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Filev K., Sokarovski J., Kon-Popovska M.

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K. FILEV, J. SŎKAROVSKI
Faculty of Agriculture, Institute of Animal,
University of Skopje (Yugoslavia)

M. KON-POPOVSKA
Faculty of Science, University of Skopje (Yugoslavia)

I. – Introduction

Poultry production in Yugoslavia is based on formulae for laying hens determined by a conventional method of linear programming. This method provides for the best combination with all nutrients essential for maintenance, growth, and egg production as well as operating at minimal cost. The choice of feedstuffs is such that it ensures good health of the birds and high quality eggs.

For this purpose estimates are made beforehand for chemical composition, energy value and cost of feedstuff ingredients. All this information and data are then put into the computer. However, this method disregards those factors that influence nutrition requirements and food consumption: live weight, environmental temperature, laying intensity, physical activity and individual variability. Under different conditions, the requirements of nutrients vary and often depend more on economic than biological factors.

Several authors have constructed accurate models for the exact determination of poultry nutrient requirements and feed intake (Hurwitz et al., 1977; Combs, 1968; Emmans, 1984; Leclercq, 1984). They have developed different equations for determining the daily energy requirements of poultry. Other authors have developed models for determining the requirements for different amino acids. Among them the most popular are the reading model (Fisher et al., 1973) and the Israeli model (Hurwitz et al., 1973).

Our task is to make use of the results described in the literature and of our own experience with the poultry industry to propose the best feed formulations for Yugoslavia.

II. – Determination of daily energy requirements

Energy requirements in the literature and in practice are expressed in MJ metabolic energy. Metabolisable energy corrected for zero N retention is also used (see European table of energy values for poultry feedstuffs, 1986). The calculation of AMEN in the different feedstuffs is done using regression analysis by combining chemical composition data of the feedstuffs and calculation factors.

The most variable part of daily rations for layers is energy because its requirement depends on live weight, temperature in the poultry house, daily egg output, growth and physical activity. Determination of daily energy requirements can be done by using different equations taken from several authors. Emmans reported two equations:

$EM = (170 - 2{,}2T)\, W + 5\, \Delta W + 2\, E$ for Leghorn hens

$EM = (140 - 2T)\, W + 5\, \Delta W + 2\, E$ for Rhode-Island hens where :

EM = Kcal metabolisable energy required day

W = mean live weight, kg

ΔW = mean daily gain, g/day

E = egg output, g/day

T = environmental temperature, °C.

The equations include the most important factors which influence daily energy requirement except physical activity and individual variability.

Hurwitz and Bornstein (1978) reported a different equation :

$$EM = 145\ W^{0,67} + 2\ \Delta W + 1,8\ E$$

In this equation some important factors are not included : environmental temperature, physical activity and individual variability.

Combs (1968) reported a more complete equation for the determination of daily energy requirements for broiler breeder hens :

$$EM = (1,78 - 0,012\ T) \times 1,45W^{0,653} + 3,13\ \Delta W + 3,15\ E$$

Daily energy requirements calculated by this equation, are higher than the empirical results of Bornstein (2,9%) because of the use of a bigger coefficient for estimating the energy amount required for daily gain and egg production.

Analysing the structure of these different equations, it appears that in the Emmans and Combs formulae, two factors are absent : physical activity and individual variability. In the Hurwitz equation, the very important factor of temperature is also absent besides activity and variability. The Emmans equation uses temperature in the correction factors, and mean live eight for calculating the requirement for maintenance energy. Combs uses $\underline{T}$ for determining the correction factor and metabolic live weight ($W^{0,653}$) for determining the maintenance energy requirement.

As the Combs equation seems to be more complete than the others, it was used in our investigations and incorporated in the program for automatic calculation of daily energy requirements for laying hens.

Assuming constant levels of daily output, live weight and daily gain, the influence of temperature on energy requirements can be determined as shown in, **Table 1**.

Environmental temperature influences on energy requirement for maintenance can vary from 0,6 to 1,2 MJ/day/hen. These variations explain the differences in the total energy requirement (from vary 1,2 to 1,96 MJ/day/hen).

The energy requirements also during the laying cycle as shown in **Table 2**.

Throughout the laying cycle, daily energy requirements for maintenance and egg production vary because of variations in live weight and daily egg output. The requirements for gain/day are small especially after 30 weeks of age and could be neglected. From the data of total energy requirement, it can also be seen that in the period from the peak of production (28th week) up to 60 weeks of age (230 days) energy requirements/hen are about 1,5 MJ. This shows that, under conditions of constant environmental temperature, energy requirements do not vary significantly.

