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IS THE LAYING HENS REARING SYSTEM RELEVANT FOR TABLE EGGS CHEMICAL AND NUTRITIONAL FEATURES?

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Abstract: *Do the changes occurred in poultry housing systems affect eggs chemical composition and dietetic parameters? To investigate this hypothesis, we used 700 ISA Brown hens, aged 26 weeks, randomly distributed in two groups: EC group-350 hens accommodated in furnished cages (800 cm^2/hen) and FR group-350 hens, reared on deep litter, with access to paddock (9 hens/m^2). Same feed (corn-wheat-soymeal) was used in both groups. 100 eggs were collected/group for chemical assessments on edible compounds (yolk, albumen, whole egg), using 20 replicates per parameter and compound. Analytical chemistry was performed via conventional methods, cholesterol through gas-chromatography and caloricity calculated on organic matters energy basis. ANOVA single factor was applied. 100g edible portion of whole eggs in EC group comprised 74.98% water, 1.14% ashes, 12.38% proteins, 10.45% lipids, 1.05% NFE, 174.25 Kcal energy (105 Kcal/egg), 397 µg cholesterol. In FR eggs, water was 75.62%, proteins and ashes didn't significantly change, lipids and caloricity were lower (9.81%, 168.65 Kcal/100 g; 101 Kcal/egg) and cholesterol was 373 µg. Significant differences occurred between groups for water and lipids content ($p<0.05$). Although the dietetic value was better in free-range eggs, it must reason if this improvement could counterbalance hygienic threats that could accompany free range production.*

Keywords: *enriched cages, free range, eggs, chemical composition, dietetic value*

1. Introduction

Changes in poultry husbandry technology and housing systems, due to compliance to the fowl welfare requirements, had imposed several studies to be done, in order to know the way in which the usage of a new rearing and exploitation system could affect hens behavior, the quality of edible poultry products (meat, eggs) and the economic efficiency of production [1, 2]. Related to behavior and welfare status, it was shown that laying hens generally accepts nesting in furnished cages and freedom of move, dust bathing, scratching and roosting behaviors are signs that the fowl adapt well in improved cages, the conditions being mimetic to those from the deep litter system [3]. Other findings revealed that, in theory, the usage of alternative rearing systems have the potential to provide satisfactory welfare conditions to laying hens, while in practice, this could not be achieved always, the main interfering factors being represented by different management, climate, design, different responses by different genotypes and interacting effects. For example there was different use of nestboxes in furnished cages by different genotypes. The design of small furnished cages also had a significant impact on dustbath use. All cage systems tend to provide a more hygienic environment with low risk of parasitic and bacterial disease and, consequently, lower probability to contaminate their edible products, including eggs [4]. When seeking a little bit more on eggs safety, as related to the conversion of production systems toward those providing better welfare conditions to hens, it could be found scientists which suggest that safety could be altered either microbiologically through contamination of internal contents with *Salmonella enterica* serovar Enteritidis (*Salmonella enteritidis*) or other pathogens, or both, or chemically due to contamination of internal contents with dioxins, pesticides, or heavy metals. Season, hen breed, flock age, and flock disease-vaccination status also interact to affect egg safety and quality and must be taken into account [5]. Therefore, it must reason clearly when choosing the husbandry system of laying hens, in order to provide a safe, but economically reliable product on the market.

