Bulgarian Journal of Agricultural Science, 30 (No 4) 2024, 666–670

Effect of temperature and storage period on the chemical composition of chicken and Guinea fowl's eggs

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Abstract

Nikolova, M., Penkov, D. & Ivanova, R. D. (2024). Effect of temperature and storage period on the chemical composition of chicken and Guinea fowl's eggs. *Bulg. J. Agric. Sci., 30*(4), 666–670

The aim of the study is to monitor the changes in the main indicators of the chemical composition of Guinea fowl eggs at 2 storage temperature regimes (0–4°C and 15°C) after 3 storage periods (1, 30, and 90 days), compared to chicken eggs.

In both temperature regimes, the storage period has a significant effect on the reduction of water content, both in the egg white and in the yolk. The water content decrease in chicken eggs is more significant, compared to those of Guinea fowl, especially at 90 days of storage.

Regarding the protein content in dry matter of egg white, the following changes were observed: At 0–4°C: chicken – from 89.10 (first day) to 90.65% (90 day); Guinea fowls – from 89.10 (first day) to 90.49% (90th day); temperature 15°C: chicken – from 89.10 (first day) to 90.36% (90th day); Guinea fowls – from 90.65 (first day) to 90.36% (90th day).

Regarding the content of protein in the dry matter of the yolk, the following changes were observed (1–90 days): 0–4°C: chicken – 29.11–31.11%; Guinea fowls – from 30.58–31.93%; 15°C: chicken – 29.11–31.83%; Guinea fowls – 30.58-32.15%.

Changes in the fat content in egg white dry matter (1–90 days): temperature 0–4°C: chicken – 0.89-0.81%; Guinea fowls – 0.76–0.73%; 15°C: chicken – 0.89–0.73%; Guinea fowls – 0.76–0.64%.

Fat content in the dry substance of the yolk (1–90 days): temperature 0-4°C: chicken – 68.47–61.65%; Guinea fowls – 63.35-60.83%; temperature 15°C: chicken – 68.47-60.65%; Guinea fowls – 63.35-60.55%. In both white and yolk, the reduction in Guinea fowl's eggs is significant lower.

The observed results are due to the specificity of the shell of Guinea fowl eggs.

Keywords: chemical composition; days of storage; Guinea fowl; hens; stock eggs; temperature

Introduction

Guinea fowl's eggs are dietary products that have low cholesterol and hypoallergenic properties. They have a very dense shell, they are easy to transport, and the chance of salmonella contamination is minimal. Their beneficial properties and egg freshness are preserved for up to six months at a temperature of 0–10°C. The high protein content makes them highly nutritious and they have bactericidal properties (Zabyakin et al., 2014).

The egg morphological qualities are an indicator that is important not only for hatching eggs, but also for table ones (Kaliasheva et al., 2017). Authors describe eggs as a perishable product that very easily loses weight and deteriorates in quality when improperly stored, causing large economic losses to poultry farming (Freeland-Graves & Peckman, 1987; Stadelman & Cotterill, 1995; Caner, 2005; No et al., 2005). However, according to Zabyakin et al. (2014), the freshness and beneficial properties of guinea fowl eggs are preserved for up to six months at a temperature of 0–10°C. The properties of egg products are significantly affected by their storage conditions (Hinton, 1968; Singh et al., 2014). The changes that occur in the egg during storage are many and affect the functional properties of the egg yolk and egg white. These changes include wight loss, protein reduction, increase in pH, weakening of the vitelline membrane, and increase in yolk water content (Jones & Musgrove, 2005; Karoui et al., 2006).

Gavril & Usturoi (2011) when investigating the effect of temperature and storage time on the quality of chicken eggs found that without providing optimal conditions for egg storage, could affect their quality even when stored for a very short period of time.

Lakins et al. (2009) found no differences in egg weight at 0 and 5 weeks at different storage temperatures. Peroxide values were significantly higher in eggs treated with microwaves at one day of storage and at 15 and 30 days no significant differences in peroxide values were noted.

