EFFECT OF URINARY NITROGENOUS COMPOUNDS ON THE ENERGY METABOLISM OF BIRD

T. S. Koh[1] W. I. Choi and S. J. Han

Animal Resources Research Center, Department of Feed & Nutritional Sciences, College of Animal Husbandry, Kon-Kuk University, 93 Mojin-dong, Seongdong-gu, Seoul 133-701, Korea

Summary

In order to study the relationships between the contents of urinary nitrogenous compounds and energy utilization of bird, the sum of nitrogen contents of uric acid, ammonia, creatine and urea voided in excreta was estimated as the urinary nitrogen (UN) in 13-33 day-old fed or fasted White Leghorn male chicks. Energy retention and heat production of birds were determined by comparative slaughter studies.

2.75 mg of endogenous urinary nitrogen (EUn) and 2.19 mg of uric acid was excreted constantly per kJ heat production in fasted bird. One mg of UN was proportionated to 32.26 J ($r = 0.999$, $n = 8$) of the urinary energy (UE) in fed and 32.97 J ($r = 0.9998$, $n = 8$) of the endogenous urinary energy (UEe) in the fasted bird. Also relationships between 1 mg of uric acid and 38.95 J of UE ($r = 0.998$, $n = 8$) or 38.97 J of UEe ($r = 0.996$, $n = 8$) were significant ($p < 0.01$). The EUn ($r = 0.997$, $n = 4$), uric acid ($r = 0.995$, $n = 4$) and metabolic fecal energy (FEm) plus UEe ($r = 0.961$, $n = 4$) were increased with the increase of body weight (g/bird). Metabolic fecal nitrogen (MFn) or energy (FEm), EUn and UEe per unit diet were not influenced by the age of day or body weight.

The results indicated that energy and protein utilization of bird can be approximated by the relationships among urinary nitrogen, urinary energy, uric acid content in excreta and body weight of bird.

(**Key Words**: Bird, Urinary Nitrogen (UN), Endogenous Urinary Nitrogen (EUn), Uric Acid, Urinary Energy (UE), Energy and Protein Utilization)

Introduction

The urinary nitrogen (UN) or endogenous urinary nitrogen (EUn) are the uncompletely oxidized protein metabolites composed mainly of uric acid, ammonia, creatine and urea in fed or fasted bird (Sturkie, 1976). And endogenous urinary energy (UEe) is comparted by the calculation of energy contents for the catabolites of protein from the metabolic fecal energy (FEm) in the droppings of poultry (Lim et al., 1986). But the relationships between the contents of uric acid and energy utilization of birds was not fully elucidated though the uric acid nitrogen constitutes from 60 to 82% of the total UN (Shoemaker, 1972). Thus the interrelationship between energy utilization of bird and the protein metabolites, uric acid, of excreta was studied for the accurate evaluation of nutrients utilization in poultry.

[1]Address reprint requests to Dr. T. S. Koh, Animal Resources Research Center, Department of Feed & Nutritional Sciences, College of Animal Husbandry, Kon-Kuk University, 93, Mojin-dong, Seongdong-gu, Seoul 133-701, Korea.

Received January 22, 1991

Accepted January 21, 1992

Materials and Methods

Day-old Single Comb White Leghorn male chicks were fed on a commercial chick mash diet for the first 12 days in an electrically heated wire floored brooder. During the next 20 days of experimental feeding period, birds were either fed on the same diet or fasted during 3 days at 23-27℃ of room temperature with 12 hrs period of light and darkness. The protein metabolites in excreta and energy utilization of birds were measured 4 times at the intervals of 5 days. For the 1st, 2nd and 3rd experiments with 4 groups of fed and 2 groups of starved 60 birds (10 birds fed × 5 groups + 5 birds starved × 2 groups) of 13-18 days-old, 46 birds of 18-23 days-old and

32 birds of 23-28 days-old, were respectively employed. For 4th experiment with 2 groups of fed and 2 groups of starved 18 birds (4 birds fed × 2 groups + 5 birds starved × 2 groups) were employed.