Speaking of poultry products nutritional quality, for instant chicken meat, certain investigations [6] revealed higher lipid content and lower proportion of PUFA and omega-3 fatty acids in conventional produced broilers, when compared to broilers issued from other husbandry system, such as free range or alternative farming. Moreover, the alternative systems provided meat with lower cholesterol content. How about eggs quality in alternative production systems? Some researchers [7] focused on the proximate composition and nutrients of the eggs issued from different husbandry systems applied in laying hens farming but mainly influenced by feed quality. Thus, in free range or cage-free systems, proportion of the yolk was lower than in other systems, which differed mainly through the used diet (vegetarian diet or animal fat included or unmedicated diet). The ratio between certain fatty acids groups, such as n-6:n-3 polyunsaturated varied from 39.2 in eggs issued from naturally nested laying to 11.5 in the eggs laid by the hens fed with complete vegetarian diet ($P<0.05$). However, no difference was reported on the total PUFA content of eggs ($P > 0.05$). Another study run on commercial eggs [8] showed that, from nutritional point of view there were found slight significant statistic differences for proteins and saturated fatty acids, but the real variations were minimal, when eggs from conventional cage and alternative productions systems were compared. No significant differences were found in the unsaturated fatty acid groups, despite the fact that eggs used in the study were bought from market, therefore probably the hens were fed with mixed feed of different quality and compositions. Other authors [9] stated that through eggs composition elasticity due to hen diet compounds, these products have immense potential to provide consumers nutritional and functional benefits, to maximize the beneficial and preventive potential. Finally a question arises: in order to provide well balanced eggs for consumer needs, therefore so-called functional or designer eggs, what eggs feeding and rearing systems should be used, to better manage all involved influential factors?

The present paper aims to briefly present the findings on the nutritional and dietetic quality of the eggs produced in two EU approved alternative housing systems, during the peak production of laying hens, as part of a greater project that aim to assess the influence of fowl welfare friendly husbandry systems on the quality of poultry meat and table eggs in Romania.

2. Materials and methods

The biological material was represented by the eggs produced by 700 ISA Brown laying hens aged 26 weeks, randomly distributed in two groups: EC group-350 hens accommodated in furnished cages (800 cm^2/hen, perches and nests inside the cage) and FR group-350 hens, reared on deep litter, with access to paddock (9 hens/m^2), in order to comply the welfare requirements stipulated in Council dir. 74/1999/EEC [10].

Hens were fed an adult layer mixed feed diet, based on corn-wheat and soybean meal. Both groups were fed the same diet, in order to avoid any influence of certain different feed nutrients on the ultimate nutritional value of the eggs, knowing that especially quality of lipids in animal products varies in relation to the feed composition [11].

At the end of 26th week of fowl life, 100 eggs were sampled from each group, in order to run chemical investigations. There have been performed analyses on all edible compounds of the eggs (yolk, albumen, whole egg-melange), in order to identify and quantify the values for the following parameters: water, dry mater, ash, proteins (total nitrogen matters), lipids, nitrogen free extract, gross energy and cholesterol. 50 eggs from each group have been broken, to separate yolk and albumen. After separation, yolks were mixed apart and albumens were mixed apart. The other 50 eggs/group were used to mix together yolk and albumen, in order to assess quality of whole fresh eggs. 20 repetitions (samples) were analyzed for each parameter, for each edible compound. The samples were well labelled, then were weighted and dehydrated at 60°C. The issued powder was used for analytical chemistry assessments, in order to evaluate eggs content in certain nutrients, accordingly to the analytical standards recognised internationally (humidity-SR ISO 1442/1997, mineral substances -SR ISO 936: 1998, total nitrogen-SR ISO 937:2007, lipids-SR ISO 1443:2008, fatty acids and cholesterol-gas chromatography). Nitrogen free extract was calculated through difference, as follows: NFE (%) = DryMatter % – Minerals % - (Total nitrogen % + Lipids %). Eggs dietetic value was evaluated, besides the cholesterol level, through their caloricity, using the theoretical relation which is based on the quantity of gross energy spread by the burning of 1 g crude protein, crude fat and nitrogen free extract into a calorimeter (GE (Kcal/100g) = 5.70 Kcal x $n_{\%}$CP + 9.50Kcal x $n_{\%}$CF + 4.2 Kcal x $n_{\%}$NFE) [12].

Most of the parameters were expressed by 100 g edible portion, while some of them, such as cholesterol and caloricity were also recalculated per one table egg (60 g), in order to better depict the nutritional involvements.

