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Chemical changes in eggs in different storage conditions

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Running title: **Egg quality during storage**

Abstract
The aging of the eggs beside that it has an influence of the internal and external changes that occur in the quality characteristics of eggs for consumption, also influence on the chemical composition of the egg. This change is expressed in the absolute and relative amounts of the eggs components, yolk color, and histologic structure. In this labour are shown the results of the examination of the chemical parameters (water, proteins, fat, minerals) of the eggs from two hybrid lineskept in different storage condition, room temperature (16°C) and in the refrigerator (4°C). The results for the changes of the chemical composition of egg white and egg yolk starting from 0^{th}, 10^{th} day, 21^{th}, until 40^{th} day of eggs storage indicate that changes depends primary from the surface of egg shell, temperature and storage dept.
Gradually, as time passes by, the mean values of water content, of eggs storage from both hybrid lines decrease, which indicates increasing of the parameters of dry matter especially protein content of egg white. Higher variation during storage does not appear in the fat content of the eggs from the white egg shell and significant variation ($p < 0.01$) is found in mineral from 10^{th} dayuntil 40^{th} day of eggs storage. The variation which is approximately 1% or lesswas notice in the mineral content of the eggs during storage from the both hybrid lines.

Practical applications
Changes that occur during egg storage have an impact on their quality. It is important to note for practice and for the food industry that the eggs kept at room temperature should be consumed within two weeks or stored in a refrigerator up to 8 weeks.

Key words: eggs for consumption, hybrid lines, storage period, quality

Introduction

Eggs as a highly valued foodstuff with an affordable price are highly demanded on the market and are a significant segment of the continuous poultry production within each country. Among the foods used by man, the eggs occupy a particularly important place, obtained due to the variety and content of high-grade nutrients (Vassilev and Kitanovski 2005).

The egg is very complex in its structure and composition. The structure of the egg wholly corresponds to the fulfillment of its function, and it contains in its composition an ideal balance of proteins, fats, carbohydrates and vitamins for the development of the embryo.

The energy value of eggs is in average 147kcal/100g. The most important outer traits are: the size (mass), the shape of the eggs, the color, the firmness, purity and the structure of the shell. Consumers mostly value the eggs with the correct shape (without deformation) and the pure color of the shell. From the inner traits the most important is the freshness of the eggs.

The main parts of an egg are the albumen (egg white), the (egg) yolk, the shell and the membranes under the shell. The total weight of the egg is not always equally distributed between these, but the ratio of the individual parts of the eggs of one type of poultry is usually the same (Hunton 1993).

According to their chemical composition, eggs belong to the category of "super foods". They represent an extraordinary, inexpensive and low-calorie source of protein and a great number of nutrients (Jurić et al. 2005). The egg contains a high percentage of water – 65.6% and 34.4% of dry matter, which include proteins, fats, carbohydrates, minerals and other organic compounds (Vassilev and Kitanovski 2005).

The diet (composition of the feed mixture), the age of the bird, the age of the laying hens, the poultry breeding technology used and the breed, all have a great influence on the chemical composition of the eggs.

The quality of the eggs is related to the physical, functional, hygienic, nutritional and chemical changes, which depending on the manner and conditions of storage. The most pronounced changes in the composition and properties of the eggs depend on the conditions of storage. The rate of change depends on the temperature regime of storing the eggs, the relative humidity of the air, the place and the manner in which the eggs are stored.

Materials and Methods

Raw materials

Eggs originating from two hybrid lines (Isa Brown that hatch eggs with a colored shell) and (De Calb that carry eggs with a white shell) were used as a research material, raised in a modern private poultry farm. According to quality, they are class A "fresh eggs" intended for consumption. L category eggs, weighing 63-73g, were used for the intended research from each hybrid line, or a total of 112 eggs from the two hybrid lines.

Half of the eggs (from two hybrid lines) were stored in room temperature (13-22°C), for which a mean was calculated (16°), and half were stored in a freezer (0 - 4°C). During the time they were stored away, the temperature of the egg storage room was measured daily with a digital thermometer, while the fridge temperature was constant, at 4°C.