III. – Determination of protein and amino acid requirements of layers

1. Protein

Protein requirements of poultry are expressed as total protein (N x 6,25). Empirical determinations of protein requirements of laying hens have shown highly variable results due to differences in live weight, egg weight, laying rate and food consumption which are caused by breed differences, age, feed, and so on. Protein requirements for poultry can also be quantified.

Several authors have worked out methods for predicting protein requirement (Scott, 1969 ; Fisher, 1967 ; Hurwitz, 1972). Most of them express protein requirement (P) as a sum of maintenance requirements (M), daily egg output (E), live weight gain (G), and, after Scott, of requirement for feather growth (F).

$$P = M + E + E + F$$

While investigating the factors affecting protein requirements of layers, Fisher (1967) found that management and environmental factors are apparently without effect on protein use and that requirements is in proportion to output. However, it is interesting to note that efficiency of protein use increases with energy intake and decreases with increasing age in the first laying year. Under these conditions, requirements are not only in proportion to output.

Economic factors can also be taken into account by comparing the marginal value of egg output at different levels of protein intake with the marginal cost of protein at different levels of dietary inclusion.

The requirements of daily protein for one laying cycle, calculated according to Scott from the peak of production, are shown in **Table 3**.

In this table it can be seen that protein requirements per hen/day decline with age and depend on egg output. This phenomenon is in agreement with the concept that, at different phases of production, nutritive needs are different. Fisher's investigations also showed that efficiency of protein use decline throughout the first laying under year, which means that the concept of phase feeding has to keep this aspect under consideration. Similar results were obtained by Wethli and Morris, (1977) about tryptophan requirements ; they reported that pullets of 63-73 weeks of age needed more tryptophan for a given egg output.

2. Amino acids

In most published papers, requirements of laying hens for amino acids have been established using linear regression analysis of empirical data or by deriving partition equations which assume linear relationships between inputs and outputs (Combs, 1968 ; Hurwitz, 1978).

Some other autors (Fisher *et al.*, 1973 ; Morris and Blackburn, 1982 ; Mc Donald and Morris, 1985) have demonstrated that a linear model may describe the response of an individual bird but a typical response involving the average outputs of a group of layers must be curvilinear. Thus there are two distinguishable models for prediction of daily amino acid intake for laying hens : Israeli and Reading.

The response curve for a flock of hens (Reading model) mathematically described by Curnow (1973) has a characteristic sigmoid shape (**Graph 1**). This curve considers the response of an individual hen as a simple factorial model and then, from the individual models, derives the flock response as an integrated average of a large number of individual responses. The resulting flock response curve is defined by seven parameters : average maximum output g/day (Emax) ; variation in maximum output (σ Emax) ; average bodyweight kg (W) ; variation in bodyweight (σ W) ; correlation between output and bodyweight (r_{EW}) ; and two constants representing the amount of amino acid required per unit of output (a mg / gE) and per unit of bodyweight (b mg/kgW).

The optimum amino acid intake which yields maximum profit is calculated by the following equation.

$$\text{A opt. (Mg/day)} = a\bar{E}max + b\bar{W} + x\sqrt{a^2.\sigma^2\,Emax + b^2.\sigma^2\,W + 2\,abr_{EW}.\sigma Emax.\sigma W}$$

where :

X = deviation from the mean of standard normal distribution which is exceeded with probability ak in one tail ;

K = marginal cost of one mg amino acid input / marginal value of one gr egg output.

In order to simplify the use of this response model, some estimates of a and b have been outlined from flocks at or near peak output because at this time minimum amounts of amino acids are being diverted for tissue and feather production, and there is a minimum of non-producing hens.

The use of this model allows one to determine the optimal level of amino acid intake that gives a maximum income, in relation to an additional amount of amino acid intake over the average of the flock's requirement.

Such an estimate is very important in practice because enabling the responsive amino acid intake go beyond optimum for the best layers is not always economical.

This model (Reading) is designed for layers in maximum egg production but the level of amino acid intake cannot be lowered with older hens because the use of amino acid and total protein declines with age especially after 60 weeks (Wethli, 1978 ; Fisher, 1967). It is interesting to note that the relationship between egg output and tryptophan intake is the same in moulted hens as in young pullets (Wethli, 1978).

