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Effect of initial body weight and body composition of TETRA SL laying hens on the changes in their liveweight, body fat content, egg production and egg composition during the first egg-laying period

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ABSTRACT

The experiment was carried out with 45 TETRA SL laying hens, which were divided into three groups based on their liveweight on the one hand and based on their body fat content (determined by means of computer tomography) on the other hand measured both at 20 weeks of age. The average liveweight of the hens in the "low liveweight" group was 1534±87g (n=14), in the "medium liveweight" group 1696±33g (n=16) and in the "high liveweight" group 1861±94g (n=15). The average fat index calculated from the CT images was 22.9±0.9 (n=15) in the "low fatty" group, 24.9±0.4 (n=14) in the "medium fatty" group and 27.2±1.6 (n=16) in the "high fatty" group. The liveweight of the experimental birds was recorded at 32, 52 and 72 weeks of age during the first egg-laying period. At the same ages the body fat content of the hens was also determined by means of computer tomography in vivo. Eggs, which were produced by the experimental birds one day before the CT examinations, were collected and, after breaking them, their yolk and albumen was separated, weighed and their ratio to the egg weight was calculated. The dry matter, crude protein and crude fat content of the eggs were analyzed chemically. Based on the results it was established that the initial body weight of the hens affected changes in the liveweight, while the initial body fat content of the hens affected changes in the body fat content significantly (P<0.05) during the whole experimental period. The low initial body weight and the high initial body fat content of the hens resulted in the lowest egg production intensity at 52 and 72 weeks of age. Neither the initial body weight nor the initial body fat content of the hens affected the chemical composition of the eggs significantly (P>0.05).

(Keywords: laying hen, body weight, body composition, egg production, egg composition)

INTRODUCTION

It is well known from former experiments that the success in the hen house is dependent upon the success in the pullet house. Therefore, the main goal of the pullet's rearing period is to develop pullets with optimal body weight and body conformation at photostimulation for a long-term and high-level production in the forthcoming egg laying period.

In the study of *Robinson and Robinson* (1991) it was already pointed out that the relative difference in the initial body weight of the laying hens maintained to the end of the experiment, namely to 62 weeks of age. It was also established in this experiment that the low-weight birds began to lay later and their total egg output was lower than that of the medium- and high-weight hens.

In the study of *Perez-Bonilla et al*. (2012) it was pointed out that the hens with low or average initial body weight had higher average daily feed intake, egg production and egg weight than the lighter hens. However, none of the egg quality variables studied was affected by the initial body weight of the hens.

In the study of *Szentirmai et al*. (2014) it was observed that the relative difference in the initial body fat content of the hens also maintained to the end of the experiment, namely till 72 weeks of age. In this experiment it was also pointed out that the composition of the eggs produced was not affected significantly by the initial body fat content of the hens.

As it is visible from the former experiments, the effect of the initial body weight and body composition was already tested in some studies on the egg production of the laying hens and on the composition of their produced eggs. However, in these experiments either the effect of the initial body weight or the effect of the initial body composition was tested. In those experiments, where the effect of the initial body weight was tested, the initial body composition of the hens was unknown and, in those studies, where the effect of the initial body composition was tested, the body weight of the hens did not differ from each other. Therefore, the aim of this study was to examine the effect of initial body weight and body composition of the hens on their egg production and egg quality in the same experiment.

MATERIAL AND METHODS

The experiment was carried out with 45 TETRA SL (brown egg layer) hens, which were kept in cages (1.800 cm² basic area), in a closed building at the Poultry Test Station of the Kaposvár University, Faculty of Agricultural and Environmental Sciences, in Hungary.

Table 1.