Determination of chemical composition

The chemical composition of the albumen and yolk (water, fats, proteins and mineral content) in both egg groups from each probe (right after laying, on the 10^{th} day, on the 21^{st} day and on the 40^{th} day) were tested in accordance with the Regulation for egg and egg products quality, Official Gazette 55/89, Article 40, 41, 42 and 43, in accordance with adequate reference methods like IDF- ISO and AOAC:

-combustion of sample material from eggs with a Digesdahl apparatus;

- determining the moisture content – ISO 712: 2009;

-gravimetric determination of total fat (Soxhlet extraction), AOAC 2003.6;

-determining the total content of nitrogen (Kjeldahl method), Spectrophotometric - HACH DR 400, Method 2140.

The testing on the chemical composition of the eggs was carried out at the Center for Public Health - Bitola.

Statistical analysis

Statistical data processing is performed on the basis of calculating the mean values and their standard deviations. The testing of statistical differences in the average values of the tested parameters between the tested groups of eggs kept at room temperature and in the refrigerator was performed using the (F test) for

($p < 0.05$) and ($p < 0.01$). The results are shown in tables and graphics using the MS Excel, 2010 program package.

Results and Discussion

Determination of chemical composition

Having in mind the manner of storing of the eggs (at room temperature and in a fridge), the chemical composition of the albumen and the yoke of eggs from both hybrid lines was analyzed. The obtained results for the changes right after laying, on the 10th day, on the 21st day and on the 40th day are shown in tables and graphically.

Changes in the chemical composition of albumen and yoke of room temperature eggs

The results for the chemical composition of the albumen and yoke are shown in (Table 1) and Fig.1, 2, 3 and 4.

From the values obtained for the chemical composition of brown and white eggs stored in room temperature, it can be stated that there are statistically significant differences ($p < 0.05$) in the water content of albumen, between the tested groups. The dry matter content in eggs is an important parameter for the quality of the eggs, especially if they are used in the food industry. As storage time passes, the water content decreases, and the dry matter content increases.

Regarding the chemical composition of yolk, there are statistically significant differences ($p < 0.05$) in the water content in white and brown eggs stored in room temperature. Such decrease is a result of the condensation of water from the albumen towards the yolk and the decrease of the partial pressure in the albumen.

There are statistically significant differences ($p < 0.05$) in the chemical composition of albumen for the protein percentage in white eggs (10.20%) in comparison with brown eggs (12.21%), stored at room temperature. Regarding the chemical composition of yolk, there are no significant differences in the protein percentage in white (15.50%) and brown (15.90 %) eggs stored at room temperature. Due to the higher percentage of simple proteins in the albumen, the differences increase the longer the eggs are stored. Regarding the content of fats in the examined groups, statistically significant differences were established ($p < 0.05$) in the fat content of the 21st day and on the 40th day (1.60% and 1.90%) in the chemical composition of albumen for white (1.20% and 1.17%) and brown eggs. If we consider the chemical composition of the yolk where the fat content is greater, the above stated can be concluded, i.e. ($p < 0.05$) for white (32.50% and 34.65%) and (32.15% and 33.86%) in brown eggs on the 21st and the 40th day, stored at room temperature. More variation in the content of minerals can be observed on the 40th day of storage (0.96%: 0.74%) in the chemical analysis of the albumen and (0.84%: 0.48%) in the chemical composition of yolk. The results of the chemical analysis are correlated with the research of Pavlovski et al. (2011a), Johansson (2010) and Rakonjac (2013).

Changes in the chemical composition of albumen and yolk for refrigerated eggs

The results of the chemical composition of albumen and yolk kept in a refrigerator are shown in (Table 2) and Fig. 5, 6, 7 and 8.

From the results shown, it can be determined that the evaporation of the water content is proportional to the chemical composition of albumen, i.e., (87.32%, 87.80%) for the white: brown eggs on the 21st day and (86.11%: 86.50%) on the 40th day of storage, with no significant discrepancies noted.

