ± 1.52	295.0[a] ± 0.55	190.0[c] ± 0.52	122.5[c] ± 0.64	356.0[a] ± 0.51
(2)	Browse trees fruits:							
	i	Khuraim	956.8[a] ± 0.78	35.7[c] ± 0.86	23.3[c] ± 0.66	245.5[b] ± 0.69	123.4[a] ± 0.45	572.1[b] ± 0.39
	ii	Mesquite	930.2[b] ± 1.05	55.8[b] ± 1.8	26.7[b] ± 0.56	240.0[c] ± 0.83	70.0[c] ± 0.8	607.5[a] ± 0.91
	iii	Dign elbasha	521.7[c] ± 1.06	96.7[a] ±3.01	74.4[a] ± 0.29	284.4[a] ± 1.22	87.5[b] ± 0.79	457.0[c] ± 1.09
(3)	Forages:							
	i	Lubia	188.4[a] ±0.67	64.7[b] ± 2.98	24.7[b] ± 0.51	165.8[b] ± 0.7	87.5[a] ± 1.1	657.3[a] ± 0.71
	ii	Sweet potato	162.0[b] ± 0.74	123.4[a] ± 3.04	37.8[a] ± 0.49	200.0[a] ± 1.0	27.5[a] ± 0.54	573.5[b] ± 0.54
	Iii	Sugar cane tops	447.3[b] ± 0.93	37.3[b] ± 1.58	37.8[b] ± 0.91	447.7[a] ± 0.81	17.5[b] ± 0.76	454.8[a] ± 1.12
	iv	Banana leaves	933.9[a] ± 0.4	173.3[a] ± 3.41	53.4[a] ± 0.55	295.0[b] ± 0.51	87.5[a] ± 1.22	390.8[b] ± 0.81
(4)	Roughage (crop residues):							
	i	Sunflower	934.5[c] ± 0.44	132.7[a] ± 3.39	45.3[a] ± 0.51	272.0[c] ± 0.45	113.8[b] ± 0.38	436.2[c] ± 2.34
	ii	Lubia adasi	954.2[a] ± 0.93	53.3[c] ± 1.99	14.0[c] ± 0.72	287.3[b] ± 0.98	52.5[c] ± 0.33	592.6[d] ± 1.4
	iii	Maize cobs	942.0[b] ± 0.7	13.3[d] ± 3.9	6.7[d] ± 0.66	365.0[a] ±1.0	17.5[d] ± 0.7	597.5[a] ± 0.51

Means in the same raw with different superscripts are significantly ($p<0.05$) different

Table 2. shows dry matter (DM) and crude protein (CP) degradability (g/100g) of feedstuffs. In protein feedstuffs, oilseeds had the lowest values for both DM and CP degradability (52.6 – 59.6 g/Kg DM and 54.7 – 56.7 g/Kg DM, respectively) than cakes. Forages and roughages had the lowest values compared with other groups. In general, The degradability showed significant differences within each group. The

high rate of degradability in cakes may be due to their high CP content and to the fact that proteins may be greatly exposed to degradation processes in rumen, similar results were reported by Ganev *et al.* (1979). The low degradability values of other groups may be due to high crude fiber contents beside high oil content in oilseeds. Similar results were reported by Kowalczyk *et al.* (1977) and Ørskov *et al.* (1978), what was uncertain, whether the cause was due to inhibition of the microbial population, or a protective coating being formed on the fibre. Also digestion can be reduced by the polyphenolic substances (Woodward and Reed, 1989).

Table 2. Dry matter (DM), crude protein (CP) degradability (g/100g) of feedstuffs

Serial number		Feedstuff	Degradability DM	Degradability CP
(1)	Protein feedstuffs:			
	A	**Cakes:**		
	i	Groundnut	76.1[a]	67.8[a]
	ii	Gurum	68.4[b]	61.1[b]
	iii	Gurum (Assara)	75.9[a]	62.7[b]
	iv	Cotton seed	59.6[c]	54.8[c]
	B	**Oilseeds:**		
	i	White cotton seed (lin)	58.7[a]	56.7[a]
	ii	White cotton seed (delin)	52.6[b]	54.7[b]
	iii	Black cotton seed	59.6[a]	54.8[b]
(2)	Browse trees fruits:			
	i	Khuraim	60.3[b]	57.9[ab]
	ii	Mesquite	65.2[a]	59.9[a]
	iii	Dign elbasha	48.5[c]	54.9[b]
(3)	Forages:			
	i	Lubia	55.9[a]	36.0[a]
	ii	Sweet potato	46.2[b]	22.7[c]
	iii	Sugar cane tops	37.6[c]	22.1[c]
	iv	Banana leaves	46.7[b]	24.4[b]
(4)	Roughage (crop residues):			
	i	Sunflower	59.0[a]	45.7[b]
	ii	Lubia adasi	49.1[b]	50.7[a]
	iii	Maize cobs	31.9[c]	47.9[ab]

