BIO-ECONOMIC IMPACT OF ENERGY AND PROTEIN LEVEL IN FEED FOR LAYING HENS RAISED IN ORGANIC SYSTEM

SIMIZ ELIZA, DRINCEANU DAN, ŞTEF LAVINIA, PĂCALĂ NICOLAE, SIMIZ FLORIN, JULEAN CĂLIN, CEAN ADA

[1]Banat's University of Agricultural Sciences and Veterinary Medicine, 300645 Timisoara, Calea Aradului 119, Romania
esimiz@animalsci-tm.ro

ABSTRACT
The economic results of organic egg production are largely dependent on the cost of the feed and productive performance. The paper aims to establish the productive performance of laying hens raised under specific conditions specific for the ecological system, and also performing a feeding costs estimation based on mathematical models starting from experimental data required. The hens in the experiment were fed a mixture of concentrated (MC) with 2728 kcal metabolizable energy (ME), 15.85% crude protein (CP), 0.67% lysine, 0.52% methionine + cystine, containing in its structure only fodder types organically certified. Throughout the entire experimental period, chickens have recorded a total MC consumption of 13.240 kg with an average daily consumption between 0.110 and 0.130 kg, when they produced a daily average of 31.55 g mass-egg. The amount of mass-egg produced (y) under this experiment can be predicted based on metabolizable energy intake (x_1) and crude protein (x_2) using the following mathematical model $y=a+b*x_1+c*x_1^2+d*x_1^3+e*x_1^4+f*x_1^5+g*x_2$ (R^2=0.99%). Between the values obtained after the experiment and the predicted values obtained using the mathematical relationship, the differences are very small 2.17% at the end of experimental period. The costs incurred by feeding the laying hens (y) organically raised can be predicted using the following mathematical model $y=exp(a*x_1+b*x2+c*x_3+d)$ (R^2=0,96), with a rate of error of less than 2.2%, depending on the amount of mass-egg produced (x1), metabolizable energy intake (x_1) and crude protein intake (x_2).

Key words: productive performance, mathematical model, costs of feeding, organic poultry

INTRODUCTION

Organic poultry could be one of the agricultural opportunities of development of agriculture in Romania since the market demand for organic products is increasing (ORBOI, 2009). Organic farming can make a significant and lasting economic development and plays an important role in improving the environment and water quality, bio-diversification and nature protection (BLAIR, 2008, DE BOER, 2002, FERRANTE, 2009, MERTENS, 2009).
The economic performance of organic egg production is largely dependent on the price of feeding and on the productive performance (SUNMER, 2010). Since feed costs are the most important economic factor, it should be closely monitored to ensure a maximum efficiency (WEERSINK, 2002). Thus, from this point of view, feeding costs represent over 90% of total variable costs.
Organic table birds and layers must be produced in accordance with the standard practices set out by the European Council Regulations and monitored by the certifying bodies in each country (EC, 2007, 2008, 2009).
The work proposes to set the productive performances of laying hens fed under required conditions specific to ecological system, and also predicts the feeding costs according to some mathematical methods starting from the experimental data obtained.

MATERIAL AND METHODS

The experiment was performed to obtain organic eggs on a total of 90 hybrid ISA BROWN hens aged between 20-36 weeks, in accordance with the Community legislation ensuring them food and maintenance conditions specific to organic system.
Hens in the experiment were fed ad libitum with a mixture of concentrated (MC) with 2728 kcal ME, 15.85% CP, 0.67% lysine, 0.52% methionine + cystine, its structure containing only forage varieties organically certified.
The experiment lasted for 16 weeks (October-January) during the ascendant phase and during a period of plateau phase of the laying curve.
Bio performance of hens was assessed using the following indicators:
- MC intake, determined weekly and expressed by MC consumption (kg/wk/hen) and average daily consumption (ADC),
- The development of the egg-mass-, based on the number of eggs produced weekly and according to their weight,
- Feed conversion ratio expressed in kg MC/kg egg-mass,
- Energy intake (kcal ME/kg egg-mass) and protein (g/kg egg-mass), determined on the use of MC.
Recorded initial data were processed statistically using the computer program SPSS 19. Based on energy and protein intake using informational software Data Fit 9, have been established equations of prediction of egg-mass quantity specific of that class of birds and also prediction using mathematical models for feeding costs registered.

