Energy Requirement of Rhode Island Red Hens for Maintenance by Slaughter Technique

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ABSTRACT : Energy requirement of Rhode Island Red (RIR) hens was studied by comparative slaughter technique. Seventeen hens above 72 weeks of age were slaughtered in batches. Batch I consisted of 5 hens which were slaughtered initially. Batch II comprised of six hens, which were fed *ad libitum* broken rice (BR)-based diet for 18 days. Record of feed intake, number of eggs laid and egg weight during the period was kept. These hens were slaughtered and body energy content was determined. Egg energy was consisted as energy deposited. Batch III consisting of six hens which were fed varying quantity of diet for 15 days, were slaughtered similarly as hens of batch II. Regression equation (body weight to body energy) developed on batch I was applied to batch II, and developed on batch II was applied to batch III hens, to find out initial body energy content of hens. Egg energy (EE) was calculated according to formula: EE (kcal) = -19.7 + 1.81 egg weight (g). Regressing metabolisable energy (ME) intake on energy balance (body energy change + egg energy), maintenance ME requirement of hens was found to be 119.8 kcal/kg $W^{0.75}$/d. Multiple regression of ME required for proiduction on energy retained as protein and fat (body plus egg energy) indicated that RIR hens synthesize proteins with an efficiency of 85.5 and fat with an efficiency exceeding 100 percent on BR based diet. *(Asian-Aus. J. Anim. Sci. 1999. Vol. 12, No. 7 : 1085-1089)*

Key Words : RIR Hens, Maintenance ME Requirement, Slaughter Technique, Broken Rice-Based Diet, Efficiency, Protein and Fat Synthesis

INTRODUCTION

Metabolisable energy requirement for maintenance (ME_m) can be determined by either long-term feeding trials or by energy balance studies. Energy balance can be measured by (a) determination of heat production from gaseous exchange with the help of respiration calorimetry (b) carbon and nitrogen balances and (c) slaughter studies.

Several drawbacks of long-term feeding method are well known, most prominent amongst which is the inadequate information on type of substrate in which energy is stored i.e., protein or fat. Calorimetry though preferred, but facility may not be available at any place. Comparative slaughter technique has been used to study energy requirement of swine (Mitchell and Hamilton, 1929) and chickens (Davis et al., 1972, 1973) in the past. As such the work on energy requirements of RIR hens seems to be scanty and not available in the literature. The present report describes about estimation of ME_m of RIR hens (heavy breed) using broken rice-based diet.

MATERIALS AND METHODS

Seventeen hens were procured from an experimental layer farm of Central Avian Research Institute, Izatnagar and were reared in laying hens cages in energy metabolism and respiration calorimetry laboratory of the institute. Before the start of experiment, the hens were dewormed and were adapted to the room conditions for 5 days (temperature 20 to 25℃, lighting was throughout). These birds were housed in battery laying cages (30×45 cm) kept in a room equipped with air conditioners to control its temperature between 20-25℃. The cages were fitted with separate feeder and dropping tray underneath the wire mesh floor. Common waterers were provided for group of birds kept in a row. The room was provided with exhaust fan and four incandescent tubes. Relative humidity was between 60±10%. During the adaptation period to room conditions, hens were given balanced maize-based diet (for composition of diet, please see previous paper in the same issue).

Hens were slaughtered in batches to determine energy balance. The method was similar to that used by Davis et al. (1972, 1973). Initially five hens (Batch I) which were kept without feed and water for 12 h were killed; hand plucked, opened and gut contents were cleared. Feather were dried and reduced to fine pluffy material and sampled for determination of energy content. Complete carcasses were reduced to very fine paste and samples were dried for estimation of energy content. Nitrogen, fat, ash and water content were also determined. Moisture was determined in hot air oven, fat by soxhlet extraction (Labcon Co.) with petroleum ether and nitrogen by the Kjeldahl's method.

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Energy determinations were done using Gallenkamp Ballistic Bomb Calorimeter. Glycogen content was not considered since contribution of this towards total body energy pool is negligible.

