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THE EFFECT OF THE FEEDING LAYING HENS ON EGG MECHANICAL PROPERTIES*

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A b s t r a c t. The effect of low-protein feeding mixture on the technological properties of the egg shell was studied and compared with commercial mixture.

On the basis of obtained results it is possible to state that the suggested composition of the low-protein feeding mixture for layers allows to reach the level and egg quality. All it is comparable with using of convention feeding mixture which is more costly due to the higher content of expensive protein components.

K e y w o r d s: egg shell, destruction, deformation energy, shear strength modulus, feeding mixture

INTRODUCTION

Cage technologies used to house laying hens expose laid eggs to damage. It is important to know the conditions under which damage occurs to egg shells. With this knowledge, it is possible to take measures to reduce the proportion of damaged eggs. Egg losses due to shell damage or breakage between producer and consumer are as much as 6 to 8 % of the total. The world financial losses caused by this waste are estimated to be over US $ 600 milion a year [5]. The authors [11] examined an amount of the eggs rejected because of poor quality shell. In their opinion, the mean egg losses by mechanical damage during collecting, storage, and transport and grading were 4.3, 3.9, and 6.9 %, respectively. Further, the authors report that 15% of eggs of the total year production on an average rank among lower quality grades or are rejected due to poor quality shell.

In view of the fact that shell quality has a direct economic impact on production, this factor has been studied by more authors [1,3, 4,7,8,10,12]. Both destructive and non-destructive methods are used for standard laboratory evaluation of shell quality. The methods are based on direct or non-direct estimation of quality factors and their correlation. Among the quality factors are breaking strength, i.e., the resistance to pressure of cracking moment, shell thickness, shell proportion of egg weight, the weight of strictly determined surface of shell, egg specific weight, shell deformation, beta particle backscatterring and other factors [12].

Referring to the above-mentioned data, the aim of this work is to present the methods of testing the physical properties of market egg shells and their impact on the economic effectiveness of using different diets. Under the dynamic conditions, the circumstances were examined, leading to shell damage of the egg that leaves a laying cage by rolling and falling into an egg-collection trough. The percentage of damaged egg shells was estimated relative to the inclination of the cage grating floor. Egg shell thickness, force necessary to

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shear shell and shearing module were tested in the static conditions. Based on the results of the experiment, the possibility of using the given test methods for putting new diets into practice were considered.

MATERIAL AND METHODS

In production conditions, the feeding experiments were applied to laying breed of hens Hifix brown. The layers were located in 4-store and 3-store half cascade laying cages. The experiments were applied in the second stage of the laying cycle and it was divided into 3 one-month periods. Within the experiment the following parameters were studied :intensity of the laying, egg weight, weight and share of egg shell, deformation energy for destruction of the egg shell in dynamic conditions, egg shell thickness, shear strength modulus for static conditions and share of demaged eggs in cage battery. The intensity of laying was determined on the basis of the number of laid eggs, duration of laying period and number of layers in group. The weight of eggs and egg shell was determined by weighing and the share of egg shell was calculated.

The deformation energy was studied on the model of the cage when eggs fell on the floor. Egg destruction was recorded in relation to the track and egg velocity on kaving the cage. On the basis of studied parameters the deformation energy necessary to destruct the egg shell, was determined.

The thickness of the egg shell was measured on the full and narrow egg end as well as in the equatorial plane.

Shear strength modulus was determined on the basis of the force needed to cut the sample given surface of the identor and measured thickness of the egg shell.

The eggs laid during the second phase of the laying cycle of 48 to 62 weeks were used for experiment. The experiment included a control and trial group which differed in diet composition. The control group was offered a commercially prepared diet for productive layers, while the trial group was given a fődder mixture with a lower content of imported protein concentrate (soybean meal and fish meal). Samples of eggs were collected from laying hens at 53, 57 and 62 weeks of age, respectively, each group containing 60 pieces. For measurements in dynamic conditions, a floor of the standard laying cage with a length of 0.52 m and a 5° angle of inclination was used. The eggs were dropped down a path of 0.13, 0.26 and 0.39 m, respectively. The cage floor inclination varied in the range of 5 to 40°. Ninety repetitions were performed in each set of eggs. The weight and diameter in the equatorial area was determined in every egg prior to testing and the speed was calculated for each of the eggs. The time of egg motion down the inclined floor was determined electronically, with an accuracy of 0.001 s. The same eggs were used to test shells under static conditions. Forty repetitions as a minimum were performed in individual experiments. Five samples were taken from each egg, three from the equatorial area, one from the full and one from the narrow end. Shell thickness was measured by a Somet slide calliper, with an accuracy of 0.01 mm. The force necessary to shear the shell was determined by an INSTRON 1112 test device using the method of forcing a 4.48 mm diameter identor into the shell [2,9]. Shearing module was calculated [6].

