STUDIES REGARDING THE INFLUENCE OF REARING SYSTEM FOR LAYING HENS (LOFT vs. BATTERY) ON QUALITY OF EGGS

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Abstract

Research was focused on quality of eggs provided by ISA Brown hybrid exploited in two different systems: Natura Nova Twin loft; Eurovent battery. Eggs were gathered at for different ages of birds (20, 31, 40 and 60 weeks). Abnormal morphological eggs were into a mean rate of 1.43% at hens reared in battery and of 1.36% at the ones from loft. Mean weight of eggs was 58.99 g at the hens from battery and 59.23 g at the ones from loft, format index was 77.97% for hens from battery and 78.42% at the ones from loft. Mean thickness of mineral shell was 0.363 mm for the eggs of the hens reared in battery and 0.381 mm at the ones from loft, shell breaking resistance was 0.329 kgf/cm^2 respectively 0.332 kgf/cm^2. Regarding eggs' structure, at the ones gathered from the hens in loft was founded a higher rate of yolk (30.33-32.99%) and shell (10.17-11.82%), while at eggs of the hens from battery, albumen was predominant (56.90-57.97%). Albumen index was at mean levels of 0.211 (rearing in battery) and 0.221 (rearing in loft), yolk index was 0.455 respectively 0.472, and Haugh index was, in average, of 96.09 HU (battery) and 96.66 HU (loft). Yolk colour was of 9.88 colour units at eggs provided by rearing in battery and 9.99 units at the ones from loft. The conclusion of our study was that loft rearing system offers optimal conditions to laying hens for evolution of metabolic processes specific for egg formation, materialized in superior qualitative and physical metabolic indexes.

Key words: hens, rearing, loft, eggs, quality

INTRODUCTION

From the aviary breeds intensively reared, laying hens are the ones which benefit of a remarkable attention regarding protection measures [14] and which were transformed in regulations regarding welfare [3, 14].

It is recognized the fact that egg production is dependant of various endogen and exogenous factors, whose influence rate is manifested in variable limits [4, 9, 14].

Even if were effectuated numerous research regarding those problem [1, 2, 8], last period was dedicated for studying on scientific basis of the action of rearing system on birds' productivity and eggs quality [7].

Rearing system generate behavioural modifications at birds, as an adaptation at new life conditions, but with effects on egg production, and especially on their quality [5].

From the total egg production laid by a bird, a certain rate is represented by eggs with deviations from normal morphology and which are improper for commercialization [4].

Apparition of such eggs is a consequence of some genetic causes, nutritional problems, or due to applied rearing technology [15].

Eggs weight had a higher genetic determinism (h^2=0.64) [11] and presents importance by the fact that influence the class in which are placed and their selling price [14].

Failure to comply the technological factors specific for laying hens rearing have a negative impact on eggs quality [9, 14].

So for example, higher temperatures determines a decrease of eggs weight, decreasing of shell rate and even reduction of yolk rate, especially in the case of association with a too higher moisture [17].

Administration of deficient mixed fodders affect eggs structure and also the quality of mineral shell [6].

For the above mentioned reasons, we aimed to study the way in which rearing system of laying hens influence the quality of eggs laid by them.

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MATERIAL AND METHOD

Studied material was represented by eggs provided from hens bellonging to ISA Brown hybrid, exploited in two rearing systems: improved battery (Eurovent) and loft (Natura Nova Twin).

Quality indicators were determined on eggs gathered at four different ages of birds (20, 31, 40 and 60 weeks), through the methods utilised in aviary research:

- *morphological anomalies:* were identified eggs with deviations from normal morphology (with bad formed shell, without yolk, without shell, with two yolks, with broken shell) and were rated at the production from that period;
- *eggs weight:* each egg was individually weighted using an analytical balance;
- *format index:* with the formula based on ratio between small diameter (measured on median area - cm) and the great diameter (measured between those 2 peaks - cm) of the egg;
- *volume of eggs:* was calculated with formula: V=0.519 x D x d^2 (V=volume in cm^3; D=great diameter-cm; d=small diameter-cm);
- *specific weight:* was established using 11 pots in which are saline solutions at the same temperature but with densities which increase with 0.004 (saline solutions method);
- *thickness of shell:* using a device with a comparator watch, as mean of the effectuated measures on fragments gathered from sharp peak, round peak and from median area;
- *breaking up resistance of shell:* with a testing device of resistance at pressure by Schröder method;
- *eggs structure:* each egg was broken and separated into components (albumen, yolk and shell), after that was made a weighting of them and rated with egg weigh;
- *albumen index:* was calculated as a rate between height (measured near yolk with micrometer) and diameter (represents the mean of four measures: two in median area and two in declivous area);
- *yolk index:* was calculated as rate between height and diameter of yolk;
- *Haugh index:* is calculated based on egg weight and dense albumen height with formula:

$$HU = 100 \log(h - 1{,}7\ G^{0,37} + 7{,}57);$$

- *yolk colour:* was appreciated by comparison with La Roche scale which includes 15 samples of colour.

The obtained data were statistically processed, calculating: arithmetic mean ($\overline{X}$), means' standard deviation (±sx) and variation coefficient (V%).

RESULTS AND DISCUSSIONS

Eggs with morphological anomalies. At start of laying were founded 1.11% abnormal eggs at hens from battery and 1.09% at the ones from loft, mentioning that predominant were eggs with broken shell (0.60-0.65%) and the ones without shell (0.22-0.20%); rarely were founded eggs without yolk (0.03-0.04%).

In peak of laying decreased the rate of eggs with deviations from normal morphology (0.92% for battery and 0.87% for loft), but in plateau period was observed a new increase of rate of eggs with anomalies (1.31% for battery and 1.27% for loft).

For end of laying, effectuated determinations showed a rate of 2.38% abnormal morphological eggs at hens accommodated in battery and 2.22% at the ones from loft. Majority were eggs with broken shell (1.25-1.20%), followed by eggs with bad formed shell (0.64-0.61%), eggs without shell (0.29-0.25%), eggs without yolk (0.12-0.10%) and eggs with two yolks (0.08-0.06%) (tab. 1).

Eggs weight. At start of laying weight of eggs was 47.75±1.26 g at hens from battery and 47.89±1.27 g at the ones from loft; between batches weren't statistical differences, but the values of variation coefficient (V%=14.88-14.87) indicated a weak uniformity of the analysed feature.

For the eggs gathered in peak laying period, weights were 59.69±1.10 g at hens from battery and 59.86±1.09 g at the ones from loft, without the difference between batches to be statistically covered; studied character being quite uniform (V%=10.17-10.32%).

In case of eggs gathered in plateau period, weight was 61.11±1.31 g at hens from battery (V%=11.61) and 61.25±1.27 g at the ones from loft (V%=12.01).

Last control was effectuated at age of 60 weeks, when mean weight of eggs was 67.42±1.95 g at the ones reared in battery and 67.95±1.90 g for the ones from loft, without statistical differences between batches; studied character was less homogenous (V%=15.41-16.42) (tab. 2).

Table 1 Incidence of morphological anomalies (%) at studied eggs

Control period	Anomaly (%)	Rearing system	
		battery	loft
Start of laying	Eggs with bad formed shell	0.17	0.16
	Eggs without yolk	0.03	0.04
	Eggs without shell	0.22	0.20
	Eggs with two yolks	0.09	0.04
	Eggs with broken shell	0.60	0.65
	Total	**1.11**	**1.09**
Peak of laying	Eggs with bad formed shell	0.35	0.33
	Eggs without yolk	0.08	0.06
	Eggs without shell	0.10	0.09
	Eggs with two yolks	0.11	0.06
	Eggs with broken shell	0.28	0.33
	Total	**0.92**	**0.87**
Laying plateau	Eggs with bad formed shell	0.46	0.40
	Eggs without yolk	0.08	0.06
	Eggs without shell	0.17	0.15
	Eggs with two yolks	0.06	0.04
	Eggs with broken shell	0.54	0.62
	Total	**1.31**	**1.27**
End of laying	Eggs with bad formed shell	0.64	0.61
	Eggs without yolk	0.12	0.10
	Eggs without shell	0.29	0.25
	Eggs with two yolks	0.08	0.06
	Eggs with broken shell	1.25	1.20
	Total	**2.38**	**2.22**