RESULTS AND DISCUSSION

After performing the experiment regarding the bioproductive parameters evaluation in laying hens reared in ecological system and under the specified condition, there were obtained the following results:

- ***MC intake*** data are presented in *Table 1*.

Table1. Evolution of feed consumption in laying hens bred in organic system.

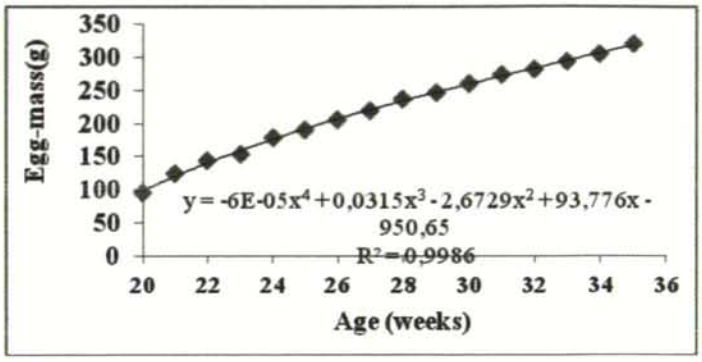
Age (weeks)	*MC intake (kg)*		*Average daily consumption (kg)*
	/period	*cumulated*	*/period*
22	1.535	1.540	0.110
24	1.535	3.070	0.110
26	1.580	4.650	0.110
28	1.624	6.270	0.120
30	1.673	7.950	0.120
32	1.780	9.730	0.130
34	1.750	11.470	0.120
36	1.765	13.240	0.130

As shown in *Table 1*, that has registered a total consumption of 13.240 kg AC throughout the experimental period, the average daily consumption (ADC) between 0.110 kg in the first period and 0.130 kg in the last experimental period.

– ***evolution of mass-egg*** Initial data on mass-egg are presented in *Table 2*. The data in *Table 2* on egg-mass obtained from hens of the experiment show that it increases from 15.72 g/hen/day at the age of 20 weeks up to 44.70 g/hen/day at the age of 36 weeks.

Table2. The evolution of egg-mass in laying hens in this experiment

Age (weeks)	Average /hen/day	Egg-mass g/hen/period
22	15.72	220.06
24	21.21	296.93
26	26.43	370.05
28	30.44	426.21
30	34.66	485.28
32	38.12	533.73
34	41.17	576.37
36	44.70	625.85
		3534.48

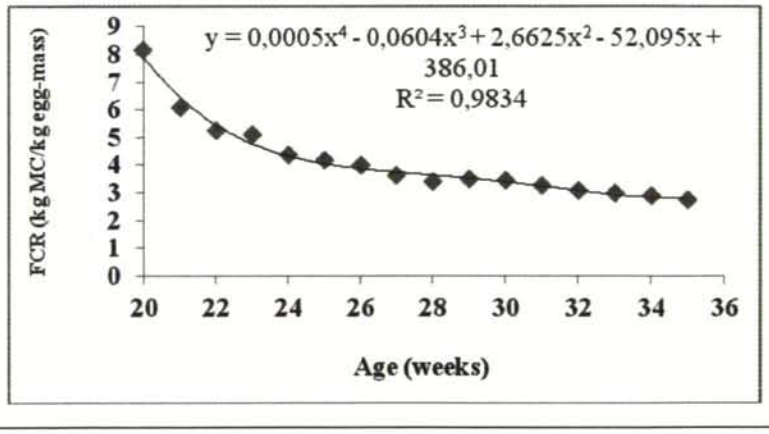


This increase of egg-mass quantity is bigger in the first weeks of the experiment, weeks coinciding with the ascendant phase of the laying curve, followed by a moderate increase when hens reach the plateau phase of the laying curve.
Throughout the experimental period, the amount of egg-mass produced was of 3534.48 g/hen, which is an average of 31.55 g egg-mass/hen/day.

– ***the feed conversion ratio (FCR)*** with fortnightly ratings is presented in *Table 3* and graphically traced, modeled using the polynomial regression of fourth degree in the figure inserted in *Table 3*.