RESULTS AND DISCUSSION

Tests in the dynamic conditions

The results from measuring the weight and a diameter in the equatorial area are given in Tables 1 and 2. Based on the measured speed of eggs dropping out of the cage, the correlation was examined among egg speed, cage floor inclination and egg path using point estimation of the regression line. The results are illustrated in Fig. 1.

When calculating the impact energy at which the E_{def}, egg shell compactness was damaged, we proceeded from the presupposition that an egg is a solid body spherical in shape. In fact, a fresh egg with solid shell and liquid inside is a system that is very hard to define from the kinematic aspect. The resulting egg motion is partially influenced by the motion of the yolk and the white inside the egg during its rolling motion. A part of the total energy, gained by the egg during its motion

Table 1. Weight of eggs. Tests in the dynamic conditions

Parameter	Feeding mixture	
	Control	Experimental
Mean, g	64.71	66.15
Standard deviation, g	4.83	4.55
Variance coefficient, %	7.46	6.88
Range, g	20.16	22.60
Minimum, g	56.11	55.40
Maximum, g	76.27	78.00
Count	88.00	90.00

Table 2. Diameter of eggs. Tests in the dynamic conditions

Parameter	Feeding mixture	
	Control	Experimental
Mean, g	44.30	44.60
Standard deviation, g	1.34	1.23
Variance coefficient, %	3.02	2.77
Range, g	5.50	6.20
Minimum, g	41.50	41.20
Maximum, g	47.00	47.40
Count	85.00	83.00

down the inclined plane is spent working against the forces generated due to rotation of the egg liquid inside. This energy is denoted E_{st}.

The energy of position (E_p) of the egg can be expressed as :

$$E_p = mgh \quad [\mathrm{J}], \tag{1}$$

where: m - egg weight, kg; g - acceleration of gravity m s^{-2}; h - height above support plate, m.

The kinetic energy (E_{kp}) of translation motion can be described as:

$$E_{kp} = \frac{1}{2}mv^2 \quad [\mathrm{J}], \tag{2}$$

where v is egg speed, m s^{-1}.

The kinetic energy (E_{kr}) of rotation motion is :

$$E_{kr} = \frac{1}{2}J\omega^2 \quad [\mathrm{J}], \tag{3}$$

where: ω - angular velocity, s^{-1}; J - moment of inertia, kg m^2.

For sphere, it is valid:

$$J = \frac{7}{5}mr^2 \quad [\mathrm{kg\ m^2}], \tag{4}$$

where r is radius of sphere, m, and:

$$E_{kr} = \frac{7}{10}mr^2\omega^2 \quad [\mathrm{J}], \tag{5}$$

if

$$v = r\omega \quad [\mathrm{m\ s^{-1}}] \tag{6}$$

$$E_{kr} = \frac{7}{10}mv^2 \quad [\mathrm{J}]. \tag{7}$$

Of this the energy of deformation (E_{def}) is:

$$E_{def} = E_{kp} + E_{kr} = \frac{6}{5}mv^2 \quad [\mathrm{J}]. \tag{8}$$

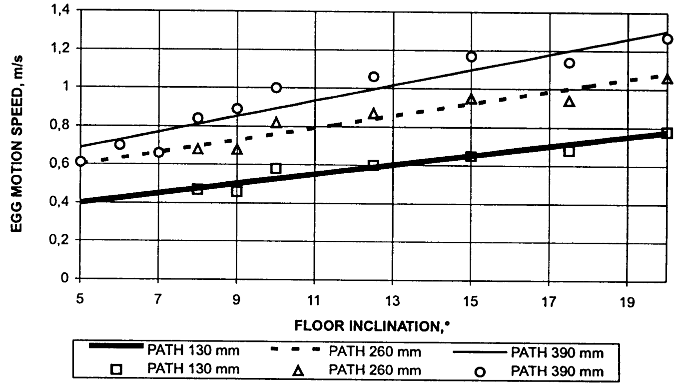

Fig. 1. Dependence of egg motion speed at dropping out of cage on the change in floor inclination.

Then the loss energy (E_{st}) is:

$$E_{st} = E_p - E_{def} \quad [\mathrm{J}]. \tag{9}$$

In order to meet the aim of this work, it was not necessary to determine this energy.