Batch II of six hens were fed broken rice-based diet (for composition see table 1). During this period, daily record of feed intake, egg production and egg weight was done. After 18 days, these hens were slaughtered and processed similarly as hens in Batch I. Batch III consisted of six hens which were fed for 15 days the same BR-based diet but in varying quantity (about 40 to 80% of *ad libitum*). During 15 days period weighed quantity of feed was given and record of number of egg laid and egg weight was kept. Egg energy (EE) was determined using equation proposed by Sibbald (1979) i.e., EE (kcal) = - 19.7 + 1.81 egg weight (in g).

The energy retained as protein in the body of hens in-group II was calculated as the difference of initial protein content (deduced using protein per centage in the body of hens of batch I) and final protein content of hens of group II. Similarly, initial protein content in group III was calculated using average figure of protein per centage in the hens of batch II. To derive total initial protein content in the body, eviscerated weight was multiplied by protein percentage of give total protein content. Energy retained as protein was calculated by retained $N \times 6.25 \times 5.6$. During calculation of energy retained as protein and fat in egg, it was assumed that 60% of the egg energy is deposited as protein (Shannon and Brown, 1970; Peterson, 1970). Retention of fat energy was the difference between total energy balance (in the body and egg) and total energy retained as protein. The value of 5.6 kcal/g used for energy contents of protein is suggested by Znaniecka (1967). For the purpose of calculating energy cost of protein and fat synthesis, energy required to achieve energy balance (ME required for production, ME_p) in each hen in group II and III was separated from ME required for maintenance (ME_m) as the ratio of energy balance to efficiency of utilisation of ME for maintenance i.e., k_m. For this purpose, k_m in each hen was calculated as ratio of energy balance plus fasting heat production (i.e., 80 kcal) to ME intake.

Statistical analysis was done according to Snedecor and Cochran (1967).

RESULTS

The chemical composition of hens of the three batches is given in table 1. It indicates that hens fed *ad libitum* broken rice (BR)-based diet (Batch II) had 2% les water than hens of Batch I which were fed maize based feed and consequently per g energy content of hens (table 2) in Batch II was also higher by 0.1 kcal.

Table 1. Chemical composition (%) of hens

Component	Batch I	Batch II	Batch III	SEM
Water	52.5	50.6	55.2	0.55
Protein	19.3	19.6	20.5	0.22
Fat	24.4	26.2	20.6	0.51
Ash	3.7	3.6	3.7	0.02

Feeding levels for hens of
Batch I : Maize-based diet *ad libitum*.
Batch II : Broken rice-based diet *ad libitum*.
Batch III : Broken rice-based diet at 40, 60 and 80% of *ad libitum*.

Table 2. Gross composition and energy content of hens

	Batch I	Batch II	Batch III	SEM
Live weight (g)	1484	2013	1860	71.72
Feather weight				
as such (g)	79.0	90.5	96.5	3.41
g DM	66.3	76.0	81.0	1.55
Eviscerated weight				
as such (g)	1052.8	1379.5	1193.0	56.4
g DM	501.3	685.8	537.6	31.65
Feather energy (kcal)	406.4	447.8	481.1	7.86
Carcass energy (kcal)				
per g	6.68	6.78	6.43	0.02
Total	3357	4657	3623	219.4
Body energy (kcal)				
Final	3762	5105	4010	218.1
Initial	-	4759	4364.3	307.2
Change	-	19.2	-23.6	6.18
Egg energy	-	40.8	18.7	6.80

Hen body contains on an average 52.8% water, 19.8 protein, 23.7% fat, 3.7% ash and 6.68 kcal/g DM gross energy with different diets and feeding level. Composition of hens fed varying quantity of diet for 15 days (Batch III) indicate that fat is mobilised to meet energy requirements when low quantity of diet is offered whereas water percentage increases. Gross energy content (kcal/kg DM) was lower in Batch III as compared to Batch I and II.

Total body energy change (kcal/d) constituting egg energy as well on respective ME intake was calculated. In Batch II, body energy change from 9 to 34.5 kcal/d was observed in hens and when egg energy was accounted total energy change was in the range of 12 to 60.2 kcal/kg $W^{0.75}$/d.

Body energy change on varying quantity of feed was in the range of 14.6 to 51.2 kcal/kg $W^{0.75}$/d whereas total energy change (body energy + egg energy) expressed relative to kg $W^{0.75}$ was in the range of -17.2 to 12.6 kcal. Regression equation relating body weight to body energy was determined. Equation developed on batch I was used to determined initial composition of Batch II. It was,

Y = 3349 X - 1213, r = 0.9 n = 5
where, Y = body energy, X = body weight in kg.