Collected data were subjected to statistical computation, using ANOVA single factor algorithm, to find out any significant differences between the studied technological systems of layer husbandry.

3. Results and discussion

The analytical findings on the 100 yolks we studied (50 from EC group an 50 from FR group) are presented in table 1. Thus, water content was higher in the eggs produced by free-range hens (+1.36%) and this difference was found as statistically significant ($p<0.05$). This aspect corresponded to a slight decrease of fat matters in the eggs produced in free range system, compared to those issued from

enriched cages (-3.59%), the differences being also found significant ($p<0.05$).
Proteins varied within 15.91±0.32% (EC eggs) – 16.08±0.03% (FR eggs), while homogeneity for this trait was good (less than 10%). Differences in lipids content led to slight different values for calоricity/100 g yolk, i.e. more (361.09±7.92 Kcal in eggs from cages) or less (353.09±7.63 Kcal in eggs from free range system) gross energy. Cholesterol was also diminished in free range eggs (1065±23.98 µg/100 g) vs. furnished cage eggs (1094±24.71 µg/100 g).

Table 1

Chemical composition and dietetic quality of the yolks from table eggs produced in improved cages or free range systems

Quality parameters of the yolk	Eggs from EC group (n=20)			Eggs from FR group (n=20)		
	Mean	Std. error.	V%	Mean	Std. error.	V%
Water (%)	52.16[a]	±1.37	11.75	52.87[b]	±1.32	11.17
Dry matter (%)	47.84	±1.26	11.75	47.13	±1.18	11.18
Ash (%)	1.72	±0.03	7.80	1.69	±0.03	7.94
Total nitrogen matters (%)	15.91	±0.32	8.99	16.08	±0.31	8.62
Lipids (%)	27.08[b]	±0.45	7.43	26.14[a]	±0.39	6.67
Nitrogen free extract (%)	3.13	±0.05	7.14	3.22	±0.04	5.56
Caloricity Gross Energy (Kcal/100g)	361.09	±7.92	9.81	353.51	±7.63	9.65
Cholesterol (µg/100 g yolk)	1094	±24.71	10.10	1065	±23.98	10.07

ANOVA: [ab]different superscripts reveal significant statistical differences ($p<0.05$) between groups

Ash content and nitrogen free extract did not vary significantly.
Extremely low caloricity was found in albumen mix, due to low lipidic content for this egg compartment (table 2).
Thus, small difference for dry matter content was detected between groups, proteins proportions of the albumens from both groups were almost similar (11.2 vs. 11.4 %), while lipids were detected at very low concentration (0.18±0.004 % in EC eggs and 0.13±0.003 % in FR eggs), hence the low energetic content (69.67-69.16 Kcal/100 g albumen). Cholesterol was not detectable, as expected. These facts reaffirm the exceptional dietetic features of egg white, which is in fact a reservoir of high quality proteins, packaged with small or absent amount of compounds that are not so friendly with consumers' health issues, such as cardiovascular diseases.

Table 2

Chemical composition and dietetic quality of the albumens from table eggs produced in improved cages or free range systems

Quality parameters of the albumen	Eggs from EC group (n=20)			Eggs from FR group (n=20)		
	Mean	Std. error.	V%	Mean	Std. error.	V%
Water (%)	86.93	±2.12	10.91	87.14	±2.24	11.50
Dry matter (%)	13.07	±0.32	10.92	12.86	±0.33	11.51
Ash (%)	0.71	±0.01	6.30	0.63	±0.01	7.10
Total nitrogen matters (%)	11.2	±0.23	9.18	11.4	±0.21	8.24
Lipids (%)	0.18	±0.004	9.94	0.13	±0.003	10.32
Nitrogen free extract (%)	0.98	±0.02	9.13	0.70	±0.02	12.78
Caloricity Gross Energy (Kcal/100g)	69.67	±1.09	7.00	69.16	±1.02	6.60
Cholesterol (µg/100 g albumen)	ND*	-	-	ND	-	-

ANOVA: [ab]different superscripts reveal significant statistical differences ($p<0.05$) between groups; *ND: not detectable

Finally, we considered interesting to quantify the chemical compounds on whole fresh eggs (mix of edible parts – yolk and albumen), knowing that human alimentation uses mostly whole eggs. The results are presented in table 3.