The experimental diet, corn-soybean type, contained 12.0% of moisture, 18.4% of crude protein, 5.0% of crude fat, 6.8% of ash, 5.5% of crude fiber and 14.74 kJ of gross energy (GE). The diet contained all the nutrients for chick growth recommended by NRC (1984). Diet and water was supplied freely.

In initial and final day of each feeding and fasting experiment at 09:00 AM, each 4 birds as representatives selected at random in fed and starved group, respectively, were sacrificed for analysis of carcass compositition. Feed consumption at 24 hr intervals and individual body weight in initial and final day of fed and fasting experiments were recorded.

The daily droppings on the plastic sheets beneath the cages were collected at 24 hr intervals of final 2 days in birds for 5 days of feeding and during 3 days in birds starved for the every experimental periods. The droppings were blended by an Waring blender with some water in the flesh state as soon as possible after the collection to prevent NH_3 loss or decomposition of uric acid and other protein catabolites. A definite amount of the blended excreta was used immidiately after blening for the determination of total nitrogen and ammonia (AOAC, 1980) and for the extraction of the nitrogenous compounds with the saturated lithium carbonate (Li_2CO_3) water solution (Tasaki and Okumura, 1964). And a definite amount of the remnant excreta was dried at 60℃ in the forced convection dry oven. The combustion value of the excreta and feed was measured by an adiabatic bomb calorimeter. For the correction of nitrogen equililbrium, 34.39 J/mg N (Hill and Anderson, 1958) was used in the calculation of metabolizable energy (MEn) and true metabolizable energy (TMEn) contents of diet.

Uric acid (Baker, 1946, Marquardt, 1983), total creatinine (Hawk et al., 1958) and urea (Iino and Kameoka, 1969) was determined using an aliquots of the extracts. The UN and urinary energy (UE) were comparted from the excreta nitrogen or energy by the sum of nitrogen or energy contents of the uric acid, ammonia, total creatinine and urea (Koh and Oh, 1984, Lim et al., 1986). The energy contents of urinary nitrogenous compounds were calculated by multiplying 11.418 kJ per gram for uric acid, 25.171 kJ for ammonia, 17.878 kJ for total creatinine and 10.569 kJ for urea (Japanese Chemical Society, 1952), respectively.

For the analysis of carcass composition, whole carcasses removed digesta and feces from the digestive tract of birds were frozen quickly at -20℃ as soon as possible and homogenized with the plumage by a chopper 4 times or more at the frozen state to prevent the leakage of moisture from the carcasses. The protein contents of carcasses were calculated by multiplying 6.25 for total nitrogen, and lipids of the homogenates were extracted by the method of Folch et al. (1957) and measured gravimetrically. Energy retention (ER) was calculated by multiplying 23.85 kJ and 39.75 kJ for gram protein and lipids retention, respectively, in the fed bird and 16.07 kJ for gram protein in the starved bird (Brouwer, 1965).

Regression analysis or studentized t-test were carried out to asses the relationships between means, and to test the significance of difference among means (Snedecor and Cochran, 1967).

Results and Discussion

Energy utilization of bird

During 20 days of experimental feeding period, daily body weight gain, energy retention (ER) and heat production (HP) in birds fed or fasted were shown in table 1.

Body weight, feed intake and HP were increased as age of day passed. When body weight was increased from 92.5 to 345.0 g, daily ER was increased from 58.83 kJ to 89.16 kJ which was estimated as the net energy for gain (NEg) in this experimenal condition. The daily gain and ER of birds during 13-18 day-old was lower than those of bird during 13-33 day, which showed even a tendency to increase with age of day.

But during 3 days of fasting period, birds reduced the body weight and increased the HP and ER linearly with the increase of body weight and age of day passed. The HP were in a range from 35.15 to 89.16 kJ according to the change of body weight, which was approximated as the net energy for maintenance (NEm).