The mean weight of the control and the trial group was 64.71 and 66.15 g, respectively. The results from the experiment show that the mean energy of deformation of egg impact at which damage was done to the shell, was 0.101 and 0.095 J, respectively, in the control and the trial group.

The results achieved are shown in Fig. 2. An evaluation of the damage to eggs dropped out of the cage has proves that the trial eggs were exposed to bigger damage at a lower inclination of the cage floor when compared with the control. The weight of the trial eggs was 0.44 g higher than that of the control ones and their kinetic energy was also higher. This result is shown in Fig. 3 where the dependence of egg shell damage on the change in the floor inclination is shown. The percentage of damaged eggs from the trial set was higher, especially when the inclination of the cage grating floor was in the range of 7 to 10°.

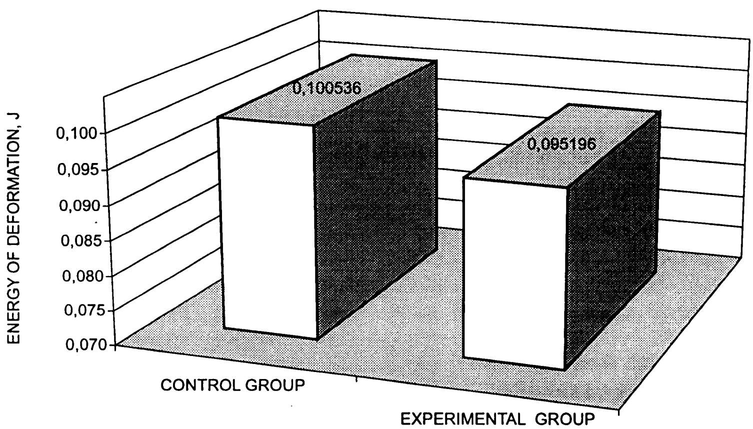

Fig. 2. Energy of deformation of the egg shells tested.

Regression and correlation coefficients $y = A + B.x + C.x^2 + D.x^3$					
	A	B	C	D	R
CONTROL GROUP	-221,140	50,844	-3,184	0,070	0,997
EXPERIMENTAL GROUP	[illegible]19,510	2,339	-3,388	0,076	0,995

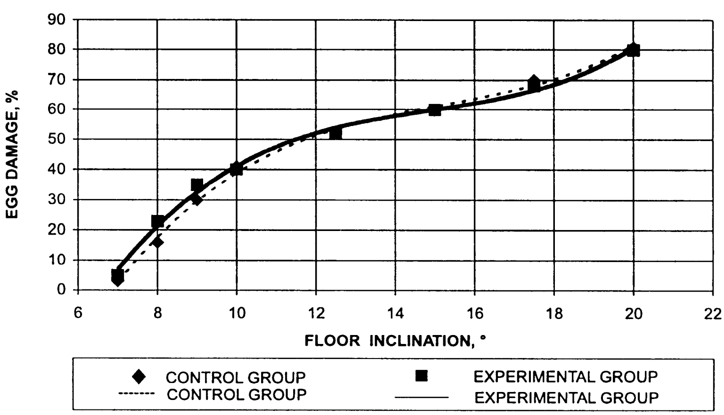

Fig. 3. Dependence of egg damage at dropping out of cage on the change in floor inclination.

Tests in the static conditions

The results on the shell thickness tests are shown in Fig. 4. The influence of diet type was manifested in shell thickness. From the viewpoint of the shell thickness of individual samples, the highest thickness was found in the equatorial area and the lowest in the full end of eggs in both the control and trial sets. A difference in samples of shell thickness within one egg was more significant in the trial. The thickness of the eggs of laying hens fed the test diet was 0.001 mm higher on average. The force necessary to shear the shells is closely associated with its thickness and structure. The test results are given in Fig. 5.