Egg yolk contains a large amount of fat. During storage, hydrolytic changes in the lipid fraction occur in eggs, in which the content of fatty acids increases (Renzone et al., 2021). The rate of oxidation processes is linearly dependent on the ambient temperature (Domínguez et al., 2019; Xiong et al., 2020). The high content of free fatty acids in eggs stored at room temperature further initiates the course of oxidative changes.

Eggs stored for longer periods lose more of their initial weight due to evaporation of water and to a much lesser extent loss of CO_2, ammonia, nitrogen and hydrogen sulphide from the egg white (Haugh, 1937; Obanu & Mpieri, 1984; Scott & Silversides, 2000).

Kumbár et al. (2015) investigated the effect of storage time (1, 2, 3, 4, 5, 6, 7 and 8 weeks at 4°C) of Rhode Island Red eggs on egg white and yolk viscosity as well as pH values. At the same time, no significant changes were reported for yolk index, contrary to what was obtained by Samli et al. (2005). The viscosity of egg yolk decreased with storage duration, is also observed by Severa et al. (2010). Some increase in viscosity between the third and fourth week was also found in the egg white.

The aim of the research is to compare the changes in the main indicators of the chemical composition of chickens and guinea fowls eggs at different temperature regimes and after certain periods of storage.

Materials and Methods

The study was conducted with eggs from Rhode Island Red hens and Guinea fowls in their first egg-laying year. The birds were raised in furnished group cages in the poultry farm at the Agricultural University – Plovdiv, Bulgaria.

Phased feeding of control (hens) and experimental (Guinea fowl) birds with specific compound feeds was applied according to the recommendations of Marinov (2004) and Lukanov (2014) – for layers: ME – 11.7 MJ; CP – 17.5%; Lysine – 0.85%; Met+Cys – 0.6%; Ca – 3.9%; for Guinea fowls (respectively): 11.73 MJ; 16.5%; 0.8%; 0.75% and 4%.

Three periods of egg storage were tested – 1, 30 and 90 days. Two temperature regimes – 0–4°C and 15°C, within each of the specified periods.

The analysis was carried out on 30 eggs of both poultry species – for each period of storage, at the two investigated temperature regimes.

Immediately before sending the samples to the laboratory, a precise separation of the constituent edible components (egg white and yolk) was carried out.

The samples were pooled in 6 so that a minimum of 5 replicates for each ingredient were provided for chemical analysis. Chemical composition analysis was performed according to the generally accepted Weende method (AOAC, 2007) in the laboratory complex of Agricultural University – Plovdiv. Data for organic matter content have been recalculated on dry matter basis (DM – 105°C).

The statistical package of IBM® SPSS® Statistics 26.0, Copyright 1989–2019 was used for data processing.

Results and Discussion

The changes in the chemical parameters of the eggs during the different periods of storage at a temperature regime of 0–4°C are presented in Table 1.

For both hen's and Guinea fowl's eggs, increasing storage time decreases the water content of both the yolk and the white. This is more noticeable with chicken eggs. The content of dry matter in the egg white of chicken eggs increases by nearly 2% at a 90-day storage period, to a value of 13.64%, and in the yolk, respectively, from 45.34 to 47.03% for the same period. A statistically significant difference was found between fresh eggs and those stored for 30 days (11.72±0.09 vs. 12.81±0.09% for the white and 45.34±0.05 vs. 45.63±0.05% for the yolk, $p< 0.05$), between fresh and those stored for 90 days – 11.72±0.09 vs. 13.64±0.06% ($p < 0.05$) for egg white and 45.34±0.05 vs. 47.03±0.04% for the yolk, as well as between the 30th and 90th day of egg storage – 12.81±0.09 vs. 13.64±0.06% for the egg white and 45.63±0.05 vs. 47.03±0.04 for the yolk.

In guinea fowl's eggs a statistically significant difference was found in the change of the dry matter index only between fresh eggs and eggs stored until the 90^{th} day – 12.36±0.04 vs. 13.11±0.05 for the egg white and 51.03±0.05 vs. 51.99±0.02 for the yolk, as well as between 30^{th} and 90^{th} day of storage – 12.39±0.04 vs. 13.11±0.05 for the egg white and 51.06±0.05 vs. 51.99±0.02 for the yolk.