TABLE 1. DAILY GAIN, ENERGY RETENTION AND HEAT PRODUCTION IN 13-33 DAY-OLD BIRDS FED OR FASTED AT 23-27℃ OF ROOM TEMPERATURE (MEAN ± SD)

Age of day	13-18	18-23	23-28	28-33
Fed[1]				
Body weight, Initial (g/bird)	92.5 ± 3.9[a]	136.4 ± 7.8[b]	202.3 ± 17.6[c]	271.8 ± 30.1[d]
Body weight, Gain (g/bird)	8.8 ± 1.6[a]	13.2 ± 3.5[b]	13.9 ± 6.0[b]	14.7 ± 2.2[b]
Feed intake (g/bird)	21.3 ± 3.1[a]	29.5 ± 3.4[b]	36.3 ± 3.4[c]	42.7 ± 2.8[d]
Energy retention[2] (kJ/bird)	58.83 ± 10.42[a]	86.90 ± 23.14[b]	91.76 ± 39.83[b]	96.32 ± 13.85[b]
Heat production[3] (kJ/bird)	152.15 ± 10.88[a]	204.76 ± 7.11[b]	268.40 ± 12.13[c]	337.36 ± 7.12[d]
Fasted[4]				
Body weight gain (g/bird)	8.2 ± 0.99[a]	11.2 ± 1.68[b]	−15.8 ± 1.89[c]	19.1 ± 2.94[d]
Heat production[5] (kJ/bird)	35.15 ± 4.10[a]	49.29 ± 7.45[b]	73.47 + 8.95[c]	89.16 + 13.68[d]

[1] As sample 14 birds in 1st, 2nd and 3rd and 8 birds in 4th experiment were used for record of body weight, and calculation of energy retention and heat production, and feed intake is average of 5 day.

[2] Calculated by protein and lipids gain during 5 days of experiment.

[3] MEn intake minus energy retention.

[4] Average values of 10 birds during 3 days of fasting period.

[5] Reduced energy retention of 10 birds.

Significantly different at $p < 0.05$ among different superscripts in the same row.

From table 1, daily NEg, NEm, HP and heat increment for maintenance and growth (HIm + g) were summarized as the function of the metabolic body size ($kg^{0.75}$) to remove the effect of the variation in body weight. Per $kg^{0.75}$ birds intaked daily 1071 kJ of MEn (table 4), retained 282.7 kJ of NEg and produced 788.5 kJ of heat, and the NEm and HIm + g of the bird reached to 247.6 and 539.8 kJ, respectively. The rate of NEg, NEm, HP and HIm + g per MEn intake were 26.4, 23.1, 73.6 and 50.4%, respectively. Thus the net availablity of metabolizable energy (MEn) for growth was reached to 49.6%.

The estimated NEm per $kg^{0.75}$ was lower than 556.1 kJ of Koh et al. (1985) who raised 11-26 day-old White Leghorn male chicks at 14-21 ℃ of room temperature. A linear decrease in metabolic heat production with increasing ambient temperature was observed (van Kampen, 1974, Romijin and Vreugdenhil, 1969, Davis et al., 1973). Thus the low value of the NEm will be due to a high ambient temperature (23-27℃). While differences between this study and 548.1 kJ of Waring and Brown (1965), 347.3 kJ of Scott et al. (1982) or 326.4 kJ of Whittow (1976) were not studied. Because of differences between strains or determination methods it is difficult to compare their metabolic rates.

Distribution of urinary nitrogenous compounds

Distribution of nitrogenous compounds expressed as percent of total UN in 13-33 days-old chicks fed or fasted at 23-27℃ of room temperature were shown in table 2. Birds fed diet voided 82.4% of uric acid nitrogen which was higher than 78.8% of the starved birds. And ammoniacal nitrogen was 3.9% in the fed bird which was lower compared with 10.8% in the fasted birds. Total creatinine nitrogen of 2.2% was excreted in the fed bird was higher than 1.3% in the fasted birds.

