PREDICTION OF GROWTH AND DEVELOPMENT PROCESS ON RHODE ISLAND PULETTES

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Abstract. The change of body composition, energy content and energy and protein balance was studied in Rhode Island pullets from hatching to 140 days of age.

The animals received standard diets ensuring maximal growth. Correlations were established between ingested feed and body weight gain both from the point of view of quantity and quality, determining the content of protein, fat, ash, water and energy in the total body and in feathers, separately.

On the basis of digestibility and comparative slaughtering the energy and protein requirements for maintenance and for protein and fat retention were calculated.

The obtained results can be utilised to develop a mathematical model for energy and protein retention in growing Rhode Island pullets.

INTRODUCTION

With the view of developing a mathematical model for energy and protein metabolism simulation in laying hens, we have considered compulsory to continue previous research (Burlacu et al., 1995) regarding to the energy metabolism in Rhode Island pullets from hatching to the onset of laying. Stress was set on influencing the body composition by different nutrient intake, with the intention of measuring some parameters less investigated but necessary to the model, which is ensuring the development of a reliable calculation for diet optimisation in this category of poultry.

MATERIAL AND METHOD

For the experiments 200 White-Leghorn pullets were used, 20 of them were slaughtered at the first day after hatching. The remaining 180 birds were assigned to 9 groups housed in the metabolic cages, using 4 compartments for each group. The experimental period of 20 weeks was divided in five sub-periods of 4 weeks each.

The experiment was conducted in an air-conditioned room (65% humidity) in thermally neutral environment.

The diets were given with different protein/energy ratio (standard, 90% and 80% of standard) and feeding levels: ad libitum, 90% and 80% of ad libitum.
The following parameters were recorded during the entire experimental period: daily feed intake, weekly gain and nutrient as well as energy digestibility (for 7 days, every month). By comparative slaughter technique (every month, four pullets of each group, besides the initial 20 birds), body chemical composition (dry matter, protein, ether extract, ash, water), the net weight gain, and the energy content. The net body weight (Wn) and the net gain (ΔWn) were determined by the difference between the gross weight of the birds and the contents of the digestive tract. Body analyses were carried out distinctly for feathers.

Feed, excreta and body composition were analyzed with the method of Weende and with an adiabatic calorimeter; starch was analyzed with the polarimetric method and sugar with the Bertrand's method. Urinary nitrogen was measured with the method of Terpstra (Burlacu, 1993) which gave us the possibility to determine the digestible crude protein (DCP), from which by subtracting the protein retained (RP) during the successive experimental periods, the deaminated protein (DP) was obtained. Based on the deaminated protein we have calculated the corrected metabolisable energy (MEc), using the formula proposed by the Whittemore adapted for poultry (Burlacu et al, 1990):

\[ MEc = DE\cdot[5.85\cdot DP + 4.9 \cdot (DP - Pm) + 6.8 \cdot (BFM - 0.1) + 1.4 \cdot S] \quad [kJ/g] \]

where: DP is the deaminated protein, g; Pm is the net amount of protein required for maintenance, g; BFM is the bacterial fermentable matter, g; S is the dietary sugar, g.

Data were processed with Gompertz type - functions.

RESULTS AND DISCUSSION

Based on the daily feed intake (g/DM), it was estimated the maximum daily intake during growth is given by equation (1), resulting in the highest daily intake of 64 g during the growth period at the age of 103 days.

\[ \text{DMI} = 1.2251 \cdot t^{1.085} \cdot (1 - e^{-0.0108 \cdot t}) \quad [g] \quad (1) \]

\[ SDy = 0.066; \quad SDb = 0.0288; \quad SDc = 0.001; \quad R = 0.996 \]

Under these feeding conditions the net weight (Wn) and the net weight gain (ΔWn) of the pullets varied according to equations (2) and (3).

