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True Metabolizable Energy Values of Poultry Feedstuffs in Pakistan

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ABSTRACT

Quick bioassay technique of Sibbald (1986) involving adult cockerels was used to determine the true metabolizable energy (TME) of commonly used feedstuffs in Pakistan. The feedstuffs evaluated for TME were cereals grain: corn, rice, sorghum and wheat; cereal by-products: corn gluten feed, rice polishings and wheat bran; molasses; vegetable meals: corn gluten meal (30%) and 60%), cottonseed meal expeller extracted (ee) and solvent extracted (se), guar meal, rapeseed meal (ee) and (se), sesame meal, soybean meal and sunflower meal; animal meals: blood meal, fish meal, meat meal and poultry by-product meal. The TME (Kcal/kg) for corn, rice, sorghum and wheat were 3672, 3619, 3476 and 3561, respectively. Corn gluten feed, rice polishings, wheat bran and molasses had 2488, 3436, 2274 and 2697 Kcal/Kg TME, respectively. The TME values were for corn gluten meal (30%) 2570, corn gluten meal (60%) 3980, cottonseed meal (ee) 2583, cottonseed meal (se) 2515, guar meal 2699, rapeseed meal (ee) 2537, rapeseed meal (se) 2508, sesame meal 2751, soybean meal 2957 and sunflower meal 2467 Kcal/kg. The blood meal, fish meal, meat meal and poultry by-product meal had TME 3091, 3126, 3070 and 3367 Kcal/kg, respectively.

Key Words: True Metabolizable Energy; Feedstuffs; Pakistan

INTRODUCTION

Poultry rations are generally formulated by matching the level of nutrient, particularly metabolizable energy in ingredients with the requirements of the birds. The apparent metabolizable energy (AME) of feedstuffs is determined through the method of Harris (1966) which is still valid but expensive, time consuming and less precise. Rapid assay for TME method of Sibbald (1986) made it possible to evaluate the poultry feedstuffs on the basis of the availability of energy. This assay has several advantages like high precision, cost effectiveness and time saving. Furthermore, direct determination of the TME of unpalatable ingredients is also possible.

Information on the biologically available nutrients in feedstuffs is scanty in Pakistan. Information on availability of nutrients in feedstuffs originate from temperate region, which may not be suitable for feed formulation in tropical and sub-tropical regions. There is a need to evaluate local poultry feedstuffs for TME and to generate information to be used for precise formulation of poultry diets. A study was, therefore, planned with the objective to determine the TME contents of indigenous poultry feedstuffs.

MATERIALS AND METHODS

Samples of 22 quality feedstuffs weighing about 2 kg were collected from primary market source. These feedstuffs included cereals grains: corn, rice, sorghum and wheat; cereal by-products: corn gluten feed, rice polishings and wheat bran; molasses; vegetable meals: corn gluten meal (30%) and (60%), cottonseed meal (ee) and (se), guar meal, rapeseed meal (ee) and (se), sesame meal, soybean meal and sunflower meal; animal meals: blood meal, fish meal, meat meal and poultry by-product meal. These feedstuffs were coarsely ground 0.5 mm mesh sieve and were stored in plastic bottles for subsequent use in the experiment.

An assay technique developed by Sibbald (1986) was used to determine TME of various feedstuffs using White Leghorn cockerels of Nick Chick strain. Six birds were used for each feedstuff to measure TME. A set of another six birds served as negative control used to determine endogenous excretion of energy. The data so obtained were used to correct the excreta outputs of all birds used for assay. The birds under trial were starved for 48 h. During fasting all the birds were crop intubated with two doses of 50 mL each of an aqueous glucose solution (500 g kg^{-1}) at 8^{th} and 32^{nd} h after feed withdrawal (McNab & Blair, 1988). After fasting period, cockerels in treatment group were crop intubated with 50 g of ground sample of the feedstuff, while cockerels in negative control group received two doses of 50 ml of aqueous glucose solution (500 g kg^{-1}) at 8^{th} and 32^{nd} h to avoid catabolism (McNab & Blair, 1988). In addition all the birds were given 50 mL water through funnel in crop at 24^{th} h during assay period. The excreta voided during the exact 48 h post feeding were collected at 24 h intervals. All the samples of excreta were collected separately for each cockerel. These were weighed, oven dried at 60^0C and ground to pass through 0.3 mm mesh sieve. The gross energy (GE) content of each feedstuff and its excreta was determined with the help of Parr adiabatic oxygen bomb calorimeter (Nukamp, 1965). Samples of 22 feedstuffs tested for TME contents were subjected to proximate analysis (AOAC, 1990). The AME and TME per kg of feed were calculated by the following formula:

$$\text{AME (Kcal/kg)} = \frac{\text{GE intake - GE excreta}}{\text{Intake}} \times 1000$$

$$\text{TME (Kcal/kg)} = \frac{\text{GE intake - (GE excreta-GE endogenous)}}{\text{Intake}} \times 1000$$

RESULTS AND DISCUSSION

The results on proximate composition and GE values of various feedstuffs are presented in Table I, while the intake, voided and retained GE, AME and TME of various feedstuffs are presented in Table II.