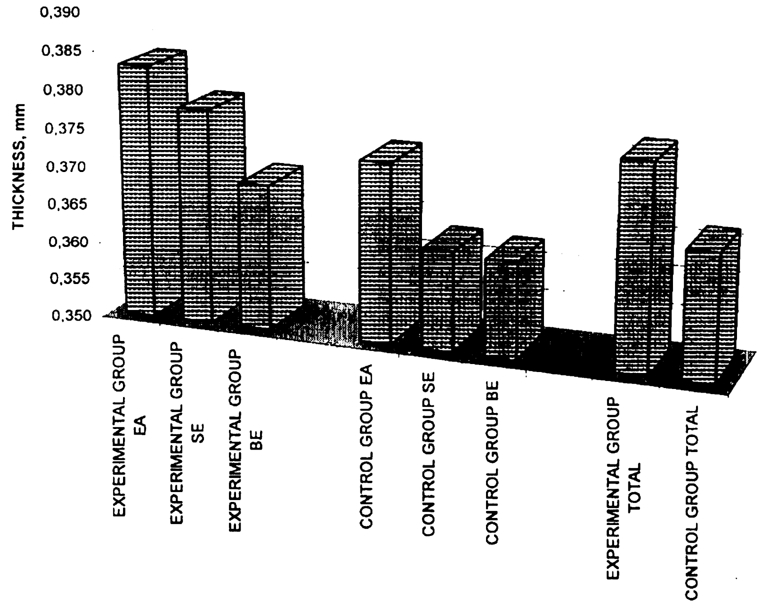

Fig. 4. Dependence of egg shell thickness on a place of sampling.

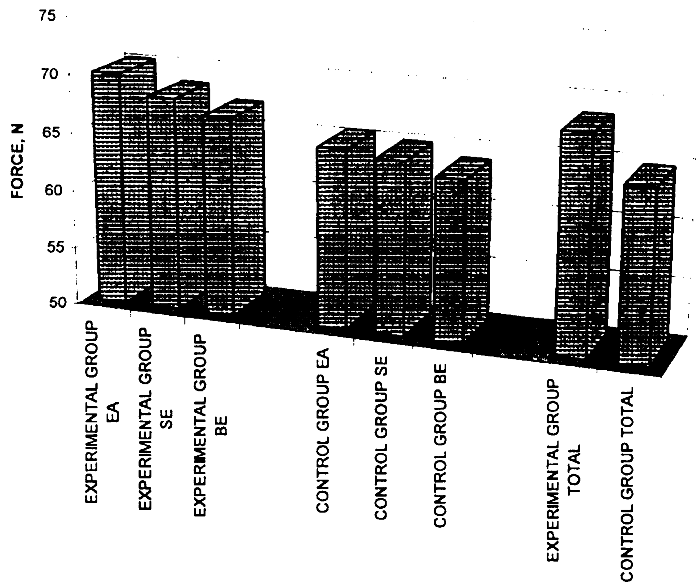

Fig. 5. Dependence of the force necessary to shear individual samples of egg shells.

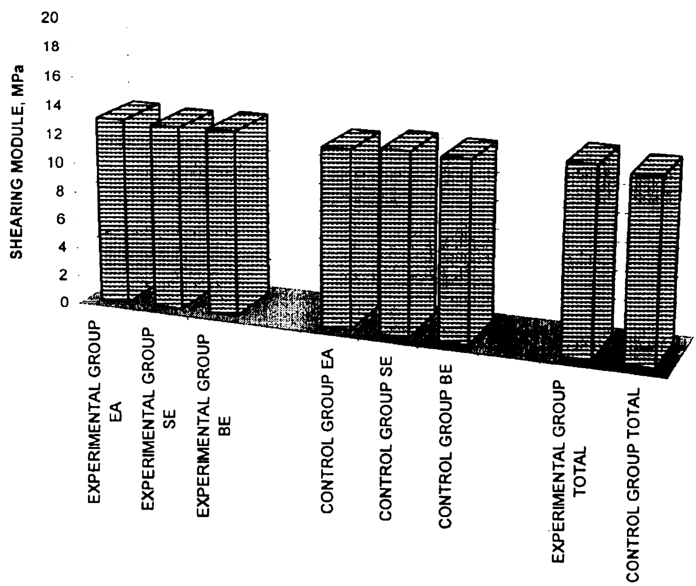

Fig. 6. Shearing module dependence of individual samples of egg shells.

Higher force values were detected in the control compared to the trial. However, the difference between samples within one control egg was less significant. Therefore, it can be stated that significant differences can be found in the eggs of laying hens fed the test diet than in those fed the control fodder mixture.

The shearing module of the shells was calculated according to the relationship :

$$G = \frac{F}{\pi da} \quad [\mathrm{Pa}], \tag{10}$$

where: F - force necessary to the shear shells, N; d - identor diameter, m; a - shell thickness, m.

From the results comparing the shearing modulus values of the shell of the tested samples shown in Fig. 6 it follows that there is a very little difference in the values determined.

CONCLUSION

The results presented suggest that knowing the basic physical parameters of egg shells can be used for comparing the suitability of using of different diets. In order to know better the relationships and correlation between the physical parameters of egg shells and the components of diets, it will be also good to study in the future the structure of components and their chemical distribution in shells.

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