The UN was estimated by the sum of nitrogen contents of the protein catabolites. Although of urinary nitrogen uric acid of 82.4% in the fed bird was similar with 81.0% reported by O'Dell et al. (1960) in birds fed practical diet and

TABLE 2. DISTRIBUTION OF NITROGEN FOR NITROGENOUS COMPOUNDS IN EXCRETA OF 13-33 DAY-OLD CHICKS FED OR FASTED AT 23-27℃ OF ROOM TEMPERATURE

Nitrogenous compounds	Fed[1]		Fasted[2]	
	%	CV	%	CV
Uric acid	82.4 ± 2.3[a]	2.8	78.8 ± 3.2[b]	4.1
Ammonia	3.9 ± 1.1[a]	28.2	10.8 ± 2.0[b]	18.5
Total creatinine	2.2 ± 0.4[a]	18.2	1.3 ± 0.4[b]	30.8
Urea	11.5 ± 2.6	22.6	9.1 ± 1.8	19.8

[1] Determined twice in bird of 13-18, 18-23, 23-28 and 28-33 day-old chicks, respectively.
[2] Determined twice at last two days during 3 days of fasting in 13, 18, 23 and 28 day-old birds, respectively.
Mean ± SD of 8 determinations.
Significantly different at $p < 0.05$ between different superscripts in the same row.

84.1% observed by Sykes (1971), while which were higher than 60% reported by Teekell et al. (1960) and 76.0% by O'Dell et al. (1960) in birds fed semipurified diet.

The uric acid nitrogen increased in the fed birds compared with that of fasted birds was similar trends with the observation of Sykes (1971). The distribution of ammoniacal nitrogen showed inverse relationlship with that of the uric acid, though Lim et al. (1986) found similar trend even in the fasted birds. Thus the uric acid excretion have an inverse relationship with ammonia excretion in the kidney and catabolism of protein was different between normal and fasting birds.

For the collection of urine free from the feces it is necessary to cannulate the ureters or to separate the openings of the ureters or the rectum by surgical colosectomy. But the operated bird can no longer be regarded as physiologically normal, since chickens with exteriorized ureters drank almost twice as much water after as before (Dicker and Halsam, 1966) and insertion of uretral cannulas is known to produce diuresis (McNabb et al., 1970). It shows that the insertion of ureters or surgical colosectomy functins possibly as a stressors and normaly excreted urinary nitrogenous compounds will be not known. It was considered that birds raised in physiologically normal state is necessary for the bioassay of energy utilization.

Urinary nitrogen and heat production

Excretion of the UN or uric acid per HP were calculated in birds fed or fasted and summarized in table 3. In the fed bird excreted 1.51 mg of UN and 1.14 mg of uric acid per kJ of HP, respectively, which were lower than 2.75 mg of EUn and 2.19 mg of uric acid per kJ of fasting heat production (FHP). The coefficient of variance were decreased in the order of UN, uric acid of fed bird, EUn and uric acid of fasted bird showing the values 13.2, 9.6, 4.0 and 2.5%, respectively. Thus the relationship between daily EUn or uric acid and FHP was constant relatively.

The EUn and uric acid to the FHP showed a constant values of 2.75 mg kJ^{-1} and 2.19 mg kJ^{-1}, respectively. This is a similar trends with that the basal metabolism have a constant relationship with the EUn (Brody, 1945). And Farrell and Swain (1977) observed even at the different ambient temperature relationship between daily EUn and FHP was constant. The value of EUn per FHP was higher than 1.14 for unacclimated and 1.30 for acclimated broilers reported by Farrell and Swain (1977), while, who did not determine the UN separately from the FN. The difference will be due to the different species or experimental methods but the reasons were could not elucidated.

The excretion of the UEe, uric acid and FEm + UEe were positiviely related to the body weight of bird with a significant linear effect. It was similar with the suggestion of Miski and Quazi (1981) who observed that UEe + FEm were voided as similar trend with the EUn + MFn expressed per unit body weight in growing broiler chicks. And they suggested that UEe + FEm losses were mainly attributed to difference in their body composition and basal metabolic rate (BMR) energy needs, who even did not measure UEe separately from the FEm.