Initial body energy content of hens in Batch III was determined using equations developed on Batch II. The equation was

Y = 3427 X - 1981, r = 0.98 n = 6

Metabolisable energy requirement for maintenance (ME_m) by this method was arrived by regression of ME intake on energy balances of hens (figure 1) during that period. ME_m was found to be 119.8 kcal/lg $W^{0.75}$/d and efficiency of utilisation of ME (k_m) was 67.4%. The multiple regression equation was computed in which ME required for production, ME_p (Y) was independent variable and energy retained as protein (ER_P) and fat (ER_F) were dependent variables (X_1, X_2). The equation was

Y (df 9) = 1.17 (SE 0.78) X_1 + 0.92(SE 0.2) X_2,
n = 12, r = 0.89

From the reciprocals of coefficients, it can be deduced that RIR hens, on broken rice based diet, synthesized proteins with and efficiency of 85.5% and fat with an efficiency of more than 100%. Expressed in a different way, this cost 6.5 kcal for production of 1 g protein (5.6 kcal/g). The value of partial energetic efficiency for fat deposition was near to unity. When ME intake (y) was regressed separately on ER_P (X) and ER_F (X), following equations were obtained.

Protein: Y = 0.142 X - 11.7, r = 0.71, n = 12, RSD ± 23, p<0.025
Fat: Y = 0.503 X - 66.8, r = 0.68, n = 12, RSD ± 88, p<0.01

The equations suggest that fat balance become positive only when ME intake exceeds 132 kcal/kg $W^{0.75}$/d, whereas protein balance become positive evenwhen ME intake is below maintenance (120 kcal), probably at an intake of 60.3 kcal/kg $W^{0.75}$/d.

DISCUSSION

Selection of feed : For feeding hens in this experiment, broken rice (BR)-based feed was used. This was selected because BR is well known for its strong lipogenic effect (Baghel and Netke, 1982; Shrivastava, 1990; Tyagi et al., 1993). During one of the experiments (Jadhao et al., 1999), it was noted that the RIR hens become fatty and egg production reduces significantly on this type of diet. Such a diet was supposed to induce a large change in body energy concentration.

Body composition : There was quiet a variation in the individual composition of hens. This may be due to old age of hens. This is in agreement with Fraps and Carlyle (1939) who pointed out of the wide variation in fat content of individual bird within the group, when older birds are used for slaughter study. However, this disagree with Davidson and Mathieson (1965) who pointed out that the composition of the birds killed at the beginning of experiment is considered as representative of the remainder only when very young chickens are used. The surplus energy is stored in the adipose tissue to the capacity of body's physiological system, size of which can increase to the genetically determined potential. This was observed on *ad libitum* fed BR-based diet for 18 days. However, when energy intake is restricted, water content of the carcass increases. This was also observed by Newburgh and Johnston (1930) who reported that obese individuals frequently maintained or even increased their weight temporarily on reducing a diet, because water was being stored despite the fact that depot fat was being used up.

In the hens, egg laying is a major form of production. By providing reducing quantity of BR-based diet, it was expected that the egg production will be reduced, cónsequently body energy will be mobilised for such an attempt and will bring about changes in body composition. Such a design helped to give sufficient points for regression equation of ME intake on energy balance.

Relationship between ME intake and energy balance (body energy change + egg energy) derived by regression is shown in figure 1. The relationship was highly significant (p<0.01). In the equation when, energy balance Y = 0, ME intake i.e. X = 119.8 kcal. this is the metabolisable energy requirement for maintenance (ME_m). When ME intake (i.e., X) is zero, 80.7 kcal/kg $W^{0.75}$/d endogenous energy is utilised which is indicated by fasting heat production (FHP).

When slaughter technique was compared with calorimetry (Jadhao et al., 1999), ME_m was similar but efficiency of utilisation of ME for maintenance k_m was 8.6% less and FHP was less by about 7 kcal/kg $W^{0.75}$ by slaughter method. This is so because calorimeter can not differentiate between feed energy or body energy (which may be mobilised for production) and so calorimetric efficiency may be higher. Moreover, in previous study, it has been indicated by regressing metabolic weight on FHP that, 82.6 kcal/kg $W^{0.75}$ component is only due to metabolic body weight (which is similar to this) and positive intercept of 26.3 depicting component of constant heat production which is independent of kg $W^{0.75}$. On high efficiency with calorimetric studies similar opinion have been expressed by Farrell (1974). Net availability of ME in this report agrees with calue of 65.5 to 70%, reported by O'Neill (1971) and O'Neill et al. (1971) for Brown and White Leghorn hens at 15-25℃ on conventional diets.