Composition of the diet used in the experiment

Component	Content
Dry matter (g/kg)	903.4
ME Poultry (MJ)	11.56
Crude protein (g/kg)	177.8
Crude fat (g/kg)	43.0
Crude fibre (g/kg)	43.1
Crude ash (g/kg)	47.6
Nitrogen-free extractives (g/kg)	591.9
Sodium (g/kg)	1.7
Lysine (g/kg)	8.7
Methionine (g/kg)	3.9
Methionine + cystine (g/kg)	7.0
Calcium (g/kg)	37.6
Phosphorous (g/kg)	7.0

In order to the correct identification, of which egg was produced by which hen, hens were assigned individually with wing tags and two hens (one experimental TETRA SL brown egg layer and one non-experimental TETRA BLANCA white egg layer) were placed into one cage. The hens were fed *ad libitum* with commercial diets during the whole experimental period (*Table 1*). Drinking water was also continuously available from self-drinkers.

The experiment was started at 20 weeks of age, when all of the experimental animals were weighed and their body fat content was determined by means of computer tomography (CT) *in vivo*. The CT measurement was carried at the Institute of Diagnostic Imaging and Radiation Oncology of the Kaposvár University.

During the CT scanning procedure birds were fixed with belts in a special plexi-glass container, without using any anaesthetics. Three animals were scanned simultaneously. Due to the special arrangement of the hens, they were separable on the CT images, therefore their body fat content was determined individually.

The CT measurement consisted of overlapping 10 mm thick slices covering the whole body using a Siemens Somatom Emotion 6 multislice CT scanner. Following scanning parameters were set in: 130 kV – 80 mAs, spiral data collection (pitch 1), FoV 500 mm. The images obtained were evaluated by means of the Medical Image Processing software (version 1.0) developed at our university. With the help of this software so-called fat indices were calculated towards the *in vivo* determination of the body fat content in the hens. The calculation was performed by determining the ratio of number of pixels with X-ray density values of fat to the total number of pixels with density values of muscle, water and fat, i.e. the range between -200 to +200 on the Hounsfield-scale.

Before starting the egg laying period hens were divided into three groups based on their liveweight on the one hand and based on their body fat content on the other hand measured both at 20 weeks of age. The basic data of the hens in the different groups are summarized in *Table 2*.

Table 2.

Basic data of the experimental TETRA SL laying hens grouped by their liveweight and body fat content measured at 20 weeks of age

Traits	Groups	n	Mean	SD	Minimum	Maximum
Liveweight (g)	Low	14	1534	87	1360	1630
	Medium	16	1696	33	1650	1760
	High	15	1861	94	1770	2080
Fat index	Low	15	22.9	0.9	20.4	24.3
	Medium	14	24.9	0.4	24.4	25.4
	High	16	27.2	1.6	25.8	32.1

Changes in the body fat content of the experimental animals were followed by means of computer tomography *in vivo*, scanning the hens at 32, 52 and 72 weeks of age. The CT examinations were carried out according to the procedure mentioned above. The liveweight of the hens was also recorded at these days of the experiment, while their egg production was recorded daily.

Eggs, which were produced by the experimental birds one day before the CT examinations, were collected and, after breaking them, their yolk and albumen was separated. After weighing the different egg components (albumen, yolk and shell) their ratio to the egg weight was calculated and the dry matter, crude protein and crude fat content of the eggs were analyzed chemically. The chemical analysis of the egg composition was performed in the laboratory of the Kaposvár University according to the regulations of the following standards (dry matter: MSZ ISO 1442, crude protein: MSZ EN ISO 5983-1:2005 [Determination of nitrogen content and calculation of crude protein content by the Kjeldahl method], crude fat: 152/2009/EK. III/H [Lipid extraction with petroleum ether]).

The effect of the initial body weight and body fat content of the hens on the changes in their liveweight, body fat content, egg production and egg composition was statistically evaluated by the Multivariate Analysis of Variance using the following General Linear Model:

$$Y_{ijk} = \mu + IBW_i + IBF_j + e_{ij}, \text{ where}$$

Y_{ijk} = observation *k* in level *i* of factor IBW, and level *j* of factor IBF;
μ = overall mean;
IBW_i = initial body weight (low, average or high) of the i^{th} hen (i=1-3);
IBF_j = initial body fat content (low, average or high) of the j^{th} hen (j=1-3);
e_{ij} = random error.