TABLE 3. EXCRETION OF URINARY NITROGEN AND URIC ACID PER HEAT PRODUCTION IN BIRDS FED OR STARVED AT 23-27℃ OF ROOM TEMPERATURE

Age of day	Fed[1]		Starved[2]	
	UN[3]	Uric acid	EUn[3]	Uric acid
	(mg kJ^{-1})	(mg kJ^{-1})	(mg kJ^{-1})	(mg kJ^{-1})
13-18	1.49 ± 0.45	1.11 ± 0.41	2.91	2.17
18-23	1.56 ± 0.16	1.29 ± 0.14	2.69	2.12
23-28	1.75 + 0.27	1.13 + 0.17	2.67	2.21
28-33	1.26 ± 0.10	1.03 ± 0.11	2.75	2.25
13-33	1.51 ± 0.20[b]	1.14 + 0.11[a]	2.75 ± 0.11[d]	2.19 ± 0.06[c]
CV[4]	13.2	9.6	4.0	2.5

[1] Mean ± SD of 8 determinations.
[2] Mean values during 3 days of starving was used.
[3] UN; urinary nitrogen, EUn; endogenous urinary nitrogen.
[4] Coefficient of variance.
Significantly different at $p < 0.05$ among different superscripts in the same row.

Since the UEe was excreted linearly with the FHP and body weight in poultry, and a linear relationships between UE and UN or uric acid was found. This would be expected that energy and protein utilization of birds will be estimated from the energy intake, excreta energy, uric acid in excreta and body weight of bird.

Relationships among UN, UE, uric acid and body weight

The interrelationships among UN, UE, uric acid and body weight were calculated from the data. As expected UE (y, J $bird^{-1}$ day^{-1}) increased with the content of UN (x, mg $bird^{-1}$ day^{-1}) in the excreta of fed bird.

$y = 268 + 32.26x$, SE for slope = 13.18, $r = 0.999$, $n = 8$ ······························ (1)

Also UEe (y, J $bird^{-1}$ day^{-1}) was related linearly with the EUn (x, mg $bird^{-1}$ day^{-1}) in the fasted bird.

$y = 4.9 + 32.97x$, SE for slope = 13.5, $r = 0.9998$, $n = 8$ ······························(2)

The slopes between UE and UEe was not differ. Then relationship between UN and UE was constant neverteless fed or fasted bird and energy equivalent to 1 mg of UN was ranged from 32.26 J of UE to 32.97 J of UEe.

Also a linear regression equations between UE (y, J $bird^{-1}$ day^{-1}) and uric acid (x, mg $bird^{-1}$ day^{-1}) was calculated.

Fed bird: $y = 387 + 38.95x$, SE for slope = 15.95, $r = 0.997$, $n = 8$ ······················ (3)

Fasted bird: $y = 366 + 38.97x$, SE(slope) = 15.93, $r = 0.999$, $n = 8$ ······················ (4)

When birds were starved the FEm + UEe (y, J $bird^{-1}$ day^{-1}), EUn (y, mg $bird^{-1}$ day^{-1}) and uric acid (y, mg $bird^{-1}$ day^{-1}) were increased positively with the body weight (x, g $bird^{-1}$).

FEm + UEe: $y = 3389 + 44.83x$, SE (slope) = 33.0, $r = 0.961$, $n = 4$························(5)

EUn: $y = 29.5 + 0.8997x$, SE (slope) = 0.637, $r = 0.997$, $n = 4$ ························ (6)

Uric acid: $y = 14.0 + 0.7838x$, SE (slope) = 0.557, $r = 0.995$, $n = 4$ ······················ (7)

All correlation coefficients between UE or UEe and UN or uric acid content in excreta, and body weight and FEm + UEe, EUn or the uric acid were significant at $p < 0.05$. The results indicated that UN and uric acid in excreta in fed or fasted bird is equivalent to 32.26-32.97 J and 38.95-38.97 J of UE or UEe, respectively, and suggested that EUn, uric acid and FEm + UEe will be estimated from the body weight of bird.

From the relationship between urinary nitrogen and energy, 1 mg of UN and EUn was equivalent to 32.26 J of UE and 32.97 J of UEe which was similar with 33.92 J reported by Lim et al. (1986) in the fasted bird. Also Koh et al. (1990) boserved 33.51 J of UE and 33.18 J of UEe per mg N in White Leghorn layer fed graded levels of a practical diet at 21-28℃ of room temperature.

For correction to zero nitrogen retention, Hill and Anderson (1958) used a value of 34.39 J per mg N retained, because this value, the energy content of uric acid, is based on the assumption that tissue protein when catabolized would yield uric acid as the sole excretory product. And Titus (1959) used 36.53 J per mg N retained which was the gross energy (GE) content of chicken urine to average UN content. Also Coulson and Hughes (1930) found an energy content of 36.40 J per mg N for chicken urine. The reported values were higher than those of this experiment, Lim et al. (1986) and Koh et al. (1990).