\[ Wn = 35 \cdot e^{0.248 \cdot (1 - e^{-0.0248 \cdot t})}, \quad [g] \quad (2) \]

\[ \Delta Wn = \frac{dWn}{dt} = 0.1004 \cdot Wn \cdot e^{-0.0248 \cdot t}, \quad [g/day] \quad (3) \]

\[ Wn = 1630 \quad [g] \]

\[ t^* = 51 \quad [\text{days}] \]

\[ Wn(t^*) = 590.6 \quad [g] \]

\[ \Delta W(t^*) = 19.7 \quad [g/day] \]

It means that Rhode Island pullets had the highest net daily weight gain of 19.7 g at the age of 51 days, corresponding to a body weight of 590.6 g; body weight at maturity was 2250 g.
Compared to White Leghorn pullets (Parvu et al., 1997) Rhode Island pullets reach their highest gain at an age about two days later, however, their body weight is 25.7% bigger compared to White Leghorn at the same age.

The ratio between gross body weight and net body weight

The pattern of the ratio between gross body weight (W, g) and net body weight (Wn, g) obtained by subtracting the digestive tract content in Rhode Island pullets is given by equation (4):

\[ Wn = 0.986 \times W \]  \hspace{1cm} (4)

\[ SDy = 0.0014; \quad R = 0.99 \]

Change of chemical composition and energy content in the body of pullets

The content of protein (Pt, g), water (Wt, g), ash (Ash t, g) and energy (RE, kJ) of the groups fed ad libitum is documented below. Figure 4 shows the age dependent values for total body protein (Pt, g) and for daily protein gain (Pr) according to equations (5) and (6)

\[ Pt = 5.55 \times e^{0.0279 \times (1-e^{-0.0279 \times t})} \] \hspace{1cm} [g] \hspace{1cm} (5)

Pt = 347 \hspace{1cm} [g]

\[ t^* = 51 \hspace{1cm} \text{[days]} \]

Pt(t*) = 128 \hspace{1cm} [g]

\[ Pr = \frac{dPt}{dt} = 0.1154 \times Pt \times e^{-0.0279 \times t} \text{ g/day} \] \hspace{1cm} (6)

Pr = Pr(t*) = 3.56 \hspace{1cm} [g/day]

It is shown that Rhode Island pullets had the highest daily protein retention (3.56 g) at 51 days of age, when the body had a total content of 128 g protein, and that the highest possible protein content of Rhode Island pullets at maturity is 357 g. As compared to broilers we can notice similarly to the weight gain, that Rhode Island pullets reach their highest protein gain 4 days later, but the retention representing only 34.8% of the value documented for broilers (Burlacu et al., 1995).

Body water content (Wt, g) is closely correlated with protein content as shown by equation (10) (Fig. 5):

\[ Wt = 4.850 - Pt^{0.927} \] \hspace{1cm} [g] \hspace{1cm} (7)

SDy = 0.059; SDa = 0.018; R = 0.998

The daily water gain is obtained by deriving equation (3) in relation with time.
\[ \Delta Wt = \frac{dWt}{dt} = 0.927 \frac{Pr}{Pt} \times Wt \ [\text{g/day}] \] (8)

where:
\( Pt \) is the total body protein given by equation (5)
\( Pr \) is the amount of daily retained protein given by equation (6)
\( Wt \) is the total body water given by equation (7).

The same close correlation can be also found between the ash and protein contents, given by equation (9):

\[ \text{Ash} = 0.144 - Pt^{1021} \ [\text{g}] \] (9)

\( \text{SDy} = 0.14; \text{SDa} = 0.046; \text{R} = 0.994 \)

which is similar to that determined in broilers \( (\text{Ash} = 0.1365 \ Pt^{1034}) \) The daily ash is obtained by deriving equation (9) in relation with time:

\[ \Delta \text{Ash} = \frac{dAsh}{dt} = 1.021 \times \frac{Pr}{Pt} \times \text{Ash} \ [\text{g/day}] \] (10)