The statistical analysis was carried out by the SPSS statistical software package, version 10.0 (SPSS for Windows, 1999).

RESULTS

Examining changes in the liveweight of the hens it was established that only the initial body weight affected this trait during the experimental period significantly (*Table 3*).

Table 3.

Effect of initial body weight and body fat content of TETRA SL laying hens on the changes in their liveweight and body fat content during the first egg-laying period

Age	Initial body weight			Initial body fat content			Level of significance (P)		S.E.
	Low n=14	Medium n=16	High n=15	Low n=15	Medium n=14	High n=16	IBW	IBF	
Liveweight (g)									
32 weeks	1847^{a}	1935^{ab}	2041^{b}	1958	1932	1933	0.006	0.868	24
52 weeks	1968^{a}	2056^{a}	2186^{b}	2101	2010	2098	0.004	0.237	26
72 weeks	2128^{a}	2201^{a}	2365^{b}	2242	2173	2279	0.010	0.329	32
Fat index									
32 weeks	31.5	31.4	32.3	30.0^{a}	32.1^{b}	33.2^{b}	0.620	0.006	0.4
52 weeks	34.2	35.0	35.3	32.7^{a}	34.3^{a}	37.5^{b}	0.716	0.005	0.6
72 weeks	34.1	35.1	36.0	33.3^{a}	34.2^{a}	37.6^{b}	0.330	0.003	0.6

IBW = initial body weight, IBF = initial body fat content, S.E. = standard error of overall mean
[a, b]Different letters in the same row indicate significant differences between the experimental groups within the examined traits ($P < 0.05$)

The liveweight of the hens starting the egg production with high initial body weight was higher during the whole examined period than that of the hens starting the egg production with low or medium initial body weight. The difference between the two extreme groups (hens with low and high initial body weight) was statistically proven at all examination days.

The initial body fat content had no significant effect on the changes in the liveweight of the hens.

In spite of the liveweight, changes in the body fat content of the hens were not affected by the initial body weight significantly (*Table 3*). In this trait only the significant effect of the initial body fat content was pointed out in this experiment. The body fat content of the hens starting the egg production with high initial body fat content was higher during the whole experimental period than that of the hens starting the egg production with low or medium initial body fat content. The difference between the two extreme groups (hens with low and high initial body fat content) was statistically proven at all examination days.

The egg production intensity of the hens with low initial body weight was lower than that of the hens with medium or high initial body weight at 52 and 72 weeks of age, but these differences were statistically not proven in this experiment (P>0.05; *Table 4*).

Table 4.

Effect of initial body weight and body fat content of TETRA SL laying hens on the changes in their egg production and egg weight during the first egg-laying period

Age	Initial body weight			Initial body fat content			Level of significance (P)		S.E.
	Low n=14	Medium n=16	High n=15	Low n=15	Medium n=14	High n=16	IBW	IBF	
Egg production (%)									
32 weeks	96.2	97.2	95.9	94.9	96.2	98.3	0.859	0.400	0.8
52 weeks	87.4	93.2	92.8	96.2^{b}	90.2^{a}	87.1^{a}	0.092	0.010	1.3
72 weeks	73.7	79.0	76.6	80.0^{b}	76.1^{ab}	73.2^{a}	0.118	0.039	1.1
Egg weight (g)									
32 weeks	63.7	60.6	63.1	63.4	62.5	61.5	0.130	0.526	0.7
52 weeks	64.3	62.9	65.0	65.9	62.0	64.2	0.437	0.112	0.7
72 weeks	67.1	64.7	65.3	66.5	65.9	64.6	0.613	0.755	0.9

IBW = initial body weight, IBF = initial body fat content, S.E. = standard error of overall mean

$^{a,\ b}$Different letters in the same row indicate significant differences between the experimental groups within the examined traits (P < 0.05)

The total egg production of the hens with low initial body weight was also lower than that of the hens with medium or high initial body weight (304±30, 315±28 and 316±17, respectively).