The nitrogenous compounds excepts the uric acid are excreted in the range from 16% (Sykes, 1971) to 19% (O'Dell et al., 1960) and from 17.6 to 21.2% in this study. The UE and UEe is energy excreted as the incomplete oxidative metabolites of the protein. Thus the energy coefficient for the correction of nitrogen equilibrium should be derived from all the nitrogenous compounds will be more accurate. But in practice the value derived from the uric acid (Hill and Anderson, 1958) has been used most frequently (Scott et al., 1982) and significant difference in the calculation of ME value was not found (Lim et al., 1986).

Utilization of protein and energy

In order to elucidate an effect of MFn + EUn, UEe and (FEm + UEe)n on the energy utilization of diet, the values per unit diet in dry matter were summarized in table 4.

During 20 days of growing period, effect of age in day-old on the MFn + EUn, UEe and (FEm + UEe)n values were not found, and relatively stable values, average 7.1 mg, 0.21 kJ and 0.11 kJ per gram diet were obtained, respectively. While diet contained 11.15 kJ g^{-1} of MEn, the (FEm + UEe)n corrected MEn. the true metabolizable energy (TMEn) was reached to 11.25 kJ g^{-1} diet. Since the difference between MEn and TMEn value was not significant, MFn, FEm, EUn and UEe expressed per unit diet were not affected by the age of day or body weight change by growth.

Since 16.6 and 34.2% of diet protein was excreted as FN and UN, respectively, nitrogen retention was 49.2 ± 1.6 (SD, n = 4) % and digestibility of protein was reached to 83.4 ± 2.2 (SD, n = 4)%. And MFn was equivalent to 3.0% of diet protein, then true digestibility of protein was calculated as 85.4 ± 2.8 (SD, n = 4)%. Also from the EUn, the biological value of protein was calculated as 81.0 ± 3.2 (SD, n = 4)%, then net utilization of protein was reached to 70.0 ± 4.2 (SD, n = 4)%.

In the dry matter basis, the experimental diet contained 16.75 kJ of GE, 12.14 kJ of digestible energy (DE) and 11.72 kJ of ME. Thus the digestibility of energy (DE/GE) and metabolizability (ME/GE) for diet were reached to 72.5 ± 2.8 (SD, n = 4)% and 70.0%, respectively. When the ME was corrected to zero nitrogen retention (table 4), the metabolizability (MEn/GE) of diet was lowered to 66.6%. The correction to zero nitrogen retention contributed 3.5% of GE loss which was higher than 2.5% of UE loss for the incomplete oxidative metabolite of protein. And the another metabolizability, TMEn/GE, was reached to 67.2% which was equivalent to the MEn value plus 0.6% of GE added by the (FEm

TABLE 4. METABOLIZABLE ENERGY VALUES PER GRAM DIET INFLUENCED BY THE METABOLIC FECAL AND ENDOGENOUS URINARY NITROGEN OR ENERGY IN 13-33 DAY-OLD MALE CHICKS AT 23-27℃ OF ROOM TEMPERATURE IN THE DRY MATTER BASIS

Age of day	13-18	18-23	23-28	28-33	13-32
MEn (kJ/g)	10.96 ± 0.13	11.01 ± 0.09	11.11 ± 0.08	11.51 ± 0.15	11.15 ± 0.25
MFn + EUn (mg/g)	7.7 ± 0.5	5.9 ± 0.9	6.8 ± 0.3	8.2 ± 2.1	7.1 ± 1.01
UEe (kJ/g)	0.21 ± 0.04	0.19 ± 0.02	0.21 ± 0.01	0.24 ± 0.04	0.21 ± 0.02
(FEm + UEe)n (kJ/g[1])	0.14 ± 0.006	0.08 ± 0.002	0.11 ± 0.005	0.11 ± 0.002	0.11 ± 0.02
TMEn (kJ/g)	11.10 ± 0.13	11.09 ± 0.09	11.22 ± 0.088	11.62 ± 0.15	11.25 ± 0.25

[1] [FEm + UEe − (MFn + EUn) × 34.39]/Feed intake.
Mean ± SD of 4 replicates.