Cereal grains. The GE of cereal grains ranged from 4.12 to 4.28 Kcal/g. The GE values of indigenous cereal grains were slightly lower than those reported from Canada and USA. The differences in GE values of cereal gains could be attributed to the differences in nutrient composition, particularly the fat content, which was lower in the indigenous cereal grains. Corn containing 4.87% fat was reported to yield 4.54 Kcal/g GE (Sibbald, 1986) as against 4.28 Kcal/g in case of local corn with 2.78% fat. Similarly sorghum with 3.37 to 6.37% fat yielded 4.37 to 4.50 Kcal/g GE (Luis & Sullivan, 1982; Storey & Allen, 1982) as against 4.12 Kcal/g of local sorghum with 1.11% fat. The GE might also be influenced by the level of CP. Wheat containing 14.7 to 15.5% CP had 4.31 to 4.43 Kcal/g GE (Sibbald, 1979a,b; Storey & Allen, 1982; Halley *et al.*, 1985; Sibbald, 1986) being 2.4 to 5.2% higher than the local wheat having 13.88% CP. Sibbald *et al.* (1980) reported 3.95 Kcal/g GE in corn containing 9.4% CP which was lower than the local corn having 13.63% CP. The AME values of local cereal grains ranged form 3.05 to 3.24 Kcal/g, being lower than the reported values in Literature. The AME for corn ranged from 3.43 to 3.94 Kcal/g (Halloran, 1980; Schang & Hamilton, 1981; Storey & Allen, 1982; Du Preez *et al.*, 1984; Sub, 1988) for sorghum from 3.32 to 3.85 Kcal/g (Chami *et al.*, 1980; Storey & Allen, 1982) and for wheat from 3.34 to 3.51 Kcal/g (Sibbald, 1976b; Schang & Hamilton, 1981; Halley *et al.*, 1985).

The TME values for corn, rice, sorghum and wheat were 3.67, 3.62, 3.48 and 3.56 Kcal/g, respectively. The TME values of indigenous cereal grains were lower than that reported by many workers. The possible reason for lower TME values of local cereal grains could be the lower fat content in them. Corn containing 4.86 to 5.25% fat had TME ranging from 3.80 to 4.27 Kcal/g (Dale & Fuller, 1980; Muztar & Slinger, 1981; Luis & Sullivan, 1982; Storey & Allen, 1982; Sibbald, 1986) as against 3.67 Kcal/g of local corn with 2.78% fat. Similarly sorghum containing 3.24 to 6.37% fat was reported to contain 3.99 to 4.03 kcal/g TME (Luis & Sullivan, 1982; Storey & Allen, 1982; Sibbald, 1986) as against 3.48 Kcal/g of local sorghum with 1.11% fat. The TME values might also had been affected by the level of CP. Wheat containing 14.7 to 15.5% CP had 3.56 to 3.73 Kcal/g TME (Storey & Allen, 1982; Sibbald, 1986) as against 3.56 Kcal/g TME of the local wheat having 13.88% CP. However, corn and wheat containing lower CP (9.5 and 11.5%) yielded lower TME (3.35 & 3.02 Kcal/g). In general, the varietial differences, climatic conditions and agronomic practices used for cultivation influence the nutrient composition of cereal grains and the TME values.

Cereal by-products and molasses. The GE values for local corn gluten feed, rice polishings and wheat bran were 4.32 4.83 and 4.43 Kcal/g, respectively. Sibbald (1986) reported almost similar GE values (4.39, 4.83 & 4.52 Kcal/g) for the above mentioned feedstuffs having almost similar nutrient composition. The AME for corn gluten feed, rice polishings and wheat bran were noted as 2.05, 3.02 and 1.84 Kcal/g, respectively which were comparable to that reported by NRC (1984) except that of local wheat bran where AME was found higher. The TME values for local corn gluten feed, rice polishings and wheat bran were 2.49, 3.44 and 2.27 Kcal/g, respectively. These values were in agreement with that of Sibbald (1986). However, higher TME values were reported for corn gluten feed (Castanon *et al.*, 1990) and wheat bran (Onol, 1992); whereas, lower TME values were reported for rice polishings (Chami *et al.*, 1980) and wheat bran (Sub, 1988). The variations in TME values among different reports were probably due to the variants in nutrient composition of feedstuffs. The TME of molasses was observed to be 2.70 Kcal/g. Sibbald (1986) reported TME for molasses as 1.63 Kcal/g. The indigenous molasses contained negligible CF and comparatively lesser ash (10%). Low ash and may be higher sugar contents in local molasses could be the possible reason for its higher TME value.