The egg production intensity of the hens with high initial body fat content was lower than that of the hens with medium or low initial body fat content at 52 and 72 weeks of age (*Table 4*). The differences between the two extreme groups were statistically proven in this case (P<0.05). However, in spite of the lower egg production intensity of the hens with high initial body fat content at 52 and 72 weeks of age, the amount of their total egg production during the whole experimental period was similar to that of the hens with medium or low initial body fat content (315±15, 309±32 and 311±30, respectively).

The weight of the eggs produced was lowest in the hens with medium initial body weight at all examination days, but it differed not siginificantly (P>0.05) from that of the hens with low or high initial body weight (*Table 4*).

The initial body fat content of the hens affected the weight of the eggs also not significantly (P>0.05), but a decreasing tendency was observed in the average egg weight with increasing the initial body fat content of the hens at 32 and 72 weeks of age.

The composition of the eggs produced was mainly not affected by the initial body weight of the hens significantly (*Tables 5-7*).

Table 5.

Effect of initial body weight and body fat content of TETRA SL laying hens on the changes in their eggs' albumen and yolk ratio during the first egg-laying period

Age	Initial body weight			Initial body fat content			Level of significance (P)		S.E.
	Low n=14	Medium n=16	High n=15	Low n=15	Medium n=14	High n=16	IBW	IBF	
Egg albumen ratio (%)									
32 weeks	64.6^{b}	63.3^{a}	62.9^{a}	63.1	63.8	63.8	0.027	0.420	0.3
52 weeks	63.2	61.9	62.1	62.2	62.7	62.3	0.260	0.794	0.3
72 weeks	63.0	61.5	61.4	61.7	61.9	62.4	0.202	0.721	0.4
Egg yolk ratio (%)									
32 weeks	23.3	24.4	24.5	24.2	23.8	24.2	0.055	0.673	0.2
52 weeks	23.9^{a}	25.7^{b}	25.3^{ab}	25.0	24.5	25.4	0.032	0.426	0.3
72 weeks	24.7	25.2	25.2	25.1	25.1	25.1	0.775	1.000	0.3

IBW = initial body weight, IBF = initial body fat content, S.E. = standard error of overall mean

[a, b]Different letters in the same row indicate significant differences between the experimental groups within the examined traits (P < 0.05)

Table 6.

Effect of initial body weight and body fat content of TETRA SL laying hens on the changes in their egg shell ratio and eggs' dry matter content during the first egg-laying period

Age	Initial body weight			Initial body fat content			Level of significance (P)		S.E.
	Low n=14	Medium n=16	High n=15	Low n=15	Medium n=14	High n=16	IBW	IBF	
Egg shell ratio (%)									
32 weeks	12.1	12.3	12.6	12.6	12.4	12.0	0.404	0.241	0.2
52 weeks	12.9	12.4	12.6	12.8	12.8	12.4	0.409	0.382	0.1
72 weeks	12.2^{a}	13.3^{b}	13.3^{b}	13.3	13.1	12.5	0.046	0.268	0.2
Eggs' dry matter content (%)									
32 weeks	23.4	23.7	23.3	24.4	22.7	23.3	0.829	0.265	0.3
52 weeks	23.0	23.5	22.7	23.4	23.1	22.7	0.510	0.728	0.3
72 weeks	22.1	23.3	22.7	23.2	22.5	22.5	0.380	0.549	0.3

IBW = initial body weight, IBF = initial body fat content, S.E. = standard error of overall mean

[a, b]Different letters in the same row indicate significant differences between the experimental groups within the examined traits (P < 0.05)

Table 7.