Means in the same raw with different superscripts are significantly ($p<0.05$) different

Table 3. shows calculated and estimated ME values of these feedstuffs. It is obviously that both the cal.ME and the est.ME of oilseeds were the highest (13.6 and 16.5 and 11.0 and 12.3 MJ/Kg DM, respectively) followed by cakes, other feedstuffs had the lowest values 10.5 and 11.9 and 6.5 and 9.1 MJ/Kg DM, respectively. It was obviously clear that the cal. ME varied according to their differences in chemical composition, while the differences in est.ME may be referred to the extent of fermentation in vitr*o* digestibility and gas production, these findings were nearly similar to the findings reported by Menke *et al*. (1979) who reported that the est.ME ranged from 7.7 – 13.2 MJ/Kg DM.

Table 3. Estimated metabolizable (Est. ME) and calculated metabolizable energy (Cal. ME) of feedstuffs (means).

Serial no.		Feedstuff	EE	CP	GP	Est. ME	Cal.ME	Est. ME/ Cal. ME
			g/Kg DM		(ml)	MJ/Kg DM		(%)
(1)	Protein feedstuffs:							
	A	**Cakes:**						
	i	Groundnut	18.4	315.0	60.5	12.6	10.2	123.5
	ii	Gurum	30.0	192.5	52.5	10.8	12.6	85.7
	iii	Gurum (Assara)	63.3	185.3	46.5	10.5	13.2	79.5
	iv	Cotton seed	23.3	175.0	44.0	9.4	12.8	73.4
	B	**Oil seeds:**						
	i	White cottonseed (lin.)	183	138.5	37.0	11.0	13.6	80.9
	ii	White cottonseed (delin.)	230.0	130.7	40.5	12.3	16.5	74.5
	iii	Black cottonseed	90.0	122.5	39.0	11.3	16.6	69.9
(2)	Browse trees fruits:							
	i	Khuraim	23.3	123.4	40.0	8.4	11.7	71.8
	ii	Mesquite	26.7	70.0	43.0	8.5	11.4	74.6
	iii	Dign elbasha	36.7	52.5	37.0	7.7	11.2	68.8
(3)	Forages:							
	i	Lubia	24.7	87.5	46.5	9.1	11.9	76.5
	ii	Sweet potato	37.8	87.5	40.0	8.4	10.5	80.0
	iii	Sugar cane tops	42.7	17.5	41.5	8.2	10.0	82.0
	iv	Banana leaves	53.4	87.5	37.0	8.3	9.7	85.6
(4)	Roughage (crop residues):							
	i	Sunflower	45.3	11.3	42.5	9.1	11.2	71.4
	ii	Lubia adasi	14.0	52.5	43.5	7.2	10.8	66.7
	iii	Maize cobs	6.5	17.5	34.0	6.5	10.6	61.3

The correlation coefficient between est.ME and cal.ME **Table 4** showed perfect positive correlation for forage and roughage (0.96 and 1.0, respectively) and strong positive correlation for browse trees fruits and oilseeds (0.72 and 0.67, respectively), while the correlation was strongly negative (-0.88) for cakes. The overall correlation coefficient showed moderate positive value (0.63).

Table 4. The correlation between the estimated metabolizable (Est. ME) and calculated metabolizable energy (Cal. ME) of feedstuffs**.**

Feedstuff	Est. ME	Cal. ME	SE	Correlation
Cakes	10.83	12.17	0.78	-0.88
Oil seeds	11.53	15.54	0.71	0.67
Browse trees fruits	8.20	11.42	0.43	0.72
Forages:	8.50	10.51	0.15	0.96
Roughage (crop residues)	7.60	10.88	0.05	1.00
All feedstuffs	9.37	12.01	1.41	0.63

Conclusion

It could be concluded that a wide range of variation existed between the calculated and estimated metabolizable energy, therefore, the computed correlation showed a moderate association between them. For more precise prediction we recommend to use the gas production technique to evaluate the energetic value of any feedstuff for ruminants feeding.

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