Vegetable meals. The GE of vegetable meals ranged from 4.33 to 5.04 Kcal/g. The GE value of the local vegetable meals was slightly lower than the reported values in the literature. The lower GE of local vegetable meals might be due to the lower CP in some of the meals and higher ash content in all the meals. Ash content in all the local vegetable meals was above the range reported by Sibbald (1986) and Ensminger *et al.* (1990). It might be due to the addition of silica due to improper handling of oilseeds during storage and processing. Corn gluten meal containing 67% CP had GE 5.54 Kcal/g (Sibbald, 1986) being 10% higher than the local corn gluten meal (64%, CP) and sunflower meal having 42% CP had GE 4.64 Kcal/g

Table I. Proximate composition and gross energy values of various feedstuffs

Feedstuff	DM	CP	CF	EE	NFE	ASH	GE Kcal/kg
				%			
Cereal grain							
Corn	93.43	13.63	3.36	2.78	78.71	1.52	4281
Rice	90.02	10.12	0.78	1.69	86.61	0.60	4255
Sorghum	89.60	13.76	3.45	1.11	79.46	2.22	4124
Wheat	87.98	13.88	3.71	1.75	79.47	1.19	4213
Cereal by-product							
Corn gluten feed	89.88	22.98	11.02	1.78	55.45	8.77	4316
Rice polishings	91.38	14.97	11.86	14.07	48.35	10.75	4829
Wheat bran	91.54	14.86	11.45	4.90	63.00	5.79	4428
Molasses	71.22	5.31	0.15	0.10	84.09	10.35	3525
Vegetable meal							
Corn gluten meal (30 %)	91.14	25.41	8.95	0.74	57.78	7.12	4333
Corn gluten meal (60 %)	92.99	63.82	1.06	1.22	26.94	6.96	5035
Cottonseed meal (ee)	90.92	48.01	11.61	5.44	25.99	8.95	4401
Cottonseed meal (se)	89.79	49.04	13.25	0.97	28.17	8.57	4376
Guar meal	96.73	40.72	10.35	4.83	39.38	4.72	4406
Rapeseed meal (ee)	89.28	34.36	11.17	7.30	35.81	11.36	4415
Rapeseed meal (se)	92.30	40.11	12.78	2.03	34.95	10.13	4383
Sesame meal	92.19	41.04	6.10	8.05	33.68	11.13	4538
Soybean meal	91.59	52.34	10.35	0.58	29.44	7.29	4508
Sunflower meal	91.15	33.76	19.64	2.71	34.97	8.92	4501
Animals meals							
Blood meal	96.73	89.23	0.88	0.57	4.20	5.12	4765
Fish meal	94.19	61.18	0.46	10.60	4.88	22.88	4622
Meat meal	93.06	54.32	1.09	8.36	12.87	23.36	4648
Poultry by-product meal	92.49	56.27	2.22	18.45	11.91	11.15	5141

DM = Dry matter, CP = Crude protein, CF = Crude fibre, EE = Ether extract, NFE = Nitrogen free extract, GE = Gross energy