Effect of initial body weight and body fat content of TETRA SL laying hens on the changes in their eggs' crude protein and crude fat content during the first egg-laying period

Age	Initial body weight			Initial body fat content			Level of significance (P)		S.E.
	Low n=14	Medium n=16	High n=15	Low n=15	Medium n=14	High n=16	IBW	IBF	
Eggs' crude protein content (%)									
32 weeks	11.8	12.1	11.6	12.2	11.5	11.8	0.374	0.269	0.1
52 weeks	12.2	12.3	12.0	12.4	12.2	11.9	0.542	0.480	0.1
72 weeks	11.4	11.9	11.9	12.0	11.5	11.6	0.325	0.286	0.1
Eggs' crude fat content (%)									
32 weeks	8.08	7.96	7.82	8.26	7.89	7.70	0.871	0.598	0.17
52 weeks	8.79	9.19	8.67	8.97	8.95	8.73	0.477	0.885	0.16
72 weeks	8.73	9.17	8.75	8.99	8.87	8.78	0.568	0.934	0.16

IBW = initial body weight, IBF = initial body fat content, S.E. = standard error of overall mean

The initial body weight of the hens affected only the albumen ratio at 32 weeks of age, the yolk ratio at 52 weeks of age and the egg shell ratio at 72 weeks of age significantly. However, in most cases no clear tendencies were observed in the changes of the examined egg components in connection with the initial body weight of the hens.

The initial body fat content of the hens had no significant effect on the examined egg components in any cases.

DISCUSSION

Similarly to the results of *Robinson and Robinson* (1991) it was established in the present study that the liveweight of the hens starting the egg production with high initial body weight remained higher during the whole experimental period than that of the hens starting the egg production with low or medium initial body weight.

The results of the present study confirmed also the former observation of *Perez-Bonilla et al*. (2012) that the initial body weight of the hens has no significant effect on the quality of the eggs. However, in spite of the finding of the mentioned authors, the significant effect of the initial body weight on the weight of the eggs was not observed in our experiment.

The finding in our study that the body fat content of the hens starting the egg production with high initial body fat content was higher during the whole experimental period than that of the hens with low or medium initial body fat content is in agreement with the result of our former experiment (*Szentirmai et al*., 2014). Similarly to the results of this former examination, no significant effect of the initial body fat content of the hens on the composition of their eggs produced was pointed out in the current experiment.

In the study of *Renden and Marple* (1986) it was pointed out that the effect of body composition on the performance efficiency of dwarf hens were related to composition changes associated with selection for body weight.

In the study of *Gregory and Robins* (1998) it was established that the body condition of laying hens could be very different at the end of the laying period. It was also pointed out in their experiment that the empty body weight increased with increasing body condition score, and on average the birds with a body condition score of 3 were over 50% heavier than the birds scoring 0. About 77% of the difference in empty body weight between the condition score 3 and 0 birds resulted from differences in muscle and fat weight. Differences in absolute fatness accounted for most of that difference, and this was evident when the results were expressed as proportions of fat in the empty body.

The body fat content could have major impact in the case of breeders. It was established by *Yannakopoulos et al*. (1995) that carcass fat as well as age are critical requirements for the onset of sexual maturity in quail.

In the study of *Renema et al*. (1995) it was pointed out that the ovary weight and the number of unreconciled postovulatory follicles correlated with abdominal fat pad weight in large white turkey hens.

Hocking et al. (2002) reported that feed-restricted and overfed hens have similar fertility when provided a similar semen source, but overfed hens have a reduced hatchability due to an increase in late embryonic death.

Overfed hens typically have shorter laying sequences (*Robinson et al*., 1991b), which will result in more 'first of sequence' eggs. These eggs contain a follicle that was held back from ovulation over the pause day(s) and is more likely to undergo embryonic death (*Robinson et al*., 1991a).

Based on these results it seems that the optimal body conformation at photostimulation seems to be more important for reproductive success than just obtaining the recommended body weight targets (*Powell*, 2004).

CONCLUSIONS

Based on the results it was established that the initial body weight affected the changes in the liveweight, while the initial body fat content the changes in the body fat content of the hens significantly during the whole experimental period. The low initial body weight and the high initial body fat content of the hens resulted in the lowest egg production intensity at all examination days. Neither the initial body weight nor the initial body fat content of the hens affected the composition of their eggs significantly.

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