Table 2 Weight (g) of studied eggs

Control period	Statistical estimators (n=30)	Rearing system	
		battery	loft
Start of laying (week 20)	$\overline{X} \pm s_{\overline{x}}$ (g)	47.75±1.26	47.89±1.27
	V%	14.88	14.87
	Significance of differences	battery vs. loft: F=0.24<F5%=4.006 NS	
Peak of laying (week 31)	$\overline{X} \pm s_{\overline{x}}$ (g)	59.69±1.10	59.86±1.09
	V%	10.17	10.32
	Significance of differences	battery vs. loft: F=0.39<F5%=4.006 NS	
Laying plateau (week 40)	$\overline{X} \pm s_{\overline{x}}$ (g)	61.11±1.31	61.25±1.27
	V%	11.61	12.01
	Significance of differences	battery vs. loft: F=0.13<F5%=4.006 NS	
End of laying (week 60)	$\overline{X} \pm s_{\overline{x}}$ (g)	67.42±1.95	67.95±1.90
	V%	15.41	16.42
	Significance of differences	battery vs. loft: F=0.58<F5%=4.006 NS	

Format index. At birds with age of 20 weeks, eggs format index presented values of 76.87±0.71% in case of the ones gathered from hens reared in battery and 77.05±0.68% for the ones from loft, in conditions of a very good homogeneity of studied character (V%=3.95-3.43).

At eggs gathered in peak laying period, format index was 77.15±0.67% (battery) and 77.91±0.86% (loft) (V%=3.35-4.27), and at the ones from the end of laying plateau 77.78±0.79% respectively 78.21±0.83% (V%=3.96-4.11).

At end of laying, determinate values for eggs format index were 80.09±0.20% - hens accommodated in battery and 80.52±0.55% - hens reared in loft; studied character was homogenous (V%=6.83-3.55), and between batches weren't observed significant statistical differences (tab. 3).

Table 3 Format index (%) for studied eggs

Control period	Statistical estimators (n=30)	Rearing system	
		battery	loft
Start of laying (week 20)	$\overline{X} \pm s_{\bar{x}}$ (%)	76.87±0.71	77.05±0.68
	V%	3.95	3.43
	Significance of differences	battery vs. loft: F=2.14<F5%=4.006 NS	
Peak of laying (week 31)	$\overline{X} \pm s_{\bar{x}}$ (%)	77.15±0.67	77.91±0.86
	V%	3.35	4.27
	Significance of differences	battery vs. loft: F=2.09<F5%=4.006 NS	
Laying plateau (week 40)	$\overline{X} \pm s_{\bar{x}}$ (%)	77.78±0.79	78.21±0.83
	V%	3.96	4,11
	Significance of differences	battery vs. loft: F=2.13<F5%=4.006 NS	
End of laying (week 60)	$\overline{X} \pm s_{\bar{x}}$ (%)	80.09±0.20	80.52±0.55
	V%	6.83	3,55
	Significance of differences	battery vs. loft: F=2.28<F5%=4.006 NS	

Volume of eggs. In case of hens reared in battery, this indicator presented values between 45.56±1.38 cm^3 (start of laying) and 65.05±1.13 cm^3 (end of laying), with a good homogeneity of character (V%=4.15-11.71).

Eggs laid by the hens accommodated in loft presented superior values for volume, with limits between 45.96±1.53 cm^3 (start of laying) and 65.43±1.31 cm^3 (end of laying) and with a good uniformity (V%=6.29-9.52).

Differences between mean values of eggs volume for those two batches weren't statistically significant (tab. 4).