Table 1. Content and chemical composition of dry matter of eggs from hen's (chicken – Ch) and Guinea fowl's eggs (GF), stored at a temperature of 0–4°C during two storage periods*

Indexes	Ash in the egg white, %	Ash in the egg yolk, %	Crude fats in the egg white, %	Crude fats in the egg yolk, %	Crude protein in the egg white, %	Crude protein in the egg yolk, %	Dry matter in egg white, %	Dry matter in egg yolk, %
	x±SEM	x±SEM	x±SEM	x±SEM	x±SEM	x±SEM	x±SEM	x±SEM
Day 1 – Ch	5.03±0.02 b	1.10± 0.11 b	0.89±0.09 ns	68.47±0.06 ab	89.10±0.10 b	29.11±0.01 b	11.72±0.09 ab	45.34±0.05 ab
Day 1–GF	4.83±0.03 ns	2.21±0.01 b	0.76±0.04 ns	63.35±0.03 b	90.65±0.05 ab	30.58±0.01 b	12.36±0.04 b	51.03±0.05 b
Day 30 – Ch	4.97±0.03 c	1.09±0.03 c	0.86±0.08 ns	67.89±0.05 ac	89.13±0.07 c	29.13±0.07 c	12.81±0.09 ac	45.63±0.05 ac
Day 30–GF	4.85±0.04 ns	2.20±0.02 c	0.74±0.04 ns	63.34±0.02 c	90.53±0.07 a	30.60±0.07 c	12.39±0.04 c	51.06±0.06 c
Day 90 – Ch	4.69±0.05 bc	2.08±0.03 bc	0.81±0.05 ns	61.65±0.03 bc	90.34±0.04 bc	31.11±0.04 bc	13.64±0.06 bc	47.03±0.04 bc
Day 90–GF	4.80±0.02 ns	2.02±0.02 bc	0.73±0.03 ns	60.83±0.03 bc	90.49±0.04 b	31.93±0.04 bc	13.11±0.05 bc	51.99±0.02 bc

* Equal indices in the same column represent statistically significant differences ($p < 0.05$), as follows: a-a between 1 day and 30 days; b–b between 1 day and 90 days; c–c between 30 and 90 days; ns – non-significant differences ($p > 0.05$)

The content of crude protein in dry matter in both types of eggs shows a significant increase at the end of the experiment in the average values, as for the yolk the increase is from 30.58±0.01 (first day), to 31.93±0.04% in Guinea fowl's, and in hen's eggs – from 29.11± 0.01 at 31.11±0.04%.

For the protein, the changes are as follows: Guinea fowl's – from 90.65±0.05 to 90.49%±0.04 ($p \geq 0.05$); in hen's – from 89.10%±0.10 to 90.34±0.04 ($p \leq 0.05$).

The content of crude fats (CF) in the egg white did not change during storage at this temperature regime for both chicken and Guinea fowl's eggs. The values obtined in the experiment for chicken eggs were 0.89±0.09% for fresh, 0.86±0.08% for 30 days of storage and 0.81±0.05% for 90 days of storage. Average values of 0.76±0.04% (first day), 0.74±0.04% (30 days) and 0.73±0.03% (at 90 days of storage) were obtined for the samples of Guinea fowl's eggs.

In contrast to the egg white, statistically significant differences were observed in the yolk's fats. The reduction was more significant in chicken eggs – 68.47±0.06% (fresh) versus 67.89±0.05% (30 days) and 61.65±0.03% (90 days). This is twice large as that in Guinea fowl's eggs (63.35±0.03% in fresh vs. 60.83±0.03% at 90 days). In fresh and stored for 30 days eggs, no significant changes was found in the yolk's fats.

Table 2 shows the changes in the chemical composition of chicken and Guinea fowl's eggs in different periods of storage at a temperature regime of 15°C. In general, the trends in parameter changes follow the same tendency as at 0–4°C storage temperature.