(Sibbald, 1986) being 3% higher than the local sunflower meal (CP, 34%). Similarly, Storey and Allen (1982) reported very high GE value for sesame meal (5.25 Kcal/g) containing 52.4% CP. The GE of meals was also influenced by the ash content. Sesame meal containing 13% ash had lower GE (4.47 Kcal/g) (Sibbald, 1986) than the local sesame meal (4.53 Kcal/g GE) having 11% ash. The AME of vegetable meals ranged from 2.05 to 3.58 Kcal/g. The AME values of indigenous vegetable meals were lower than the reported values in literature. The AME values had been reported as 3.93 Kcal/g for corn gluten meal 60% (Sub, 1988), 3.52 Kcal/g for sesame meal (Storey & Allen, 1982) and 2.82 and 2.96 Kcal/g for soybean meal (Muztar & Slinger, 1981; Storey & Alen, 1982). The TME value of corn gluten meal 60% was 3.98 Kcal/g. Similar but slightly higher TME values as 4.17 and 4.13 Kcal/g had been reported by Dale and Fuller (1984) and Sub (1988), respectively. Sibbald (1986) however, reported higher TME value (4.4 Kcal/g) in 11 samples of corn gluten meal, which contained on an average 67% CP. Low TME in local corn gluten meal could be due to comparatively lower CP content (63.82%). The TME values of cottonseed meal were 2.52 Kcal/g for solvent extracted and 2.58 Kcal/g for expeller processed. Similar but slightly lower TME values for solvent extracted cottonseed meal (2.41-2.49 Kcal/g) were reported by Dale and Fuller (1984), Sibbald (1986) and Onol (1992). However, Sub (1988) noted low TME value (2.32 Kcal/g) probably due to lower CP content than the local meal (CP: 30 vs 49%). Sub, 1988 also observed lower TME in expeller processed cottonseed meal with lower CP as against local meal having higher CP. Variations in CP contents of meals could be due to varietial as well as agro-climatic differences under which cotton is cultivated. The TME value of expeller processed rapeseed meal was slightly higher than solvent extracted (2.54 vs 2.51 Kcal/g). Shire *et al.* (1980), Schang and Hamilton (1981) and Sibbald (1986) observed some what similar TME values for solvent extracted rapeseed meal (2.45-2.50 Kcal/g). High TME value (2.66 Kcal/g) had been reported by Jones and Sibbald (1979) in meal having higher CP (53%) than that having lower CP (35%) in case of solvent extracted rapeseed meal which was reported as 2.10 Kcal/g (Sub, 1988). Salmon (1984) reported higher TME value (2.72 Kcal/g) for expeller processed rapeseed meal than local one. The reported rapeseed meal contained 38.5% CP and 8 to 11.2% fat against 34% CP and 7% fat in local rapeseed meal. Lower CP and fat in local rapeseed meal appears to be the reason for lower TME value. The TME value of sesame meal was 2.75 Kcal/g. Storey and Allen (1982) reported very high TME value (3.70 Kcal/g) for sesame meal, which had very high CP (52.4%) and fat (18%) as compared to local sesame meal (CP, 41% & fat, 8%). The lower TME in local sesame meal could be due to its lower CP and fat contents. Sibbald (1986) also observed lower TME (2.56 Kcal/g) in sesame meal with low fat (4.7%) and high ash (12.9%) content. The TME value of soybean meal was 2.96 Kcal/Kg. Sibbald (1976a), Chami *et al.* (1980), Kessler and Thomas (1981), Schang and Hamilton (1981), Salmon

Table II. Proximate composition and gross energy values of various feedstuffs

Feedstuff	Gross Energy (Kcal)				Metabolizable Energy (Kcal/Kg	
	Intake	Voided	Retained	Endog.	Apparent	True
Cereal grain						
Corn	199.99	48.45	151.53	20.01	32.44	3672+18.64
Rice	191.53	48.66	142.87	20.01	3174	3619+2031
Sorghum	184.77	48.26	136.51	19.21	3047	3476+26.75
Wheat	185.34	48.72	136.62	20.01	3106	3561+27.26
Cereal by-product						
Corn gluten feed	193.95	101.80	92.15	19.65	2051	2488+25.37
Rice polishings	220.65	82.87	137.78	19.21	3016	3436+25.79
Wheat bran	202.67	118.26	84.41	19.65	1844	2274+32.32
Molasses	125.54	48.84	76.70	19.32	2154	2697+27.13
Vegetable meal						
Corn gluten meal (30 %)	197.44	99.99	97.45	19.65	2139	2570+25.39
Corn gluten meal (60 %)	234.10	67389	166.21	18.82	3575	3980+25.90
Cottonseed meal (ee)	200.07	67.89	166.21	18.82	3575	3980+25.90
Cottonseed meal (se)	196.46	102.35	94.11	18382	2096	2515+28.08
Guar meal	208.69	99.22	109.47	18.36	2311	2699+34.17
Rapeseed meal (ee)	197.09	102.02	94.89	18.36	2126	2537+32.33
Rapeseed meal (se)	202.28	104.92	97.36	18.36	2110	2508+35.30
Sesame meal	209.18	101.29	107.89	18.92	2341	2751+2831
Soybean meal	206.44	89.95	116.50	18.92	2544	2957+19.37
Sunflower meal	205.13	111.63	93.51	18.92	2052	2467+34.12
Animals meals						
Blood meal	230.46	99.63	130.83	18.67	2705	3091+26.96
Fish meal	217.66	89.10	128.56	18.67	2730	3126+2954
Meat meal	216.27	91.74	124.53	18.32	2677	3070+35.56
Poultry by-product meal	237.75	100.71	137.03	18.67	2963	3367+24.88