Table 4 Volume (cm^3) of studied eggs

Control period	Statistical estimators (n=30)	Rearing system	
		battery	loft
Start of laying (week 20)	$\overline{X} \pm s_{\bar{x}}$ (cm^3)	45.56±1.38	45,.96±1.53
	V%	11.71	9.52
	Significance of differences	battery vs. loft: F=2.54<F5%=4.006 NS	
Peak of laying (week 31)	$\overline{X} \pm s_{\bar{x}}$ (cm^3)	59.91±0.88	60.45±1.03
	V%	5.71	6.59
	Significance of differences	battery vs. loft: F=2.49<F5%=4.006 NS	
Laying plateau (week 40)	$\overline{X} \pm s_{\bar{x}}$ (cm^3)	61.97±0.64	62.33±1.12
	V%	4.15	6.29
	Significance of differences	battery vs. loft: F=2.63<F5%=4.006 NS	
End of laying (week 60)	$\overline{X} \pm s_{\bar{x}}$ (cm^3)	65.05±1.13	65.43±1.31
	V%	7.25	7.77
	Significance of differences	battery vs. loft: F=2.58<F5%=4.006 NS	

Specific weight. At the eggs gathered from the shelter with hens reared in battery, specific weight presented values between 1.088±0.001 (week 20 of birds' life) and 1.098±0.014 (week 60).

In case of eggs laid by hens from loft, specific weight was a little bit greater, with limits between 1.089±0.005 (start of laying) and 1.099±0.001 (end of laying).

At both batches, variation coefficients were very low (V%=0.40-1.07 at eggs gathered from battery and V%=0.13-1.77 at the ones laid by the hens from loft), which demonstrate a very good homogeneity of the character. Between batches weren't differences with statistic significance (tab. 5).

Table 5 Specific weight of studied eggs

Control period	Statistical estimators (n=30)	Rearing system	
		battery	loft
Start of laying (week 20)	$\bar{X} \pm s_{\bar{x}}$	1.088±0.001	1.089±0.005
	V%	0.49	1.77
	Significance of differences	battery vs. loft: F=1.44<F5%=4.006 NS	
Peak of laying (week 31)	$\bar{X} \pm s_{\bar{x}}$	1.090±0.001	1.091±0.001
	V%	0.40	0.41
	Significance of differences	battery vs. loft: F=1.49<F5%=4.006 NS	
Laying plateau (week 40)	$\bar{X} \pm s_{\bar{x}}$	1.094±0.001	1.095±0.001
	V%	0.44	0.13
	Significance of differences	battery vs. loft: F=1.33<F5%=4.006 NS	
End of laying (week 60)	$\bar{X} \pm s_{\bar{x}}$	1.098±0.014	1.099±0.001
	V%	1.07	0.51
	Significance of differences	battery vs. loft: F=1.28<F5%=4.006 NS	

Thickness of mineral shell. Eggs gathered from hens reared in battery had a shell thickness of 0.432±0.015 mm at the beginning of laying, 0.377±0.009 mm in peak of laying, 0.325±0.010 mm at the end of plateau period and 0.320±0.011 mm at the end of laying; variability of analysed feature was medium (V%=13.21-19.05).

In case of eggs laid by birds accommodated in loft, were observed the following thicknesses of mineral shell: 0.446±0.013 mm at the beginning of laying; 0.402±0.009 mm in peak of laying; 0.344±0.010 mm at the end of laying plateau; 0.333±0.011 mm at the end of laying. Also in this case was identified a medium variability of character, the values of variation coefficients oscillating between 12.45% (peak of laying) and 17.41% (end of laying).

Between mean values of mineral shell thickness of the eggs obtained from hens reared in those two systems weren't identified statistic differences (tab. 6).

Table 6 Shell thickness (mm) of studied eggs

Control period	Statistical estimators (n=30)	Rearing system	
		battery	loft
Start of laying (week 20)	$\bar{X} \pm s_{\bar{x}}$ (mm)	0.432±0.015	0.446±0.013
	V%	18.82	15.68
	Significance of differences	battery vs. loft: F=1.21<F5%=4.006 NS	
Peak of laying (week 31)	$\bar{X} \pm s_{\bar{x}}$ (mm)	0.377±0.009	0.402±0.009
	V%	13.21	12.45
	Significance of differences	battery vs. loft: F=1.20<F5%=4.006 NS	
Laying plateau (week 40)	$\bar{X} \pm s_{\bar{x}}$ (mm)	0.325±0.010	0.344±0.010
	V%	16.18	15.39
	Significance of differences	battery vs. loft: F=1.19<F5%=4.006 NS	
End of laying (week 60)	$\bar{X} \pm s_{\bar{x}}$ (mm)	0.320±0.011	0.333±0.011
	V%	19.05	17.41
	Significance of differences	battery vs. loft: F=1.12<F5%=4.006 NS	

Breaking up resistance. In case of eggs obtained from hens reared in battery was noticed that shell resistance recorded a decreasing evolution: 0.339±0.010 kgf/cm^2 at start of laying; 0.331±0.007 kgf/cm^2 in peak of laying; 0.325±0.009 kgf/cm^2 in plateau of laying and 0.321±0.010 kgf/cm^2 at the end of laying.