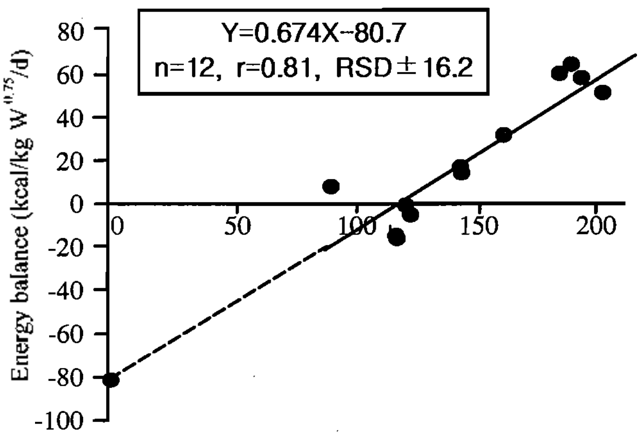

Figure 1. The relationship between ME intake and energy balance in RIR hens fed broken rice-based diet (each point is average of 15 to 18 days)

Sirnik and Schurch (1967) found difference of only 0.1% in balance trial and carcass analysis method for measuring deposition of body substances and energy retention in rats. In studies of Farrell (1972), difference in heat production measured by calorimetry and slaughter method was of -4 to 7% magnitude. Our value can be compared with Davis et al., (1973), who found 114 kcal ME_m/kg $W^{0.75}$ of laying hens kept at room temperature of 7.2℃.

The energy cost of protein synthesis in terms of ME (6.4 kcal/kg $W^{0.75}$) as found in this experiment can be compared with the caloric cost of protein synthesis of 7.2 kcal in egg laying WL hens (Burlacu and Baltac, 1971), 7.07 kcal in milk fed lambs and 7.51 kcal in baby pigs (Kielanowscki, 1965a) and 7 kcal for milk production (Kielanowscki, 1965b). Figure of 51% efficiency of ME for egg protein synthesis as found by Farrell (1975) was lower than our deduced value of 85.5%. His higher value may be due to combined equation for three breeds. However, present cost of protein synthesis was lower than that of 11 kcal in growing pigs (Kotarbinska and Kielanowscki, 1969), 14.38 kcal/g in Muzaffarnagari sheep (Chandramoni et al., 1999), 11.2 kcal (Peterson, 1970), 10 kcal (MacLeod, 1990), 11.71 kcal (Nieto et al., 1995) in growing chickens.

The low cost of protein synthesis in this experiment may be attributed to the reason that amino acids are incorporated into egg protein during a comparatively short period of time and consequently turnover of amino acids is unlikely to be significant making it a energetically efficient process. Buttery and Annison (1973) reported that the energy cost of protein synthesis is met with an efficiency of about 90%. By stoichiometric calculations, it can be calculated that the cost fo protein synthesis is 1.15 kcal ME/kcal of protein energy (Millward et al., 1976). The high energetic efficiency for fat deposition may due to various reasons. Firstly, RIR is a fatty (heavy) breed. Secondly, broken rice is strong lipogenic ingredient and thirdly, because of collinearity between protein and fat deposition, which is known to limit the reliability of multiple regression for estimating energetic cost associated with protein and fat deposition (Roux et al., 1976). MacLeod (1990) also found energetic efficiency of >100% for fat deposition in high protein diet in female broilers, which support the present results. The finding that fat retention occurs only when ME intake exceeds 132 kcal/kg $W^{0.75}$/d, respectively is in agreement with Burlacu and Baltac (1971) and Farrell (1975). The study indicated that diets-based on broken rice of rice grains which produce large change in body energy content in less time due to its lipogenic nature are suitable to study energy requirement of chickens by slaughter technique. The ME requirement of RIR hens for maintenance by slaughter technique is 119.8 kcal/kg $W^{0.75}$/d.

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