Table 3. The evolution of the *feed conversion ratio* (kg MC/kg egg-mass)

Age (weeks)	*Feed conversion ratio/period*
22	6.06
24	5.09
26	4.17
28	3.63
30	3.50
32	3.24
34	2.97
36	2.76
Total	**4.12**



Throughout the period under review there was a feed conversion ratio of 4.12 kg MC/kg of egg-mass. At the beginning of experimental period that coincides with the beginning of laying process, the conversion ratio is higher due to the reduced production of mass-egg. The aim is downward as hens lay more eggs, so in the last week the experimental FCR is only of 2.76 kg MC/ kg egg-mass.
The coefficient of determination (R^2) of the polynomial regression equation of fourth degree, which helped us to graphically represent the conversion index with birds' age as a ratio, was higher (98.34%).

– average daily energy and protein intake

On the basis of the average daily consumption of MC and its content in nutritional criteria, there was determined the weekly intake of metabolizable energy and crude protein.

Average daily intake of metabolizable energy ranged between 205.60 kcal/kg egg-mass in the first experimental week and 241.25 kcal/kg egg-mass in the last experimental week.

Average crude protein intake was between 11.95 g/kg egg-mass and 14.02 g/kg egg-mass, which is variable depending on the experimental week and definitely of the amount of egg-mass.

We followed the development of egg-mass equations based on energy and crude protein intake. With the help of the informational soft Data fit 9.0 there were obtained several mathematical models, of which we chose to present the equation with the highest multiple coefficient of determination (R^2) and the lowest percentage of error for the entire experimental period.

The type of equation is: $y = a+b*x_1+c*x_1^2+d*x_1^3+e*x_1^4+f*x_1^5+g*x_2$, where:

y- the amount of mass-egg,

x_1- the metabolizable energy intake (kcal ME)

x_2- crude protein intake (g).

The resulted mathematical model coefficients and its statistical indices are presented in *Table 4*.

Table 4. Coefficients and statistical indices of mathematical equation of prediction for mass-egg according to metabolizable energy and crude protein intake

Coefficient	*Value*	*St. error*	*t-ratio*	*Prob(t)*
a	1.19E+08	17137361	6.920391	0.00007
b	-2648323	381952.6	-6.93364	0.00007
c	23631.16	3403.48	6.943232	0.00007
d	-105.337	15.15239	-6.95187	0.00007
e	0.234557	3.37E-02	6.958677	0.00007
f	-2.09E-04	3.00E-05	-6.96367	0.00007
g	1892.864	3039.428	0.62277	0.54889

$Y = 1{,}19E+08+-2648323*EM+23631{,}16*EM^2+-105{,}337*EM^3+0{,}234557*EM^4+-2{,}09E-04*EM^5+1892{,}864*PB$

Variance Analysis

Source	*DF*	*Sum of Squares*	*Mean Square*	*F Ratio*	*Prob(F)*
Regression	6	64575.56	10762.59	18.08398	0.00015***
Error	9	5356.306	595.1451		
Total	15	69931.87			

After applying this mathematical equation, we can predict egg-mass in laying hens kept in organic system under similar conditions with those carried out in this experiment (*Table 4*). The analysis of these data show that the calculated values (egg-mass) are similar to those obtained experimentally during the 16 weeks. Model error is small, and at the end of the tested period the recorded error rate was of about 2.18%.

Another indicator followed in this study was a bio-economic analysis based on athematical models of prediction of feeding expenses within this system of laying hens breeding.

Because feeding costs constitute a significant percentage of the total recorded production of eggs, we followed the development of models of prediction for expenditure necessary for hens feeding under the ecological breeding system, according to intake of metabolizable energy, crude protein and also according to the quantity of egg-mass.

With the help of informational soft Data fit 9.0, we have obtained three mathematical models presented in *Table 5*.

