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ORGANOLEPTIC, CHEMICAL AND MICROBIOLOGICAL QUALITY OF TABLE EGGS OBTAINED IN DIFFERENT EXPLOITATION SYSTEMS FOR LAYING HENS IN ROMANIA

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Abstract

Table eggs represent one of the most valuable sources of proteins for the human diet. Therefore, their quality is a very important aspect for food safety and for public health. During a period of 6 months, samples of table eggs were collected as it follows: 20 samples of each category of exploitation systems for laying hens (organic, free-range, aviary and cage production). Duplicates of the following examinations were performed: Roche index (10 samples/week); total content of proteins, lipids, water and ash (two samples/week); CFU/eggshell as well as presence of Salmonella in the contents using three different selective agar media (8 samples/week). From the total number of 480 samples of each category, results showed the following: for the Roche index, organic eggs were evaluated at 10-11, for free-range and aviary ones, values reached 13 and for cage production systems, 8-9. The content of proteins (%) was higher for free-range eggs (12.48). The content in lipids showed high values for cage production eggs (11 %), but with close values for the other categories, reaching the minimum to 10.7 % in aviary eggs. As for the water content, the highest value was observed for free-range eggs, and for ash the lowest value was observed for cage production eggs, while the highest for organic eggs. Microbiological quality of table eggs revealed a significant bacterial load for the eggshell, of up to 5.06 log CFU/eggshell for free-range eggs, and 5.04 log CFU/eggshell for organic ones. Industrial systems revealed a lower bacterial load, of up to 4.83 log CFU/eggshell for aviary-obtained eggs and 4.67 log CFU/eggshell for cage production eggs. The number of samples in which Salmonella presence was detected was at it follows: 33 % of the organic table eggs samples, 28 % for the free-range table eggs, 25 % for the aviary-obtained table eggs and 14 % for the cage production ones. From the consumer point of view, eggs obtained in free-range and aviary systems could be the most appreciated ones. Chemically, results are very close from a category to the other, while the microbiological quality may differ, as a wide range of factors contribute to a certain bacterial load on the eggshell as well as for the presence of Salmonella.

Key words: laying hens, eggs, quality, Salmonella, exploitation systems.

INTRODUCTION

Table eggs represent a very important source of proteins, through their structure being built to provide vital nutrients to the embryo, during its development [13][23].

In the European Union, breeding and exploitation systems designed for egg production are now designed focusing on the welfare of laying hens, without a decrease in egg production and profit as well. Their classification nowadays is resumed to “cage” or “non-cage ones” [17].

Husbandry techniques can differently influence the quality characteristics that are important when evaluating table eggs, among them: yolk color, chemical composition and microbiological quality [22][23].

In different parts of the world, yolk color is considered one of the most important factors when evaluating egg quality [3], consumers preferring coloration to be between 10 and 14 on the Roche yolk color fan scale [9].

The chemical composition of table eggs is another important quality factor, being already acknowledged that table eggs are the

richest source of proteins among all food products. Yolk represents 36 % of the whole egg weight and it consists mainly on lipoproteins [13]. The albumen contains also a high amount of proteins, small quantities of mineral elements and hydrosoluble vitamins [23].

Considering microbiological quality of table eggs available on the market, selection at the farm level already ensures that dirty of cracked eggs are discarded. Still, egg washing is banned in the E.U., but the safety is ensured by a tough and rigorous selection [6]. The eggshell may become contaminated with different aerobic bacterial species, due to direct or indirect action of different factors: age [18][4][15], air quality [12], percentage of dirty or cracked eggs [15][8].

Salmonella spp., especially serotype Enteritidis is considered a high risk foodborne pathogen. It causes human salmonellosis through ingestion of different food products, among these table eggs being considered as the most important source [7]. *S.* Enteritidis is able to contaminate table eggs through vertical as well as horizontal transmission, both ways being intensely investigated lately [11][10][16].

The present paper aims to reveal the results of a study considering table eggs quality, reflected on Roche yolk color value, chemical composition showed by the values of the main nutrient classes evaluated as well as microbiological quality, revealed through the results obtained when evaluating eggshell microbial load as well as *Salmonella* spp.'s presence in the samples.

MATERIAL AND METHOD

In order to evaluate the egg quality, during a period of 6 months, 20 samples of table eggs were collected from random stores. They were classified considering the exploitation system they would originate from, according to the package information provided to the customer: organic, free-range, aviary and cage production. Duplicates of the following examinations were performed: Roche index (10 samples/week); total content of proteins, lipids, water and ash (two samples/week); CFU/eggshell as well as presence of Salmonella in the contents using three different selective agar media (8 samples/week).

Eggs were stored at 4-6^{o}C until examination.

Roche yolk color fan was used when evaluating the yolk color and natural light instead of artificial one was used, according to the standard method [22][23].

Chemical composition was evaluated using four samples/week, each category of exploitation system being represented by a duplicate of two samples, afterwards being obtained a mean of the two results.