At hens accommodated in shelter with loft, resistance of egg shell was a little bit better than the one of hens from battery, also at the beginning of laying (0.341±0.009 kgf/cm^2), as well as in peak (0.333±0.007 kgf/cm^2), in plateau (0.329±0.008 kgf/cm^2) and at the end of laying (0.327±0.010 kgf/cm^2).

Character presented a medium variability (V%=11.09-16.39 for eggs gathered from hens reared in battery and V%=10.66-15.22 at the ones from loft) (tab. 7).

Table 7 Breaking up resistance of shell (kgf/cm^2) for the studied eggs

Control period	Statistical estimators (n=30)	Rearing system	
		battery	loft
Start of laying (week 20)	$\overline{X} \pm s_{\overline{x}}$ (kgf/cm^2)	0.339±0.010	0.341±0.009
	V%	15.21	13.54
	Significance of differences	battery vs. loft: F=0.25<F5%=4.006 NS	
Peak of laying (week 31)	$\overline{X} \pm s_{\overline{x}}$ (kgf/cm^2)	0.331±0.007	0.333±0.007
	V%	11.09	10.66
	Significance of differences	battery vs. loft: F=0.22<F5%=4.006 NS	
Laying plateau (week 40)	$\overline{X} \pm s_{\overline{x}}$ (kgf/cm^2)	0.325±0.009	0.329±0.008
	V%	14.57	13.18
	Significance of differences	battery vs. loft: F=0.23<F5%=4.006 NS	
End of laying (week 60)	$\overline{X} \pm s_{\overline{x}}$ (kgf/cm^2)	0.321±0.010	0.327±0.010
	V%	16.39	15.22
	Significance of differences	battery vs. loft: F=0.24<F5%=4.006 NS	

Eggs structure. At the beginning of laying period, participation rate of albumen in egg structure was 57.97±1.77% at the ones gathered from hens in battery and 57.85±1.28% at the ones from loft, yolk was 30.30±0.97% - battery and 30.33±0.79% - loft, and mineral shell was 11.73±0.29% and respectively 11.82±0.34%.

At hens with age of 31 weeks, structure of eggs gathered from shelter with battery was as follows: 57.59±1.43% - albumen; 31.32±0.67% - yolk and 11.09±0.26% - mineral shell. At eggs gathered from hens reared in loft the rate of components was: 57.50±1.65% - albumen; 31.35±0.66% - yolk and 11.15±0.35% - mineral shell.

Eggs obtained at the end of laying plateau had almost the same participation rate of albumen (57.52±1.38% in battery and 57.39±1.49% in loft), but had increased the yolk rate at levels of 32.03±0.74% - battery and 32.08±0.98% - loft and decreased the shell rate (10.45±0.32% in battery and 10.53±0.304% in loft).

The above mentioned situation was valid also for end of laying, when albumen rate in egg structure was 56.90±1.31% at the ones obtained at the hens reared in battery and 56.84±1.28% at the ones from loft, yolk was 32.97±0.79% at hens from battery and 32.99±0.79% at hens from loft, and rate of mineral shell was of only 10.13±0.34% (battery) and 10.17±0.31% (loft).

In all analysed situations, variation coefficient was at levels specific to a medium variability, both for albumen (V%=12.70-16.81 at eggs from battery and V%=12.21-15.77 at eggs from loft), as well as for yolk (V%=11.89-14.30 at battery and V%=11.57-16.82 at loft) and respectively, mineral shell (V%=13.16-18.44 at battery and V%=15.84-17.21 at loft).

Statiscally speaking, between those to egg batches weren't significant differences regarding their structure (tab. 8).