Mean ± SE
ee = Expeller extracted, se = Solvent extracted

(1984) and Dale *et al.* (1985) reported TME for soybean meal in the range of 2.91 to 3.08 Kcal/g. Storey and Allen (1982) and Sibbald (1986) observed higher TME values (3.15 and 3.18 Kcal/g) for soybean meal containing 50 and 53% CP. However, Muztar and Slinger (1981) and Sub (1988) noted lower TME value (2.80 and 2.67 Kcal/g) of meals containing 45 and 42% CP. Differences in CP content might have resulted in the variation of TME values. The TME value of sunflower meal was 2.47 Kcal/g. Schang and Hamilton (1981) and Du Preez *et al.* (1984) reported similar TME values for sunflower meal (2.45 & 2.58 Kcal/g). However, Sub (1988) observed lower TME value (2.10 Kcal/g) for sunflower meal, probably due to its very low CP (25%) and high CF (29%) contents.

Animal meals. The GE values of animal meals ranged from 4.62 to 5.14 Kcal/kg. These were found to be lower than the values reported in the literature. The possible reason for lower GE values of local animal meals could be their comparatively lower CP and high ash contents. Sibbald (1986) reported that blood, fish and poultry by-product meals containing 96, 68, and 65% CP had 5.93, 4.95 and 5.47 Kcal/g GE, respectively. These values were 6-23% higher than those of local meals. Similarly, Sibbald (1979a) reported 4.79 Kcal/g GE for fish meal which was 4% higher than that of local meal. However, Sibbald and Morse (1982) and Storey and Allen (1982) reported 4.45 and 4.28 Kcal/g GE, respectively for fish meal being lower than that of local fish meal. This was probably due to lower CP (44.5%) in reported fish meal. Similarly Sibbald (1979b), Sibbald *et al.* (1980) and Sibbald and Morse (1982) reported GE of meat meal ranging from 3.94 to 4.39 Kcal/g. Their values were lower than the local meat meal because of their higher ash content (25.9-27.3%). The AME values for animal meals ranged from 2.68 to 2.96 Kcal/g. Halloran (1980), Schang and Hamilton (1981) and Du Preez *et al.* (1984) reported higher AME value of fish meal ranging from 3.05 to 3.49 Kcal/g. Schang and Hamilton (1981) also reported higher AME value for meat meal as 2.85 Kcal/g.

The TME value for local blood meal was 3.09 Kcal/g. Sibbald (1986) reported higher TME value (4.00 Kcal/g) for blood meal which contained 96.6% CP against 89% in local blood meal. Kessler and Thomas (1981) also observed higher TME value (3.89 Kcal/g) for blood meal. The lower TME in local blood meal might be attributed to lower CP in it. The local fish meal also had lower TME (3.13 Kcal/g) than the values reported by Sibbald (1979a), Halloran (1980), Dale and Fuller (1984), Du Preez *et al.* (1984), Salmon (1984) and Sibbald (1986). Higher TME values (3.31-4.16 Kcal/g) reported for fish meal were due to higher CP (64-72%) and lower ash (12-20%) content than the local fish meal (CP, 61% and ash 23%). The TME value of local meat meal was 3.07 Kcal/g. Similar TME values (2.90-3.14 Kcal/g) of meat meal were observed by Schang and Hamilton (1981), Salmon (1984) and Sibbald (1986). However, Sub (1988) reported higher TME value 4.55 Kcal/g for meat meal containing high CP (71%). While

Sibbald (1979b) and McNab and Blair (1988) found low TME values (2.43-2.72 Kcal/g) for meat meal containing 25-35% ash content. The difference in TME among local and reported values could be due to variation in CP and ash contents. The TME value of local poultry by-product meal was 3.37 Kcal/g which was lower than the valued reported by Dale and Fuller (1980), Dale and Fuller (1984), Dale *et al.* (1985) and Sibbald (1986). They observed higher TME values (3.52-4.48 Kcal/g) for poultry by-product meal containing 47-67% CP, 13-30% fat and 13-16% ash against local having 56, 18 and 11%, CP, fat and ash, respectively. The possible reason for low TME in local poultry by-product meal could be the higher feather contents having poor protein digestibility. The possible reason for low energy utilization from animal meals could be poor processing of meals which resulted into higher indigestible protein and ash contents.

CONCLUSION

It is concluded from the findings of the present study that the TME values of local cereal grains and animal meals are lower, of cereal by-products and vegetable meals comparable and of molasses higher than the reported values.

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