Equations (11) and (12) were used for the determination of body lipids \( (Lt) \) and daily lipid retention \( (Lr) \):

\[ Lt = Wn - (Pt + Wt + Ash) \ [\text{g}] \] (11)
\[ Lr = \Delta Wn - (Pr + \Delta Wt + \Delta Ash) \ [\text{g/day}] \] (12)

where:
\( Wn \) is the net weight given by equation (3)
\( \Delta Wn \) is the daily net weight gain given by equation (4)
\( Pt \) is the body protein given by equation (5)
\( Pr \) is the daily protein gain given by equation (6)
\( Wt \) is the body water given by equation (7)
\( \Delta W \) is the daily water gain given by equation (8)
\( Ash \) is the body ash gain by equation (9)
\( \Delta Ash \) is the daily ash gain given by equation (10).

The age depend values for body energy retention \( (RE) \) is given by equations (13) and (14)

\[ RE = 205 \times e^{\frac{0.120}{0.0265}} \times (1 - e^{-0.0265 \times t}) \ [\text{kJ}] \] (13)
\[ RE = 18983 \ [\text{kJ}] \]
\[ t^* = 56.9 \text{ days} \]
\[ \Delta RE = \frac{dRE}{dt} = 0.12 \times RE \times e^{-0.0265 \times t} \ [\text{kJ/day}] \] (14)
\[ \Delta RE = \Delta RE(t^*) = 185.1 \ [\text{kJ/day}] \]
It can be seen that the largest amount of energy retained was calculated for the age at about 57 days, nearly 6 days later than for the optimal daily weight and protein gain, due to the shift in the ratio between protein and lipid gain. The values for body energy per kg body mass varying from 6.384 kJ at hatching to 9.188 kJ at 57 days and to 10.755 kJ at maturity.

**Estimation of the corrected metabolisable energy**

The average daily amount of corrected metabolisable energy (MEc) was determined starting from the amount of digestible energy (DE), measured on the basis of the gross energy of the daily feed intake and of its digestibility coefficients, from which the urine energy (UE), the energy for deamination (EDeam) were subtracted. The energy of the bacterial fermentable matter (BFM) and of the sugar (S) being negligible.

Related to the age, the highest daily intake of ME (kJ/day) measured up to 115 days is given by function (15)

\[
MEc = 53.055 t^{0.7502} e^{-0.0063 x t} \text{[kJ/day]} \quad (15)
\]

SDy = 0.049; SDa = 0.023; SDb = 0.009; R = 0.98

The intake of metabolisable energy measured is similar to that determined in previous experiments (Burlacu et al, 1970).

In order to measure the requirement of metabolisable energy for maintenance (MEm), the amount of metabolisable energy for production (MEp) was calculated accepting an efficiency of ME utilisation for protein and lipid synthesis of 47.6% and of 70.7%, respectively (Burlacu 1993) given by function (16). By calculating the difference compared to the total amount of ingested ME the MEm value related to the net body weight expressed in kg, is given by function (17):

\[
MEp = 50 \times Pr + 56 \times Lr \text{[kJ/day]} \quad (16)
\]

\[
MEm = 559 \times \left( \frac{Wn}{1000} \right)^{0.646} \text{[kJ/day]} \quad (17)
\]

SDy = 8.2; SDa = 0.01; R = 0.893

This is a value which is very close to that determined in broiler, White Leghorn pullets and turkey (Burlacu 1995, Parvu 1997, Parvu 2004).

**CONCLUSIONS**
The experiments presented in this paper show the correlations between feed intake and qualitative and quantitative changes in body of Rhode Island pullets, determining the content of protein, lipids, ash, water and energy.

On the basis of digestibility and comparative slaughtering using different feeding levels and nutrients the requirement of energy and protein for maintenance and for protein and lipid synthesis was determined. The results can be used for developing a mathematical model for energy and protein retention during the growing period of Rhode Island.

BIBLIOGRAPHY