Table 5. Mathematical prediction models for feeding costs per bird

Rank	Model	StdError	Residual Sum	Residual Avg.	RSS	R^2
1	*exp(a*x1+b*x2+c*x3+d)*	0.01811	7.00E-05	4.37E-06	0.00393	0.96684
2	*a*x1+b*x2+c*x3+d*	0.01868	-8.88E-16	-5.55E-17	0.00419	0.96472
3	*a*x1+b*x2+c*x3*	0.02429	0.00718	0.00045	0.00767	0.93536

x_1- egg-mass quantity, x_2- energy intake, x_3- protein intake, y- ingested feed cost.

The data analysis presented in *Table 5* show that all three mathematical models from processing experimental data recorded a coefficient of multiple determination (R^2) higher than 0.93.

We chose to predict the feeding costs recorded using the first mathematical model resulted, with the highest coefficient of determination and the lowest percentage of error.

Coefficients and statistical index of the resulting mathematical equations (R^2=0.966

$y = exp\ (a * x1 + b * x2 + c * x3 + d)$ are presented in Table 6.

Table 6. The coefficients and statistical indices of mathematical equation for prediction of feeding costs

Coeficient	*Value*	*St. error*	*t-ratio*	*Prob(t)*
a	0.00035	0.00011	3.11172	0.00899
b	0.00253	0.00094	2.70288	0.01921
c	0.00187	0.01253	0.14940	0.88372
d	-0.27652	0.10046	-2.75251	0.01752

$y=exp(0.00035*x_1+0.00253*x_2+0.00187*x_3+-0.27652)$

Variance Analysis

Source	*DF*	*Sum of Squares*	*Mean Square*	*F Ratio*	*Prob(F)*
Regression	3	0.1147	0.0382	116.6234	***0.0000***
Error	12	0.0039	0.0003		
Total	15	0.1186			

y- ingested feed cost, x_1-produced mass-egg quantity, x_2 energy intake, x_3 protein intake.

The data analysis presented in *Table 6* show that between the experimental and predicted data obtained under this equation, the differences are very small throughout the experimental period. Throughout the production of eggs produced in the 16 experimental weeks, feeding costs were of 23.835 lei (5.48 €), which is 6.744 lei/kg egg-mass (1.55 €), value resulting from the application of the mathematical equation presented in Table 6.

Following the application of these mathematical equations, we can determine the cost of laying hens feeding kept in organic system under conditions similar to this experiment, after setting the metabolizable energy intake, crude protein and egg-mass quantity.

The analysis of these data show that the calculated values (predicted price) are close to those obtained experimentally during the 16 weeks. Model error is smaller, resulting a percentage of error less than 2.2%.

CONCLUSIONS

Hybrid ISA BROWN hens aged between 20 and 36 weeks bred in organic system and fed under required conditions, have registered a total consumption of MC 13.240 kg

with a daily average consumption between 0.110 and 0.130 kg, a period that produced a daily average of 31.55 g mass-egg.

The amount of egg-mass produced (y) under conditions similar to this experiment can be predicted based on metabolizable energy intake (x_1) and crude protein (x_2) using the following mathematical model $y=a+b*x_1+c*x_1^2+d*x_1^3+e*x_1^4+f*x_1^5+g*x_2$ (R^2=0.99%).

Between the values obtained experimentally and the predicted values obtained using the mathematical relationship, the differences are very small: 2.17% at the end of experimental period.

Costs incurred by feeding organic laying hens kept in organic system can be predicted using the following mathematical model $y=exp(a*x1+b*x2+c*x3+d)$ (R^2=0.96), with a error percentage lower than 2.2%.

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*** REGULAMENT (CE) NR. 834/2007 AL CONSILIULUI din 28 IUNIE 2007 privind producţia ecologică şi etichetarea produselor ecologice, precum şi de abrogare a Regulamentului (CCE) nr. 2092/91.

*** REGULAMENT (CE) NR. 889/2008 AL SOMISIEI din 5 septembrie 2008 de stabilire a normelor de aplicare a Regulamentului (CE) nr. 834/2007 al Consiliului privind producţia ecologică şi etichetarea produselor ecologice în ceea ce priveşte producţia ecologică, etichetarea şi controlul.

*** REGULAMENTUR (CE) NR. 953/2009 AL COMISIEI din 13 octombrie 2009 privind substanţele care pot fi adăugate cu anumite scopuri nutriţionale în produsele alimentare destinate unei alimentaţii speciale.