The total protein content (%) was obtained using Kjeldahl method, the content of total lipids (%) was obtained using Soxhlet method, the water content (%) was obtained using the drying oven method and the ash content (%) was obtained through calcination [20][21].

The total number of germs on the eggshell was obtained using decimal dilutions number and Plate Count Agar [1]. For the identification of *Salmonella* in the egg contents' samples, three different selective culture media were used, for each sample: MacConkey agar, Salmonella-Shigella (SS) agar and Xylose-Lysine-Deoxycholate (XLD) agar [1]. The sampling and examinations took place from October 2010 until March 2011.

Statistical analysis was performed using SAS 9.2 software [19].

RESULTS AND DISCUSSIONS

Roche yolk color fan values

The results obtained for this analysis are as it follows: 8 and 9 for cage originating eggs, 10 and 11 for organic eggs, 12 and 13 for both free-range as well as for aviary originating eggs (table 1). Table 2 shows the overall frequencies for each value of Roche yolk color fan examination.

Chemical composition reflected in general nutrients classes

The results for the chemical composition are included in table 3. The highest as well as the lowest values for the percentages of the different nutrient classes, by category, were included in table 4. The lowest levels

observed for each class of nutrients were as it follows proteins – 11.29 % for cage eggs, lipids – 10.02 % for aviary eggs, water – 66.06 % for organic eggs and ash – 0.761 % for aviary eggs.

Table 1 – Frequencies (number of samples) for each category of examined table eggs considering Roche yolk color fan value

Roche Value	Organic eggs frequency	Free-range eggs frequency	Aviary eggs frequency	Cage eggs frequency
8	-	-	-	53
9	-	-	-	67
10	35	-	-	-
11	85	-	-	-
12	-	75	14	-
13	-	45	106	-

Table 2. One-Way Frequencies for overall Roche yolk color fan values.

Roche Value	Frequency	Percent	Cumulative frequency	Cumulative percent
8	53	11,04	53	11,04
9	67	13,96	120	25,00
10	35	7,29	155	32,29
11	85	17,71	240	50,00
12	89	18,54	329	68,54
13	151	31,46	480	100,00

On the other side, the highest levels were 12.97 % total protein content for free-range eggs, 11.74 % total lipids content for aviary eggs, 73.38 % water content for free-range eggs and 0.994 % ash content for both organic and cage eggs.

Table 3 – Global nutrients' levels for each category of examined table eggs (on 24 values obtained using duplicate samples for each category) (means ± standard deviation) (0 = organic eggs; 1 = free-range eggs; 2 = aviary eggs and 3 = cage eggs)

Proteins content (%)[1]	Lipids content (%)	Water content (%)[2]	Ash content (%)[3]
11.64 ± 0.19	10.90 ± 0.20	68.93 ± 1.52	0.918 ± 0.042
12.47 ± 0.28	10.84 ± 0.29	71.53 ± 0.95	0.909 ± 0.040
11.96 ± 0.27	10.71 ± 0.58	69.97 ± 1.37	0.856 ± 0.057
11.84 ± 0.32	11.00 ± 0.23	68.69 ± 1.16	0.847 ± 0.055

[1] $p < 0.0001$ by category;
[3] $p < 0.0001$ by category and by month of study; $p = 0.0096$ for category x month;
[4] $p < 0.0001$ by category; $p = 0.0005$ by month of study.

The correlations between the different general classes of nutrients of table eggs were included in table 5. There has been observed a highly significant correlation between the content of proteins and the water one ($p < 0.0001$).

Table 4 – Global nutrients' minimum and maximum levels for each category of examined table eggs (on 24 values obtained using duplicate samples for each category) (0 = organic eggs; 1 = free-range eggs; 2 = aviary eggs and 3 = cage eggs)

Proteins content (%)		Lipids content (%)		Water content (%)		Ash content (%)	
Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
11.31	11.95	10.61	11.29	66.06	71.36	0.851	0.994
12.03	12.97	10.52	11.48	70.04	73.38	0.824	0.968
11.52	12.47	10.02	11.74	67.65	71.89	0.761	0.946
11.29	12.48	10.71	11.46	66.72	70.78	0.772	0.994

Table 5. Pearson correlation coefficients for the general nutrients' classes examined for each category of table eggs (N = 96; Prob > |r| under H0: Rho = 0)

	Proteins	Lipids	Water	Ash
Proteins	1.00000	-0.02066 0.8416	0.46914 < 0.0001	0.12963 0.2081
Lipids	-0.02066 0.8416	1.00000	-0.09315 0.3667	0.16673 0.1045
Water	0.46914 < 0.0001	-0.09315 0.3667	1.00000	0.17251 0.0928
Ash	0.12963 0.2081	0.16673 0.1045	0.17251 0.0928	1.00000

Microbiological evaluation of the eggshell

The values obtained for the microbiological evaluation of the eggshell are included in table 6. All results were highly significant, with the highest mean observed for organic and free-range eggs, while the lowest was allotted to cage eggs category. During 2010-2011, eggs available on the market were still obtained in systems with conventional cages, at that time, this practice was still legally applied. Concerning this category, Protais et al. [18] obtained values for log CFU/eggshell between 4.1 and 4.23, lower than those obtained in this study. However, the results obtained for cage eggs during this study are in agreement with De Reu et al. [4].

