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ENDOGENOUS ENERGY, A CAUSE OF BIASED TRUE METABOLISABLE ENERGY VALUES

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J.J. du Preez, J.P. Hayes and J.S. Duckitt
Department of Poultry Science, University of Stellenbosch, Stellenbosch, 7600

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OPSOMMING: ENDOGENE ENERGIE, DIE OORSAAK VAN SYDIGHEID BY WARE METABOLISEERBARE ENERGIEWAARDES

Gevaste hane word gewoonlik gebruik om 'n skatting van endogene energie (EE) uitskeiding te maak en hierdie meting speel 'n belangrike rol by die bepaling van ware metaboliseerbare energie van voere. Bewys word hier gelewer dat EE oorskat word deurdat gevaste hane 'n energiekrisis beleef en derhalwe behoort die meting eerder gedoen te word met hane wat in 'n positiewe energiebalans verkeer. Die moontlikheid om die skatting van EE te verbeter deur middel van meting van die stikstofuitskeiding, word aangetoon.

SUMMARY:

Generally fasted birds are used for estimating endogenous energy (EE) excretion, this measurement being a critical factor in determining the TME of feeds and ingredients. Evidence is presented that EE is overestimated because the fasted birds lack energy during the bio-assay period and that estimation of EE should be made rather from birds in a positive energy balance. The possibility of an improved procedure for estimating EE making use of nitrogen excretion is discussed.

EE represents metabolic faecal energy plus endogenous urinary energy. Endogenous energy excreted by birds is fundamentally the difference between Metabolisable Energy (ME) and True Metabolisable Energy (TME) values. The reason why ME values of ingredients are lower than TME values is that ME values are penalised with the endogenous urinary energy and metabolic faecal energy values. It was pointed out by Guillaume & Summers (1970) that the difference between ME and TME becomes smaller as energy intake by the bird increases, although the difference remains significant due to the physical limit on the bird to be able to consume sufficient feed. In the TME procedure, as published by Sibbald (1976), endogenous energy excretion is determined with fasted animals, a situation which can be regarded as being physiologically undesirable since birds would be in an energy-deficient state and to an extent also in a protein deficient state. When in a negative energy balance, the animal will catabolize body protein reserves to supply its energy needs. The uric acid thus excreted would inflate the value of the actual energy excretion. The present study was thus undertaken to determine the effect on the excretion of nitrogen of supplying the maintenance energy requirement of roosters by roosters. Furthermore, by attaching an energy value to the excreted nitrogen, it was possible to predict the effect of a positive energy balance on the excretion of endogenous energy.

Procedure

Determination of maintenance energy requirements

Feed-intake data was collected over as a 10 week period from 12 adult Rhode Island Red (R.I.R.) roosters that had been trained to consume their daily feed requirement in $1\frac{1}{2}$ hours (procedure of Farrell, 1978). A diet containing 14,1 kJ ME/g was fed. The average daily feed intake was 77 ± 13,5 g, the mean body mass was 3,0 ± 0,36 kg and the mean change in body mass 0,9 ± 7 g.

Environmental temperature could not be controlled to the limits normally required for the type of work. Howe-ever, the work involving determination of maintenance energy requirement and estimation of EE were performed under conditions where daily environmental temperatures ranged from 8,3 ± 4 to 20 ± 5 degrees centigrade, minimum and maximum respectively for the period including the 48 hours EE determination.

From our data we calculated a maintenance energy requirement of 1086 kJ per day for a 3 kg rooster. This value corresponds very closely to most other values calculated from equations reported in the literature, e.g. from Fontaine & De Munter (1980), 1067 kJ; Byerly (1979), 1 055 kJ; Gous, Byerly, Thomas & Kessler (1978), 1 057 kJ; and according to Farrel (1974) 1 110 kJ. However, the value reported by Guillaume & Summers (1970) was substantially higher viz. 1 469 kJ/day for a 3 kg rooster (Single Comb White Leghorn).

There can be little doubt that if the required amount of maintenance energy is not supplied, the bird will catabolize its body protein reserves which in turn would lead to an increased uric acid excretion.