Albumen index. In case of hens reared in battery, eggs presented an albumen index of 0.156±0.008 at beginning of laying, 0.207±0.009 in peak of laying, 0.220±0.005 at the end of laying plateau and 0.263±0.017 at the end of laying, while for hens reared in loft the values were 0.162±0.005, 0.216±0.009, 0.231±0.008 respectively 0.278±0.015.

The analysed feature presented a medium and very high variability (V%=12.24-30.06) case of eggs gathered from battery, respectively a medium and high variability (V%=13.74-21.17) at the ones gathered from loft (tab. 9).

Table 8 Structure (%) of studied eggs

Specification			Rearing system		Significance of differences (n=30)
			battery	loft	
Start of laying (week 20)	Albumen	$\bar{X} \pm s_{\bar{x}}$ (%)	57.97 ± 1.77	57.85 ± 1.28	battery vs. loft: F=1.17<F5%=4.006 NS
		V%	16.81	12.21	
	Yolk	$\bar{X} \pm s_{\bar{x}}$ (%)	30.30 ± 0.79	30.33 ± 0.79	battery vs. loft: F=2.14<F5%=4.006 NS
		V%	14.30	14.45	
	Shell	$\bar{X} \pm s_{\bar{x}}$ (%)	11.73 ± 0.29	11.82 ± 0.34	battery vs. loft: F=3.11<F5%=4.006 NS
		V%	13.56	15.88	
Peak of laying (week 31)	Albumen	$\bar{X} \pm s_{\bar{x}}$ (%)	57.59 ± 1.43	57.50 ± 1.65	battery vs. loft: F=1.01<F5%=4.006 NS
		V%	13.62	15.77	
	Yolk	$\bar{X} \pm s_{\bar{x}}$ (%)	31.32 ± 0.67	31.35 ± 0.66	battery vs. loft: F=2.65<F5%=4.006 NS
		V%	11.89	11.57	
	Shell	$\bar{X} \pm s_{\bar{x}}$ (%)	11.09 ± 0.26	11.15 ± 0.35	battery vs. loft: F=2.96<F5%=4.006 NS
		V%	13.16	17.21	
Laying plateau (week 40)	Albumen	$\bar{X} \pm s_{\bar{x}}$ (%)	57.52 ± 1.38	57.39 ± 1.49	battery vs. loft: F=1.12<F5%=4.006 NS
		V%	13.19	14.23	
	Yolk	$\bar{X} \pm s_{\bar{x}}$ (%)	32.03 ± 0.74	32.08 ± 0.98	battery vs. loft: F=2.15<F5%=4.006 NS
		V%	12.81	16.82	
	Shell	$\bar{X} \pm s_{\bar{x}}$ (%)	10.45 ± 0.32	10.53 ± 0.30	battery vs. loft: F=2.22<F5%=4.006 NS
		V%	16.89	15.84	
End of laying (week 60)	Albumen	$\bar{X} \pm s_{\bar{x}}$ (%)	56.90 ± 1.31	56.84 ± 1.28	battery vs. loft: F=1.62<F5%=4.006 NS
		V%	12.70	12.39	
	Yolk	$\bar{X} \pm s_{\bar{x}}$ (%)	32.97 ± 0.79	32.99 ± 0.79	battery vs. loft: F=2.02<F5%=4.006 NS
		V%	13.16	13.21	
	Shell	$\bar{X} \pm s_{\bar{x}}$ (%)	10.13 ± 0.34	10.17 ± 0.31	battery vs. loft: F=1.75<F5%=4.006 NS
		V%	18.44	17.13	

Table 9 Albumen index for studied eggs

Control period	Statistical estimators (n=30)	Rearing system	
		battery	loft
Start of laying (week 20)	$\bar{X} \pm s_{\bar{x}}$	0.156±0.008	0.162±0.005
	V%	30.06	14.59
	Significance of differences	battery vs. loft: F=0.82<F5%=4.006 NS	
Peak of laying (week 31)	$\bar{X} \pm s_{\bar{x}}$	0.207±0.009	0.216±0.009
	V%	18.18	16.03
	Significance of differences	battery vs. loft: F=0.79<F5%=4.006 NS	
Laying plateau (week 40)	$\bar{X} \pm s_{\bar{x}}$	0.220±0.005	0.231±0.008
	V%	12.24	13.74
	Significance of differences	battery vs. loft: F=0.73<F5%=4.006 NS	
End of laying (week 60)	$\bar{X} \pm s_{\bar{x}}$	0.263±0.017	0.278±0.015
	V%	25.37	21.17
	Significance of differences	battery vs. loft: F=0.88<F5%=4.006 NS	