They obtained for the same category of eggs, a value of 4.8 logCFU/eggshell. In addition, Huneau-Salaün et al. [12] showed a value of 4.4 logCFU/eggshell, considering conventional cage eggs, and Cepero et al. [2] obtained a value of 4.52 logCFU/eggshell.

Aviary eggs showed a 4.82 logCFU/eggshell value. This is very high compared to the values of Vučemilo et al. [24]. They obtained values of 3.73, 3.91 and 3.98 logCFU/eggshell, when studying different ages of the egg producing-laying hens. However, the mean value is in agreement

with the one obtained by De Reu et al. [6] which is closer 4.95 logCFU/eggshell. Protais et al. [18] obtained values of 4.9, 5.22, 5.41 and 5.44 logCFU/eggshell, these being higher than the values obtained in this study.

Table 6. Microbiological evaluation of the eggshell (log CFU/eggshell)

Category	logCFU/eggshell[1]
Organic	***5.01 ± 0.03**[2]***
Min.	4.91
Max.	5.07
Free-range	***5.01 ± 0.04**[3]***
Min.	4.91
Max.	5.09
Aviary	***4.82 ± 0.08**[4]***
Min.	4.64
Max.	4.99
Cage	***4.64 ± 0.14**[5]***
Min.	4.15
Max.	4.87

* $p < 0.0001$
[1] mean ± standard deviation
Variance: [2] 0.00123; [3] 0.00166; [4] 0.00684; [5] 0.02243;

Organic eggs and free-range ones revealed the highest values concerning the microbial load of the eggshell. De Reu et al. [5] also obtained values of more than 5.00 logCFU/eggshell: 5.30 and 5.86 logCFU/eggshell. However, Huneau-Saläun et al. [12] obtained 4.79 logCFU/eggshell.

***Salmonella* spp. presence in the contents of table eggs**

From the total number of 384 samples examined for the presence of *Salmonella* spp., the results showed no samples containing this pathogen in the yolk, but 110 samples with *Salmonella* spp. present in the albumen. All positive samples of albumen were observed on the three types of selective media used in this study, with an overall percentage of 28.65 %.
For each category taken into account for the examination, the number of samples with positive results as well as the percentage allotted is included in table 7.

Table 7. Number of samples with positive and negative results for *Salmonella* spp. presence in the albumen for each category of table eggs

Category of table eggs	Number of negative samples (no.)	Percentage of negative samples (%)	Number of positive samples (no.)	Percentage of positive samples (%)
Organic	64	66.67	32	33.33
Free-range	68	70.83	28	29.17
Aviary	65	67.71	31	32.29
Cage	77	80.21	19	19.79

The highest numbers of samples with positive results as well as the highest percentage were observed for organic eggs, and with a very small difference followed by aviary eggs. On the other side, the smallest value was observed for cage eggs, only 19 samples being tested positive for the presence of *Salmonella* spp. in the albumen.
Horizontal transmission of *Salmonella* spp. is strongly influenced by the quality of the eggshell. De Reu et al. [5] investigated the ability of *S.* Enteritidis' ability to penetrate the eggshell, following the inoculation. After 3 weeks of storage, it was found that *S.* Enteritidis was recovered from the content of 32 % of the examined eggs, and the bacterial contamination of the contents was higher on the eggshell of the penetrated eggs, in comparison to non-penetrated ones. Another authors showed the same in another study, performing a comparison between different ages of the egg-producing layers. This resulted in a correlation of *S.* Enteritidis' levels in the egg contents with the hen age, being proved that as hen ages, the shell quality decreases, microorganisms of different species being able to contaminate the eggs much easier [14].

CONCLUSIONS

Free-range and aviary eggs have higher values of Roche index (12 and 13, respectively), showing that these eggs would easily be more appreciated by the consumer, on this trait's basis.
The differences considering the general nutrient classes among the different categories of table eggs were not highly significant, but the content of proteins was positively correlated with the water one ($p < 0.001$).
The eggshell contamination with different microorganisms was evaluated through the total number of germs. This analysis revealed a high contamination for organic and free-range eggs, probably due to contact with exterior environment, the soil as well as the natural factors contributing to an easier contamination of the eggshell.

The highest number of *Salmonella* spp. free-table eggs was observed for cage eggs, while the highest number of positive samples was observed for organic eggs. Aviary eggs were also very close considering this value. These two exploitation systems can enhance the chances of *Salmonella* spp. contamination of table eggs.

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