As the storage time increases, the values of the dry matter indicator for both types of eggs increase, and a decrease in the water content is clearly noted at the end of the third month of storage in both temperature regime. Statistically significant changes ($p < 0.05$) in the values of chicken eggs were reported: for egg white – 11.72±0.09 (first day), 12.86±0.01 (30th day), and 14.01±0.05% (90th day); yolk: 45.34±0.05, 45.71±0.04, and 47.44±0.06%, respectively. For Guinea fowl's eggs, the values are as follows: egg white – 12.36±0.04, 12.38±0.03 and 13.20±0.04%; yolk – 51.03±0.05, 51.04±0.05 and 52.14±0.03% respectively. As well as the lower temperature, a sustainable trend is outlined here, that water loss in Guinea fowls, especially up to 30

Table 2. Content and chemical composition of dry matter of eggs from chicken (Ch) and Guinea fowl's eggs (GF), stored at a temperature of 15°C during two storage periods*

Indexes	Ash in the egg white, %	Ash in the egg yolk, %	Crude fats in the egg white, %	Crude fats in the egg yolk, %	Crude protein in the egg white, %	Crude protein in the egg yolk, %	Dry matter in egg white, %	Dry matter in egg yolk, %
	x±SEM	x±SEM	x±SEM	x±SEM	x±SEM	x±SEM	x±SEM	x±SEM
Day 1 – Ch	5.03±0.02 b	1.10±0.11 b	0.89±0.09 b	68.47±0.06 ab	89.10±0.10 ab	29.11±0.01 ab	11.72±0.09 ab	45.34±0.05 ab
Day 1–GF	4.83±0.03 b	2.21±0.01 b	0.76±0.04 b	63.35±0.03 b	90.65±0.05 ab	30.58±0.01 b	12.36±0.04 b	51.03±0.05 b
Day 30 – Ch	5.02±0.02 c	1.09±0.02 c	0.85±0.07 c	67.61±0.09 ac	89.93±0.04 ac	29.24±0.05 ac	12.86±0.01 ac	45.71±0.04 ac
Day 30– GF	4.89±0.04 c	2.21±0.01 c	0.73±0.03 c	63.35±0.02 c	90.55±0.05 ac	30.59±0.01 c	12.38±0.03 c	51.04±0.05 c
Day 90 – Ch	4.59±0.05 bc	2.09±0.01 bc	0.73±0.03 bc	60.65±0.02 bc	90.34±0.04 bc	31.83±0.04 bc	14.01±0.05 bc	47.44±0.06 bc
Day 90– GF	4.78±0.03 bc	2.01±0.01 bc	0.64±0.04 bc	60.55±0.05 bc	90.36±0.03 bc	32.15±0.03 bc	13.20±0.04 bc	52.14±0.03 bc

* Equal indices in the same column represent statistically significant differences ($p < 0.05$), as follows: a–a between 1 day and 30 days; b–b between 1 day and 90 days; c–c between 30 and 90 days; ns – insignificant differences ($p > 0.05$)

days of storage, is lower compared to chicken eggs (Table 1 and Table 2).

At the higher storage temperature (15°C), relatively lower variations of the crude protein in the egg white during the different periods were observed. For chicken eggs, the corresponding values move as follows: first day – 89.10±0.10%, 30th day – 89.93±0.04%, and 90th day – 90.34±0.04%. The percentage variation of the crude protein content in the yolk was 29.11±0.01, 29.24±0.05 and 31.83±0.04%, respectively. For Guinea fowl's eggs, the data of crude protein content were: egg white: first day – 90.65±0.05, 30th day – 90.55±0.05, and 90th day – 90.36±0.03%; egg yolk – 30.58±0.01, 30.59±0.01 and 32.15±0.03%, respectively. As with the previous lower temperature (0–4°C), a stable trend of lower variation of the presentent contents by periods is again observed in the Guinea fowl's eggs. The smaller changes in the protein fraction in the Guinea fowl's eggs are probably due to the greater stability of the egg protein, especially in the egg white.