Effect of feeding a non-protein diet on nitrogen excretion

Twenty-four R.I.R. roosters, approximately 15 months of age, were used. Twelve of these birds had been caecectomized when they were 13 months old, using the technique of Payne, Kifer, Snyder & Combs (1971). They had thus sufficient time to recover from the effects of the operation. All the birds were subjected to a 24 hr fast, their body mass was measured and 6 of the normal birds and 6 of the caecectomized group were selected at random and were fed 24 g of a N-free diet. The same amount was again force-fed 6, 24 and 30 hours later. This amount of feed (96 g) supplied each rooster with 700 kJ of ME per day. The formula of the N-free diet was in g/100 g diet: Maize starch, 60,57; Sucrose, 24; Maize oil, 4; Mineral mixture, 3; Vitamin mixture, 0,25; Choline chloride (40%), 0,2; KH_2PO_4, 1; Ca $HPO4.2H_2O$, 1,2; $CaCO_3$, 1,78; Sellulose, 4. The mineral- and vitamin mixtures supplied the appropriate minerals and vitamins to meet the N.R.C. (1971) requirements. The remaining birds were fasted during this time, but water was available *ad libitum* to all birds.

Collection of excreta from the birds was initiated immediately after the first meal was fed and samples collected during the first 24-hour period were kept separate from those collected during the second 24-hr period. Faeces were collected from all birds according to the procedure of Hayes (1981), where polythene bags (Whirl-pak sample bags, 6 oz.

Fisher catalogue 01-812-5A) are attached to a plastic connecting tube sutured to the skin surrounding the cloacal orifice. The collected samples were subsequently freeze-dried, equilibrated to atmospheric conditions and the N content was determined by means of the macro-Kjeldahl procedure.

Results and discussion

From Table 1 it is clear that during fasting the normal birds excreted significantly more nitrogen in the faeces than their counterparts which were given the N-free diet. This was true for the first and the second 24-hr collection period. During the second collection period there was a tendency for lower N excretion than during the first collection period by the birds on the N-free diet, although this difference was not statistically significant.

Table 1

Effect of fasting or feeding a protein-free diet on the nitrogen excretion by normal and caecectomized roosters, mg N per rooster

	Collection period 0 - 24 hrs*	
	Normal	Caecectomized
Positive energy balance; N-free diet force-fed	682 ± 161^a (212)**	703 ± 127^a (218)
Fasted	1094 ± 362^b (259)	826 ± 213^{ab} (361)
	Collection period 24 – 48 hrs	
	Normal	Caecectomized
Positive energy balance; N-free diet force-fed	434 ± 176^a (157)	521 ± 156^{ab} (138)
Fasted	966 ± 569^b (265)	839 ± 232^{ab} (316)

* Collection period started at first forced feeding which was preceded by a 24 hr starvation period. the two periods were analysed separately.

** Values in brackets are the nitrogen excretions in mg/kg body mass.

The values with a common superscript do not differ significantly ($P > 0,01$) and comparisons are only valid within a period.

The analysis of variance for nitrogen excretion per bird during the 2 collection periods is presented in Table 2.

In the caecectomized birds the feeding of a N-free diet did not result in a statistically significant decrease in N excretion. Although large differences existed between caecectomized and normal birds in both periods, the individual variation between similarly treated birds was probably responsible for the lack of any significant difference between treatments. The fasted birds, for example, excreted 361 mg N/kg body mass during the first 24 hrs compared with 218 mg N/kg excreted by the fed birds. During the second collection period the differences were even larger, the fasted birds excreting 316 mg N/kg, while the fed birds excreted only 138 mg N/kg body mass.

No tendency could be detected during either of the 2 collection periods to show that caecectomy had a consistent effect on the excretion of nitrogen, of the fasted or fed birds. It is thus reasonable to assume that

Table 2

Analysis of variance of nitrogen excreted by adult male birds per kg body mass

Source of variance	df	Mean squares	
		24 hr	24 hr – 48 hr
Treatments	3	28595**	43942*
Feeding status	1	54088**	122672***
Ceaca	1	17579	1668
Interaction	1	14116	7486
Residual	20	6235	12824
Total	23		

Statistical significance: * P = 0,050
** P = 0,010
*** P = 0,006

very little indigestible nitrogenous material had been retained in the caeca after the initial pre-experimental fast. The difference in nitrogen excretion between fasted and fed birds was thus mainly due to the excretion of nitrogen in the urine, probably in the form of uric acid from the breakdown of protein reserves in the body.

By pooling the data in Table 1 for normal and caecectomized birds it was found that during the first 24 hr collecting period, during which endogenous energy excretion was measured, the difference in N excretion between fasted and fed birds amounted to 95 mg/kg body mass. During the following 24 hr period it amounted to 143 mg/kg. The energy equivalent of these differences can be calculated by using the factor of 36,5 kJ/g N as suggested by Sibbald & Slinger (1962). This means that the predicted endogenous energy excreted by starved birds is overestimated by at least 10,4 kJ per bird during the first 24 hr collection period if the bird does not receive a supply of maintenance energy during that period.