+ UEe)n.

Thus to know an effect of the higher TMEn value than MEn on the energy metabolism of birds, the TMEn intake, heat production (HPt) and heat increment (HIt) calculated by the TMEn value of diet were compared to those of MEn were summarized in table 5.

The rate of TMEn/MEn were 101.0% and HPt/HP were 101.4% which were lower ($p < 0.05$) than 101.95% of HIt/HI. Since the TMEn value of diet do not affect on the NEg and NEm determined by the retention of protein and lipids in the body, the HPt is equivalent to the difference between the TMEn intake and NEg, and the HIt, the TMEn intake minus the NEg and NEm, varied with the increased value of the TMEn. Accordingly the major part of the increased TMEn/MEn was associated with the increase of the HI in energy metabolism of bird. Thus when other energy values of diet, DE or ME, were applied on the energy metabolism of bird, the HI only will be changed. It is still questionable, for the precise evaluation of nutrients, that the correction of nitrogen retention for calculation of ME is right expession of the real energy metabolism of bird (Kleiber. 1965).

The results suggests that if it were possible to determine the energy intake, nitrogen intake, energy or nitrogen and uric acid contents in excreta and body weight of bird, this would provides an accurate means of estimating the energy and protein utilization of bird.

TABLE 5. EFFECT OF TMEn VALUE OF DIET ON THE DAILY ENERGY UTILIZATION OF BIRD

	$kJ/kg^{0.75}$		%
TMEn	1083.0 ± 19.7	TMEn/MEn	101.01 ± 0.24^{a}
HPt[1]	799.3 ± 43.9	HPt/HP	101.37 ± 0.34^{a}
HIt[2]	550.9 ± 38.9	HIt/HI	101.95 ± 0.42^{b}

[1] Heat production calculated by the TMEn value.
[2] Heat increment calculated by the TMEn value.
Mean ± SD of 4 replicates.
Significantly different at $p < 0.05$ between different superscripts in the same column.

Acknowledgements

A part of this report was published in the Memoria Proceeding of Ⅷ European Poultry Conference took place in Barcelona, Spain from June 25th to 28th, 1990.

Literature Cited

AOAC. 1980. Official Method of Analysis. 13th edn. William Horwitz (Ed.), Washington, D. C., Association of Analytical Chemists.

Baker, C. T. I. 1946. A note on the estimation of the poultry uric acid radical in avian excreta. Poultry Sci. 25:593.

Brody, S. 1945. Bioenergetics and Growth. New York, Hafner Press.

Brouwer, E. 1965. Report of subcommittee on constant and factors. Symposium on Energy Metabolism. EAAP Pub. No. 11. London, Academic Press, pp. 441-444.

Coulson, E. J. and J. S. Hughes. 1930. Collection and analysis of chicken urine. Poultry Sci. 10:53-58.

Davis, R. H., O. E. M. Hassan and A. H. Sykes. 1973. Energy utilization in the laying hen in relation to ambient temperature. J. Agric. Sci. 80:173.

Dicker, S. E. and J. Halsam. 1966. Water diuresis in the domestic fowl. J. Physiol. 183:173.

Farrell, D. J. and S. Swain. 1977. Effects of temperature treatments on the heat production of starving chickens. Br. Poultry Sci. 18:725-734.

Folch, J., M. Lees and G. H. Sloane-Stanley. 1957. A simple method for the isolation and purification of total lipids from animal tissues. J. Biol. Chem. 226:497-509.

Hawk, P. B., B. L. Oser and W. H. Summerson. 1954. Practical Physiological Chemistry. New York, Mcgraw Hill Book Co., Inc., pp. 899.

Hill, F. W. and D. L. Anderson. 1958. Comparison of metabolizable energy and productive energy determinations with growing chicks. J. Nutr. 64:587-603.

Iino and Kameoka. 1981. in Protein, Nucleic Acid & Enzymes, '81-11, Supplements, No. 24. Tokyo, Kyoritsu Suppan Co., Ltd., pp. 83-84.