With evaporation of the water, dry matter increases, especially because of lower temperature storage, where the air is drier, and the changes are adequately expressed in these examined groups of eggs. In the chemical analysis of albumen in the hybrid lines of eggs stored in a refrigerator during the entire period of storage, significant changes were noted in the protein content ($p < 0.05$) on the 40th day of storage (11.83%: 11.21%), while in the chemical analysis of yolk statistically significant differences were found ($p < 0.05$) on the 10th day (13.68%:14.30%), the 21st day (14.26%: 15.37%), and the 40th day (15.40% : 15.90%) in white and brown eggs. Such difference is due to the evaporation of water and the increase of dry matter in the albumen and yolk. The differences recorded in the chemical composition of yolk between the hybrids lines are probably due to the complex compounds of fat proteins.

As yolk fat increases with evaporation of water, the protein content increases. Fats, especially in yolk, are an important source when it comes to human nutrition. In the chemical composition of albumen, significant differences at the level of ($p < 0.05$) were established for the entire storage period in eggs and in both hybrid lines. While in the chemical analysis

of yolk, evident differences in the content of fats were found between white and brown eggs on the 21st day (33.72%:32.15%) and the 40th day (34.60%:33.86%). Such differences are once again due to the greater weight of yolk in white eggs. The content of minerals shows notable differences ($p < 0.01$) over the whole period of storage of the refrigerated eggs and in the chemical analysis of albumen and yolk.

Conclusions

The change in water content in the chemical composition of the egg albumen and yolk in white and brown eggs (De Calb and Isa Brown), during the whole period of storage at room temperature and in the refrigerator, showed almost constant values. As the water content decreases, the parameters of the dry matter, including the proteins, are increased. The percentage is 10.20% on the 40th day of storage in those at room temperature and 11.83% among those refrigerated. The differences are statistically significant at the level of ($p < 0.01$).

Statistically significant differences were found ($p < 0.05$) in the fat content of the chemical composition of albumin on the 21st day and on the 40th day (1.60% and 1.90%) for white and (1.20% and 1.17%) brown eggs. If we consider the chemical composition of yolk where the fat content is greater, it can be stated that the above mentioned ($p < 0.05$) will be (32.50% and 34.65%) for the white and (32.15% and 33.86%) the brown eggs on the 21st and 40th day, kept at room temperature.

During the entire storage period there is also a variation in the minerals content in both groups of eggs and in both storing conditions, but it is approximately smaller than or equal to 1%. Statistical differences are in favor of the eggs kept at room temperature.

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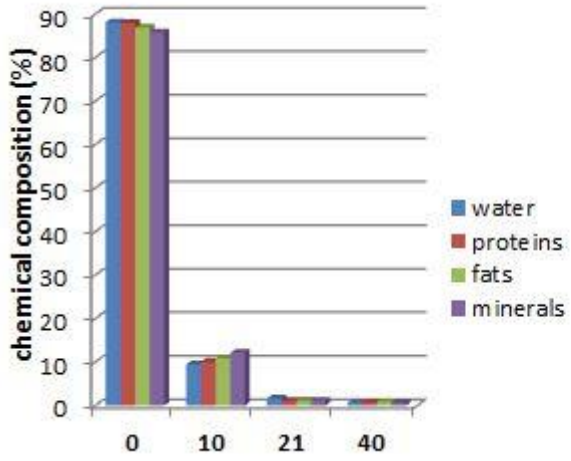
Table 1. Chemical composition of albumen and yolk of eggs stored in room temperature

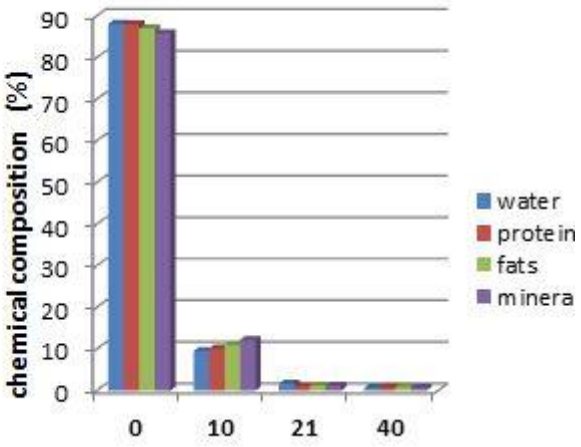
Parameters (%)					
Hybrid lines	**Day**	**Water**	**Proteins**	**Fats**	**Minerals**
White eggs Albumen	0	88.20	10.00	1.50	0.30
	10	88.13	9.87	1.90	0.10
	21	87.10	10.60	1.60	0.70
	40	86.94	10.20	1.90	0.96
White eggs Yolk	0	53.12	14.58	31.20	1.10
	10	52.24	14.94	31.90	1.00
	21	50.90	15.80	32.50	0.80
	40	49.04	15.50	34.65	0.81
Brown eggs Albumen	0	88.16	9.50	1.66	0.68
	10	87.99	10.10	1.10	0.81
	21	86.97	10.90	1.20	0.93
	40	85.88	12.21	1.17	0.74
Brown eggs Yolk	0	56.93	12.20	29.90	0.97
	10	53.13	14.30	31.80	0.77
	21	51.93	15.37	32.15	0.55
	40	49.76	15.90	33.86	0.48