Yolk index. For the eggs laid by the hens with an age of 20 weeks, yolk index presented values of 0.395±0.010 (rearing in battery) and 0.415±0.009 (rearing in loft), at eggs obtained by the birds in their 31 week of life was 0.436±0.019 (battery) and 0.454±0.023 (loft), at eggs gathered from hens aged 40 weeks the mentioned indicator was 0.460±0.013 (battery) and 0.473±0.014 (loft), and at eggs of hens aged 60 weeks was 0.532±0.011 respectively 0.545±0.012.

Differences between those two egg batches hadn't a statistical coverage.

Variation coefficient of eggs from hens reared in battery was 7.86-16.73%, and at the ones from loft was 8.74-19.64%, indicating a low to medium variability (tab. 10).

Haugh index. For the eggs gathered from hens reared in battery resulted values for Haugh index between 102.59±1.37 HU as was at the beginning of laying and 87.98±1.02 HU as was at the end of laying; studied character being very homogenous (V%=4.91-6.38).

In case of eggs laid by hens reared in loft, Haugh index oscillated between 103.16±1.68 HU (start of laying) and 88.50±1.06 HU (end of laying), with a good uniformity of the character (V%=4.08-6.29).

Statiscally speaking, between those to egg batches weren't recorded significant differences (tab. 11).

Table 10 Yolk index for studied eggs

Control period	Statistical estimators (n=30)	Rearing system	
		battery	loft
Start of laying (week 20)	$\bar{X} \pm s_{\bar{x}}$	0.395±0.010	0.415±0.009
	V%	9.09	8.74
	Significance of differences	battery vs. loft: F=1.17<F5%=4.006 NS	
Peak of laying (week 31)	$\bar{X} \pm s_{\bar{x}}$	0.436±0.019	0.454±0.023
	V%	16.73	19.64
	Significance of differences	battery vs. loft: F=1.19<F5%=4.006 NS	
Laying plateau (week 40)	$\bar{X} \pm s_{\bar{x}}$	0.460±0.013	0.473±0.014
	V%	11.01	11.64
	Significance of differences	battery vs. loft: F=1.03<F5%=4.006 NS	
End of laying (week 60)	$\bar{X} \pm s_{\bar{x}}$	0.532±0.011	0.545±0.012
	V%	7.86	10.57
	Significance of differences	battery vs. loft: F=1.08<F5%=4.006 NS	

Table 11 Haugh index (HU) for studied eggs

Control period	Statistical estimators (n=30)	Rearing system	
		battery	loft
Start of laying (week 20)	$\bar{X} \pm s_{\bar{x}}$ (HU)	102.59±1.37	103.16±1.68
	V%	6.06	6.29
	Significance of differences	battery vs. loft: F=3.05<F5%=4.006 NS	
Peak of laying (week 31)	$\bar{X} \pm s_{\bar{x}}$ (HU)	98.97±1.77	99.55±1.04
	V%	4.91	4.08
	Significance of differences	battery vs. loft: F=3.09<F5%=4.006 NS	
Laying plateau (week 40)	$\bar{X} \pm s_{\bar{x}}$ (HU)	94.85±1.29	95.46±1.37
	V%	5.31	5.55
	Significance of differences	battery vs. loft: F=3.14<F5%=4.006 NS	
End of laying (week 60)	$\bar{X} \pm s_{\bar{x}}$ (HU)	87.98±1.02	88.50±1.06
	V%	6.38	6.23
	Significance of differences	battery vs. loft: F=3.17<F5%=4.006 NS	

Yolk colour. At the first three effectuated controls, yolk colour of eggs from battery was 10.01±0.20 La Roche units (start of laying), 10.11±0.21 La Roche units (peak of laying) and 10.33±0.15 La Roche units (laying plateau), and at the eggs laid by hens reared in loft was 10.13±0.16 La Roche units, 10.20±0.13 La Roche units, respectively 10.45±0.17 La Roche units.