Japanese Chemical Society. 1952. Kagakubinran. Tokyo, Maruzen. pp. 83-84.

Kleiber, M. 1975. The Fire of Life, an introduction to animal energetics (revised Ed.), Malabar, Florida, Robert E. Krieger Publ. Co.

Koh, T. S. and C. H. Oh. 1984. Biological value of earthworm (Eisenia Foetida) cake protein in chick. Korean J. Anim. Sci. 26:389-395.

Koh, T. S., K. W. Lim and J. S. Shin. 1985. A study of energy metabolism of chicks by analysis of body composition. Korean J. Anim. Sci. 27:717-723.

Koh, T. S., M. Y. Ju, D. S. Shin and B. S. Won. 1990. Effect of feed restriction on energy and protein utilization of diet in layer. in: Proceedings of the 5th AAAP Animal Science Congress, Taipei, Republic of China, vol. 3, pp. 129.

Lim, K. W., W. J. Maeng and T. S. Koh. 1986. Excretion of nitrogenous compounds in fasting chicks and true metabolizable energy. Korean J. Anim. Sci. 28:411-418.

Marquardt, R. R. 1983. A simple spectrophotometric method for the direct determination of uric acid in avian excreta. Poultry Sci. 62:2106-2108.

McNabb, F., M. Anne and T. L. Poulson. 1970. Uric acid excretion in pigeons. Comp. Biochem. Phlysiol. 33:933.

Miski, A. A. and S. Quazi. 1981. Influence of age and sex of growing broiler chicks and body weight of roosters on their endogenous and metabolic energy losses. Poultry Sci. 60:781-785.

National Research Council. 1984. Nutrient Requirements of Poultry. 8th edn., Washington, D. C., National Academy Press.

O'Dell, G. L., W. D. Woods, O. A. Laedal, A. M. Jeflay and J. E. Savage. 1960. Distribution of the major nitrogenous compounds and amino acids in chicken urine. Poultry Sci. 39:426-432.

Romijin, C. and E. L. Vreugdenhil. 1969. Energy balance and heat regulation in the White Leghorn fowl. Neth. J. vet. Sci. 2:32.

Scott, M. L., M. C. Nesheim and R. J. Young. 1982. Nutrition of the Chicken. 3rd edn., New York, W. J. Humphrey Press, Inc.

Shoemaker, V. H. 1972. Osmoregulation and excretion in birds. in: Farner, D. S. & J. R. King (Eds.) Avian Physiology, vol. II. New York, Academy Press.

Snedecor, G. W. and W. G. Cochran. 1967. Statistical Methods. 6th edn., Ames, IA, The Iowa State University Press.

Sturkie, P. D. 1976. Kidneys, extrarenal salt excretion, and urine. in: P. D. Stukie, (Ed.) Avian Physiology, 3rd edn. pp. 263-285. New York, Springer-Verlag.

Sykes, A. H. 1971. Formation and composition of urine. in: D. J. Bell and B. M. Freeman, (Eds.) Physiology and Biochemistry of the Fowl. vol. 1, pp. 233-277. New York, Academic Press.

Tasaki, I. and J. Okumura. 1964. Effect of protein level of diet on nitrogen excretion in fowls. J. Nutr. 83:34-38.

Titus, H. W., A. Mehringer, Jr., D. Johnson, Jr., L. L. Nesbitt and T. Thomas. 1959. An evaluation of MCF (micro-cell-fat), a new type of fat products. Poultry Sci. 38:1114-1119.

van Kampen, M. 1974. Physical factors affecting energy expenditure. in: Morris, T. R. & Freeman, B. M. (Eds.), Energy Requirement of Poulty. Edinburgh, Br. Poultry Sci., Ltd.

Waring, J. J. and W. O. Brown. 1965. A respiration chamber for the study of energy utilization for maintenance and production in the laying hen. J. Agr. Sci., Cambridge, 65:139-146.

Whittow, G. C. 1976. Regulation of body temperature. in: Stukie, P. D. (Ed.) Avian Physiology, 3rd edn. pp. 146-173. New York, Springer-Verlag.