Storage time influences significant ($p \leq 0.05$) the reduction of egg white and yolk crude fats in both types of birds, in both storage conditions. For the chicken eggs, the decrease is already visible on the 30th day of storage (0.89±0.09 vs. 0.85±0.07% crude fats for egg white and 68.47±0.06 vs. 67.61±0.09% for the yolk crude fats). On the 90th day the crude fats values in chicken eggs decrease to 0.73±0.03% and 60.65±0.05%, respectively. In guinea fowl's eggs, the changes from first day up to 30 days were minimal (egg white – 0.76±0.04 vs. 0.73±0.03%; yolk – 63.35±0.03 vs. 63.35±0.02%). Only after 90 days of storage, the crude fats values dropped significantly – egg white – 0.64±0.04% and yolk – 60.55±0.05%. During storage, hydrolytic changes in the lipid fraction occur in eggs, in which the content of fatty acids increases (Renzone et al., 2021). This explains the reduction of fat in the yolk, which is more pronounced in chicken eggs and can be explained by the lower stability of chicken egg's fat.

Although most of the authors agree that the temperature and the storage period have an effect both individually and in combination on biochemical and technological changes in the egg (Renzone et al., 2021; Kaliasheva et al., 2017; Gavril & Usturoi, 2011; Severa et al., 2010; Jones & Musgrove, 2005). Many authors are on the opinion that with proper storage, eggs can retain for a long time their main nutritional qualities in terms of energy and protein security for humans (Lakins et al., 2009; Scott & Silversides, 2000; Kumbár et al., 2015). This applies to a higher degree for guinea fowl's eggs, thanks to the specific properties of the shell (Zabyakin et al., 2014; Nikolova et al., 2021; Angelov, 2019).

Our researches confirm the latter statement for both chicken and guinea fowl's eggs.

Conclusion

At the investigated temperature regimes and storage periods, the chemical composition of the eggs shows the following variations:

In both temperature regimes, the storage period has a significant effect on the reduction of water content, both in the egg white and in the yolk. The decrease in chicken eggs is more significant, compared to those of Guinea fowl, especially at 90 days of storage.

Regarding the protein content of the dry matter of egg white, the following changes were observed:

– temperature 0–4°C: hens – from 89.10 (first day) to 90.65% (90th day); Guinea fowl – from 89.10 (first day) to 90.49% (90th day).

– temperature 15°C: hens – from 89.10 (first day) to 90.36% (90th day); Guinea fowl – from 90.65 (first day) to 90.36% (90th day).

Regarding the protein content of the dry matter of the yolk, the following changes are observed:

– temperature 0–4°C: hens – from 29.11 (first day) to 31.11% (90th day); Guinea fowl – from 89.10 (first day) to 90.49% (90th day).

– temperature 15°C: hens – from 89.10 (first day) to 90.36% (90th day); Guinea fowl – from 30.58 (first day) to 31.93% (90th day).

Regarding the fat content of the protein dry matter of egg white, the following changes are observed:

– temperature 0–4°C: hens – from 0.89 (first day) to 0.81% (90th day); Guinea fowl – from 0.76 (first day) to 0.73% (90th day).

– temperature 15°C: hens – from 0.89 (first day) to 0.73% (90th day); Guinea fowl – from 0.76 (first day) to 0.64% (90th day).

Regarding the fat content of the fats in dry matter of the yolk, the following changes are observed:

– temperature 0–4°C: hens – from 68.47 (first day) to 61.65% (90th day); Guinea fowl – from 63.35 (first day) to 60.83% (90th day).

– temperature 15°C: hens – from 68.47 (first day) to 60.65% (90th day); Guinea fowl – from 63.35 (first day) to 60.55% (90th day).

In both the egg white and the yolk, the fat reduction in Guinea fowl's eggs is substantially lower.

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Received: **February, 20, 2024**; *Approved*: **March, 30, 2024;** *Published:* **August, 2024**