IV. – Level of energy and protein in the mixtures

On the above mentioned bases it can be concluded that daily energy requirement is the most variable part of the laying ration. It depends on egg output, live weight, activity and environmental temperature. The environmental temperature has a significant influence on the maintenance requirement and total daily energy requirement. It also significantly influences daily feed intake. Daily requirements of protein and amino acids are constant during the laying cycle.

These findings are important for feed formulation because laying hens daily require the same amount of amino acid and protein intake during the laying cycle, but different amounts of energy in various temperature conditions.

Because of very large temperature oscillations during the year in Yugoslavia, feed intake decreases during the summer and increases in winter. This is always followed by declining egg production, egg weight and shell strength.

On the basis of this evidence, several types of feed mixtures can be recommended for different temperature conditions during the year (**Table 5**).

With the above mentioned levels of energy and protein in the mixtures and the probable feed intake at different temperature conditions, daily intake of protein and amino acids will be constant and consumption of energy appropriate, which a prerequisite for stable egg production throughout the year.

The phase feeding of the layers according to this recommendation could be changed to seasonal feeding.

V. – Conclusions

In order to develop the best model for feed formulation for layers, the following conclusions are suggested:

I. Determination of daily energy requirements for laying hens by Combs' equation because it contains all the important parameters for this purpose, i.e. temperature, liveweight, daily gain and daily egg output. Physical activity and individual variability are ignored in the equation but there is no model taking into account these parameters.

II. The most precise way for determining daily consumption of amino acid and protein is that from Reading University, the so-called Reading model. It determines the optimum daily consumption of amino acids and cost of eggs.

III. In regions with extreme temperature changes during the year, it is possible to use seasonal feeding for the layers which ensures constant daily intake of protein and amino acids and appropriate consumption of energy.

IV. Phase feeding cannot be recommended for the nutrition of layers because of the constant requirement for daily intake of protein and amino acids. There should also be a daily input of minerals, like Ca, the requirements of which depend on the age of laying hens.

References

- Combs, G.F., 1960 - Protein and energy requirement of laying hens.- *Proc. Maryland Nutrition Conf. Fd. Manufacturers*, pp. 28-45.

- Combs, G.F., 1968.- Amino acid requirement of broilers and laying hens.- *Proc. Maryland Nutrition Conf. Fd. Manufacturers*, pp. 86-96.

- Emmans, G.C. ; Fisher, C., 1984.- Problems in nutritional theory.- In : *Nutrient Requirement of Poultry and Nutritional Research* (Eds. Fisher C. and Boorman K.N.).- London : Butterworths, pp. 9-40.

- Emmans, G.C., 1986.- Growth, body composition and feed intake. 28th *British Poultry Breeders' Round Table*. Edinburgh School of Agriculture, Scotland.

- Fisher, C., 1967.- Factors affecting protein requirement of layers.- In : *Protein utilisation by poultry*.- Edinburgh : Oliver and Boyd.

- Fisher, C., 1980.- Protein deposition in poultry.- In : *Protein deposition in animals*.- London : Butterworths, chap. 14, p. 251.

- Fisher, C., 1976.- Protein in the diets of the pullet and laying bird.- In : *Protein metabolism and nutrition*.- London : Butterworths.

- Fisher, C., 1983.- The physiological basis of the amino acid requirement of poultry. *4th European Symposium. Poultry nutrition*, 5-9 september, France.- Paris : I.N.R.A.

- Fisher, C., 1980.- Amino acid requirement for laying poultry.- *2nd European Symposium. Poultry nutrition*, 8-11 october 1979, Beekbergen, Netherlands.

- Fisher, C. ; Morris, T.R. ; Jennings, S.R.C., 1973.- A model for the description and prediction of the response of laying hens to amino acid intake.- *Br. Poultry Sci.*, **14**, pp. 469-484.

- Fisher, C., 1987.- Calculating amino acid requirement.- *Proc. Symp. Poultry Husbandry, Research Foundation*, University of Sydney, pp. 104-122.

- Hurwith, S. ; Bornstein, S., 1973.- The protein and amino acid requirement of laying hens : suggested models for calculation.- *Poultry Science*, **52**, pp. 1124-1134.

- Hurwitz, S. ; Bornstein, S., 1978.- The protein and amino acid requirement of laying hens : experimental evaluation of models of calculation. II Valin Requirement and Layer-Starter Diets.- *Poultry Science*, **57**, pp. 711-718.