Yolk chemical composition influenced whole egg constituants dynamics and also differentiations between the two groups. Thus, water content varied between 74.98±1.08 % (enriched cage eggs) and 75.62±1.08% (free range eggs), significant differences occurring for this trait ($p<0.05$). Protein content was found close between groups (12.38-12.56%), while lipids were 1.06% higher in cage produced eggs, than in free range (10.45±0.17 %-EC group vs. 9.81±0.19 %-FR group). Therefore, caloricity was a little bit higher in those eggs issued from cages (174.25±3.26 Kcal/100 g or 105.00±3.26 Kcal/egg of 60 g), compared to those produced within the free-range system (174.25±3.26 Kcal/100 g or 105.00±3.26 Kcal/egg of 60 g).

Table 3

Chemical composition and dietetic quality of the whole edible table eggs produced in improved cages or free range systems

Quality parameters of the whole edible table egg	Eggs from EC group (n=20)			Eggs from FR group (n=20)		
	Mean	Std. error.	V%	Mean	Std. error.	Mean
Water (%)	74.98[a]	±1.08	6.44	75.62[b]	±1.08	6.39
Dry matter (%)	25.02	±0.36	6.43	24.38	±0.35	6.38
Ash (%)	1.14	±0.02	7.85	1.09	±0.02	8.21
Total nitrogen matters (%)	12.38	±0.21	7.59	12.56	±0.18	6.41
Lipids (%)	10.45[b]	±0.17	7.28	9.81[a]	±0.19	8.66
Nitrogen free extract (%)	1.05	±0.02	8.52	0.92	±0.02	9.72
Caloricity Gross Energy (Kcal/100g)	174.25	±3.26	8.37	168.65	±2.97	7.88
Caloricity Gross Energy (Kcal/egg of 60g)	105.00	±1.97	8.37	101.00	±1.78	7.88
Cholesterol (µg/100 g)	397	±6.83	7.69	373	±6.25	7.49
Cholesterol (µg/egg of 60g)	238.20	±4.10	7.69	223.80	±3.75	7.49

ANOVA: [ab]different superscripts reveal significant statistical differences ($p<0.05$) between groups

Cholesterol content was found at 238.2-223.8 µg/egg of 60g, thus housing environment did not affect the inner cholesterol content of the egg, results quite similar to those found by other authors [13, 14].

Overall, the variability of all analyzed traits was good, depicting homogeneity for the nutritional and dietetic parameters of table eggs. However, it would be interesting to use more eggs as biological material, in order to increase confidence degree of the statistical processing. The researches are still ongoing, in order to assess chemical composition and nutritional value of these products throughout the entire productive period of a commercial laying hen (20-72 weeks). Moreover, the researches should be completed with fatty acids spectrum studies, knowing that are opinions among the scientists that the quality of lipids in eggs and meat (ratio ω-3:ω-6 FA) varies with the husbandry system and feeding conditions, mostly when fowl have or not access to pasture and, consequently, could lead to exacerbation of pain conditions, cardiovascular disease and probably most cancers [15].

4. Conclusion

Most chemical components of the eggs produced in enriched cages and free range systems did not vary among the assessed samples, but the lipids and water value, thus the production system is relevant for these nutrients dynamics.

All analyzed edible eggs parts or even whole fresh eggs were found to have less gross energy and less cholesterol in the samples issued from free range production system. However, the differences were not statistically significant.

Deeper investigations on lipids profile of table eggs could enlighten more aspects related to nutritional quality, especially the ratio between saturated: monounsaturated: polyunsaturated fatty acids that affect indeed the health status of consumers.

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