The question may be raised whether the extra nitrogen excreted by the starved birds was in the form of uric acid. We therefore followed a different approach by using nitrogen and energy excretion values obtained with colostomized roosters (Hayes, unpublished). With these birds, which had also been fed a N-free diet, we assumed that it would be mainly nitrogenous compounds which would represent metabolic faecal energy. Therefore, by applying the energy equivalent of protein (108 kJ/g N), we used this as a factor to arrive at an energy value for the faeces during N-free feeding. The energy content of the urine was determined directly by bomb calorimetry and then by combining the 2 values we calculated, for the 8 roosters for which this was done, that under conditions of N-free feeding a total of 73,7 ± 4,4 kJ/g N is excreted. If this factor is used instead of the 36,5 kJ/g N for uric acid (Sibbald & Slinger, 1962) it can be calculated that under the conditions of our study the starved roosters excreted 21 kJ per bird more than those receiving a N-free diet.

Table 3

Summary of the endogenous energy excretion by birds during starvation

	kJ/kg body mass 24 hr*	CV**
Guillaume & Summers (1970)	21,76	–
Sibbald (1975)	14,10	–
Sibbald (1976)	17,03 (±0,49)	2,9
Farrell (1978)	18,00 (±2,6)	14,4
Du Preez (1979)	19,60 (±3,7)	18,7
Leghorn males, body mass 2 kg	15,20 (±1,3)	8,5
Euribrid males, body mass 5 kg	12,60 (±1,3)	10,0
Minnaar & Erasmus (1980)	23,93 (±2,76)	11,5
Mean endogenous energy excretion calculated from the energy equivalent of endogenous nitrogen excretion of fasted birds	19,0	

* Following an initial 24 hr fasting to empty alimentary tract
** CV = Coefficient of variation

A number of published reports on endogenous energy excretion by starved roosters are summarised in Table 3 and some values which have been obtaining for different breeds in our own studies are also included.

From Table 3 it is clear that there is wide variation between the results of different workers as values ranged from 12,6 to 23,9 kJ/kg body mass. Also shown in Table 3 is the endogenous energy excretion calculated from the nitrogen excretion value of fasted birds. The reliability of endogenous energy values estimated via endogenous nitrogen must be established in further work and in trials where the additivity of values for feedstuffs is investigated. We do feel, however, that this approach is preferable to that where birds are starved in an attempt to determine endogenous energy excretion.

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References

BYERLY, T.C. (1979). Prediction of the food intake of laying hens. *Proc. of the 14th Poultry Science Symposium.* Ed. K.N. Boorman & B.M. Freeman. pp. 327.

DU PREEZ, J.J. Report at Worlds Poultry Science study group meeting, Stellenbosch. *S.A. Poultry Bulletin*, July 1981, pp. 233.

FARRELL, D.J. (1974). Energy requirements of Poultry. Ed. T.R. Morris & B.M. Freeman, Edinburgh Scotland: British Poultry Science Ltd. pp. 13.

FARRELL, D.J. (1978). Rapid determination of metabolisable energy of foods using cockerels. *Br. Poult. Sci.* 19, 303.

FONTAINE, G. & DE MUNTER, G. (1980). Energiebehoeftes voor onderhoud en produktie bij halfzware leghennen. *Landbouwtijdschrift* 33, 101.

GOUS, R.M., BYERLY, T.C., THOMAS, O.P. & KESSLER, J.W. (1978). A partitition equation to predict food and energy intake by laying hens. *Proc. World Poultry Congr.* Rio de Janeiro. Vol. 2, 1–8.

GUILLAUME, J. & SUMMERS, J.D. (1970). Maintenance energy requirement of the rooster and influence of plane of nutrition on metabolisable energy. *Can. J. Anim. Sci.* 5-, 363.

HAYES, J.P. (1981). A rapid and accurate method for the collection of faeces in roosters (Submitted for publication).

MINAAR, A. DU P. & ERASMUS, J. (1980). Unpublished results.

N.R.C. (1971). National Research Council. *Nutrient requirements of Poultry.* 5th ed. National Academy of Science.

PAYNE, W.L., KIFER, R.R., SNYDER, D.G. & COMBS, G.F. (1971). Invéstigation of apparent amino acid digestibility of fish meal protein using caecectomized adult male chickens. *Poultry Sci.* 50, 143.

SIBBALD, I.R. & SLINGER, S.J. (1962). The relationship between classical and corrected metabolisable energy value. *Poultry Sci.* 41, 1007.

SIBBALD, I.R. (1975). The effect of level of feed intake on metabolisable energy values measured with adult roosters. *Poultry Sci.* 54, 1990.

SIBBALD, I.R. (1976). A bioassay for true metabolisable energy in feedingstuffs. *Poultry Sci.* 55, 303.