Table 2. Chemical composition of albumen and yolk of the refrigerated eggs

Parameters (%)					
Hybrid lines	**Day**	**Water**	**Proteins**	**Fats**	**Minerals**
White eggs Albumen	0	88.70	9.50	1.60	0.20
	10	88.25	9.60	1.90	0.25
	21	87.32	10.60	1.83	0.25
	40	86.11	11.83	1.90	0.16
White eggs Yolk	0	54.10	14.10	30.90	0.90
	10	53.70	13.68	31.60	1.02
	21	51.28	14.26	33.72	0.74
	40	48.91	15.40	34.60	1.09
Brown eggs Albumen	0	88.70	9.30	1.90	0.10
	10	88.10	10.10	1.10	0.70
	21	87.80	10.70	1.20	0.30
	40	86.50	11.21	1.65	0.60
Brown eggs Yolk	0	54.93	13.50	30.70	0.80
	10	54.00	14.30	31.80	0.77
	21	52.80	15.37	32.15	0.55
	40	50.30	15.90	33.86	0.48

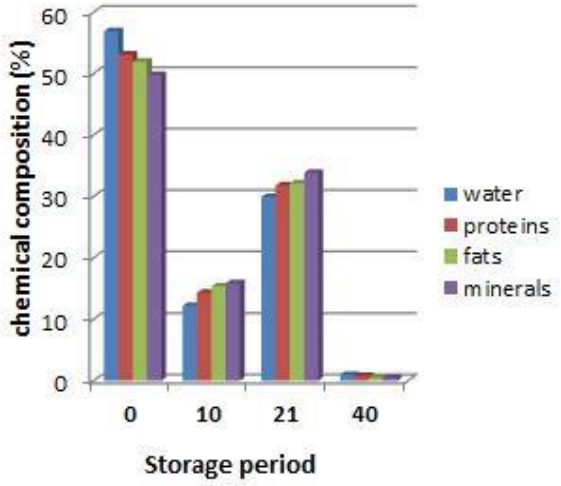