At eggs gathered from hens with an age of 60 weeks, yolk colour was 9.08±0.23 La Roche units (battery) and 9.16±0.16 La Roche units (loft).

Studied character was less homogenous at the beginning of laying (V%=14.71-12.22) and homogenous at the next three control stages (V%=5.74-6.30 for hens from battery and V%=4.78-5.95 at the ones from loft).

Between batches weren't recorded differences with statistical significance (tab. 12).

Table 12 Yolk colour (La Roche units) for studied eggs

Control period	Statistical estimators (n=30)	Rearing system	
		battery	loft
Start of laying (week 20)	$\bar{X} \pm s_{\bar{x}}$ (La Roche units)	10.01±0.20	10.13±0.16
	V%	14.71	12.22
	Significance of differences	battery vs. loft: F=1.79<F5%=4.006 NS	
Peak of laying (week 31)	$\bar{X} \pm s_{\bar{x}}$ (La Roche units)	10.11±0.21	10.20±0.13
	V%	5.74	4.78
	Significance of differences	battery vs. loft: F=1.66<F5%=4.006 NS	
Laying plateau (week 40)	$\bar{X} \pm s_{\bar{x}}$ (La Roche units)	10.33±0.15	10.45±0.17
	V%	5.97	5.95
	Significance of differences	battery vs. loft: F=1.58<F5%=4.006 NS	
End of laying (week 60)	$\bar{X} \pm s_{\bar{x}}$ (La Roche units)	9.08±0.23	9.16±0.16
	V%	6.30	5.44
	Significance of differences	battery vs. loft: F=1.69<F5%=4.006 NS	

CONCLUSIONS

From the obtained data regarding the influence of rearing system of laying hens on quality of eggs laid by them resulted some aspects which will be presented bellow.

Abnormal morphological eggs were observed into a mean rate of 1.43% at hens reared in shelter with battery and 1.36% at the ones from loft.

Eggs weight was of 47.75-67.42 g at hens from battery and a little bit higher, of 47.89-67.95 g at the ones from loft, with mean levels for those four control stages of 58.99 g respectively 59.23 g.

For eggs' format index resulted mean values of 77.97% at hens reared in battery and 78.42% at the ones from loft, for eggs' volume 58.12 cm^3 and 58.54 cm^3, and for specific weight 1.093 respectively 1.094.

Thickness of mineral shell decreased with birds age, having a mean value of 0.363 mm at eggs gathered from hens reared in battery and 0.381 mm at the ones accommodated in loft; naturally also the breaking up resistance of shell was better at eggs from hens in loft (0.332 kgf/cm^2), than the one of the hens from battery (0.329 kgf/cm^2).

Data regarding eggs structure show a little bit higher levels at the ones laid by hens reared in loft for yolk (30.33-32.99%, with a mean of 31.69%) and for mineral shell (10.17-11.82%, with a mean of 10.92%), while at eggs from hens in battery albumen was predominant (56.90-57.97%, with a mean of 57.49%).

Albumen index was at mean levels of 0.211 in case of the ones gathered from the shelter equipped with battery and 0.221 for the ones obtained in shelter with loft, while yolk index recorded mean values of 0.455 respectively 0.472.

For Haugh index, values resulted as means for those four control stages were of 96.09 HU at eggs laid by hens reared in battery and 96.66 HU at the ones provided from loft.

Yolk colour varied between gathering periods, being of 9.88 La Roche units at the eggs provided by rearing in battery and 9.99 La Roche units at the ones from loft; explanation of differences between controls 1-3 and 4 being that mixed fodder administrated till age of 45 weeks included 0.004% „carophyll red" colorant, and the second one only 0.003%.

The final conclusion of our research was that rearing system in loft offer optimal conditions to laying hens for evolution of specific metabolic processes involved in formation of eggs, materialized in morphological and physical quality indexes superior to the ones which characterise the eggs laid by hens exploited in battery.

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