- Hurwitz, S. ; Bornstein, S., 1977.- The protein and amino acid requirement of laying hens : experimental evaluation of models of calculation. I. Application of two models under various conditions.- *Poultry Science*, **56**, pp. 969-979.

- Morris, T.R. ; Nethli, E., 1978.- The tryptophan requirements of young laying pullets.- *Poultry Science*, **19**, pp. 455-466.

- Morris, T.R. ; Harzel, A. ; Blackburn, 1982.- The shape of the response curve relating protein intake to egg output for flocks of laying hens.- *Poultry Science*, **23**, pp. 405-424.

- Mc Donald, M.W. ; Morris, T.R., 1985.- Quantitative review of optimum amino acid intakes for young laying pullets.- *Poultry Science*, **26**, pp. 253-264.

- Pilbrow, P.J. ; Morris, T.R., 1974.- Comparison of lysin requirements amongst eight stocks of laying fowl.- *Poultry Science*, **15**, pp. 51-73.

- Wethli, E. ; Morris, T.R., 1978.- Effects of age on the trypophan requirement of laying hens.- *Poultry Science*, **19**, pp. 559-565.

- Wethli, E., 1986.- European Table of Energy Values for Poultry Feedstuffs. Wageningen, Netherlands.

- Wethli, E., 1984.- *L'alimentation des animaux monogastriques*.- Paris : INRA, chapitre 9, pp. 85-104.

Table 1: Influence of temperature conditions on energy requirements of laying hens[1]

t°C	Energy requirement (MJ/hen/day)			
	Maintenance	Growth	Egg output	Total
0	1.25	0.03	0.69	1.96
5	1.15	0.03	0.69	1.87
10	1.06	0.03	0.69	1.77
15	0.96	0.03	0.69	1.67
20	0.86	0.03	0.69	1.57
25	0.77	0.03	0.69	1.48
30	0.67	0.03	0.69	1.38
35	0.57	0.03	0.69	1.19

(1) Age of hens, 40 weeks ; live weight 2,1 kg ; daily gain 2 g ; daily egg output 52 g.

Table 2: Energy requirement during the laying cycle

Age in weeks	Live weight kg	Weight gain g/day	Egg output g/day	Energy requirement MJ/day			
				Mainte-nance	Growth	Egg output	Total
22	1.76	7.1	9	0.74	0.09	0.12	0.95
26	1.91	2.8	47	0.78	0.04	0.62	1.44
30	1.98	1.9	53	0.79	0.02	0.71	1.52
40	2.11	1.1	52	0.83	0.02	0.69	1.53
50	2.19	0.9	49	0.85	0.01	0.65	1.51
60	2.25	0.7	46	0.86	0.01	0.61	1.48
70	2.30	-	43	0.88	-	0.56	1.44

Table 3: Requirement of protein intake for layers

Age in weeks	Live weight kg	Weight gain g/day	Egg output g/day	Requirement of protein intake g/day
22	1.76	7.1	9	10.2
26	1.91	2.8	47	17.0
30	1.98	1.9	53	18.2
40	2.11	1.1	52	18.0
50	2.19	0.9	49	17.5
60	2.25	0.7	46	16.9
70	2.30	-	43	16.0

Table 4: Estimates a (mg/gE) and b (mg/kgW) in laying hens

Amino acid	Estimates		
	a	b	
	McDonald & Morris 1985	Fisher 1973-1976	McDonald & Morris 1985
Arginine	8.98	50	53
Lysine	9.99	85	73
Methionine	4.77	25	31
Total sulphur amino acid	8.30	60	80
Threonine	6.90	40	32
Leucine	12.50	-	32
Isoleucine	7.97	50	67
Histidine	3.30	10	16
Triptophan	2.62	10	11
Valine	8.90	60	76

Table 5: Energy and protein recommendations for laying hen diets

	Environmental temperature °C			
	1 - 10 winter	11 - 20 spring and	21-30 autumn	> 30 summer
1. Recommendation				
– M. Energy MJ/kg	13.5	12.5	12.5	12.5
– Protein, %	14.0	15.0	16.0	18.0
2. Daily intake requirement				
– Energy MJ/hen/day	1.8	1.6	1.5	1.3
– Daily intake of feed, g	130-135	125-130	115-120	100-110

Figure 1: The relationship between the calculated amino acid requirement for the average bird in the flock (indicated thus : ●) and the "requirement" of the whole flock in economic terms. The line representing the limit of economic response has a slope which reflects the optimum ratio between the cost of the input and the value of the output (Fisher *et al.*, 1973).