a) DeCalb (white eggs) albumen

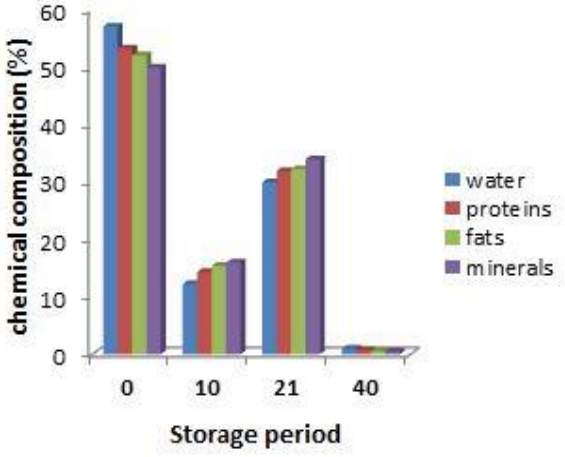


b) ISABrown (brown eggs) albumen

Figure 1. Chemical composition of albumen of eggs stored in room temperature

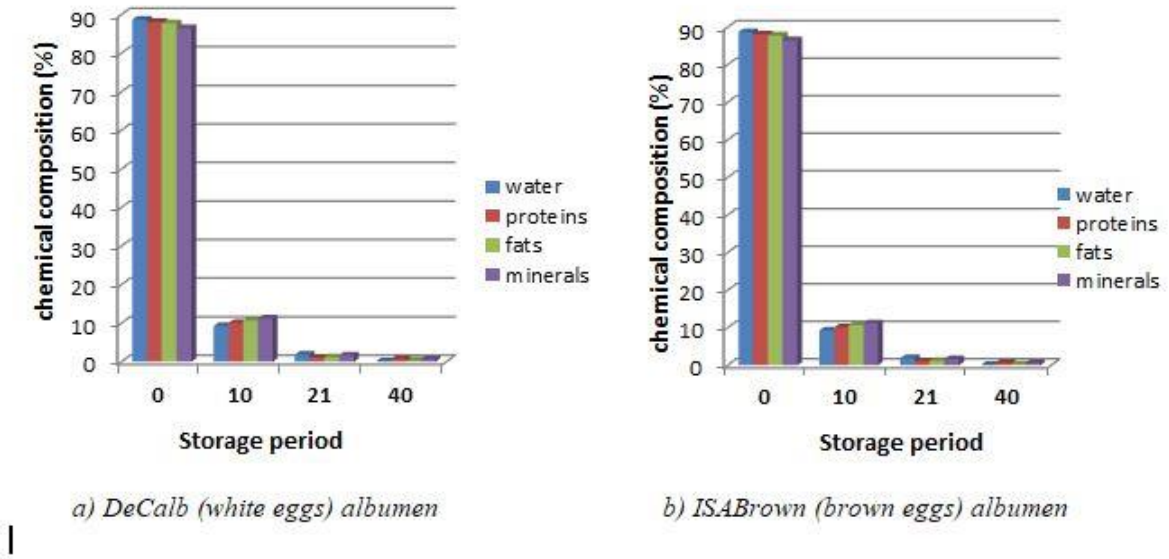


a) De Calb (white eggs) yolk



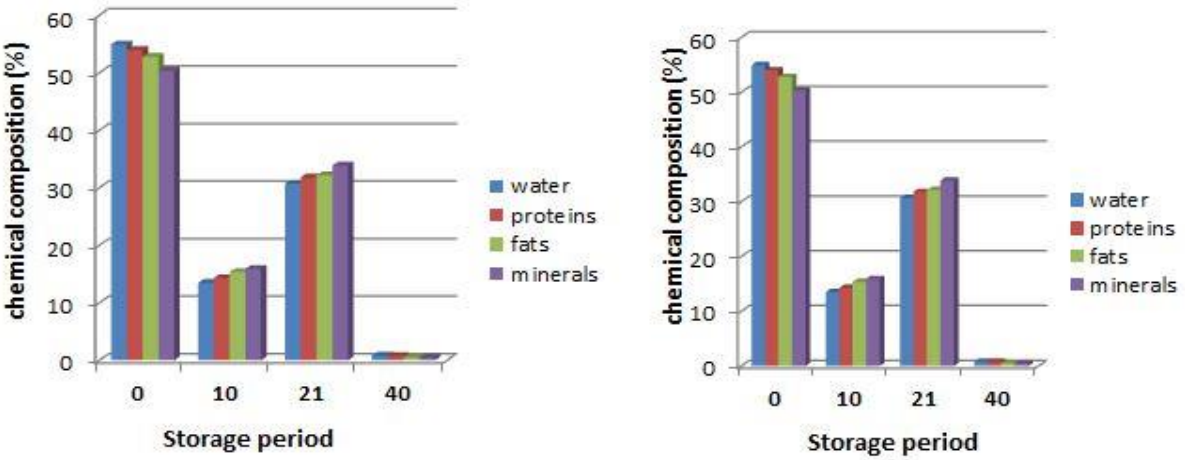
b) ISABrown (brown eggs) yolk

Figure 2. Chemical composition of yolk of eggs stored in room temperature



a) DeCalb (white eggs) albumen *b) ISABrown (brown eggs) albumen*

Figure 3. Chemical composition of albumen in refrigerated eggs



a) DeCalb (white eggs) yolk *b) ISABrown (brown eggs) yolk*

Figure 4. Chemical composition of yolk in refrigerated eggs