POLISH JOURNAL OF NATURAL SCIENCES
Abbrev.: Pol. J. Natur. Sc., Vol 32(1): 39–47, Y. 2017

VARIATION IN EGG QUALITY TRAITS DEPENDING ON STORAGE CONDITIONS

Marek Adamski, Joanna Kuźniacka, Rafał Czarnecki, Joanna Kucharska-Gaca, Emilia Kowalska

Department of Animal Science
University of Science and Technology in Bydgoszcz

K e y w o r d s: table egg, storage time, quality yolk, albumen, shell.

A b s t r a c t

The aim of the study was determination of changes in quality traits of eggs depending on storage conditions. The study material were 360 table eggs laid by 52 weeks of age laying hens, Tetra SL, being in their peak of egg production. The eggs were stored at a temperature of 4 and 23°C. Evaluation of egg quality was carried out on the 1st, 7th, 14th, 21st, and 28th day, analyzing 40 eggs from each group. It was found that storage conditions had a significant effect on the loss of egg weight and thick albumen as well as on an increase in its pH value. Temperature of 23°C had a greater effect on the dynamics of these changes, while eggs stored at a temperature of 4°C even after 28-day storage were characterized by a good quality and freshness. Long-term storage had no significant effect on the shell weight, its thickness and elastic deformation and resistance to crushing.

ZMIENNOŚĆ CECH JAKOŚCIOWYCH JAJ W ZALEŻNOŚCI OD WARUNKÓW PRZECHOWYWANIA

Marek Adamski, Joanna Kuźniacka, Rafał Czarnecki, Joanna Kucharska-Gaca, Emilia Kowalska

Katedra Nauk o Zwierzętach
Uniwersytet Technologiczno-Przyrodniczy w Bydgoszczy

S ł o w a k l u c z o w e: jajo spożywcze, czas przechowywania, jakość żółtka, białka, skorupy.

Address: Marek Adamski, University of Science and Technology in Bydgoszcz, ul. Mazowiecka 28, 85-084 Bydgoszcz, Poland, phone: +48(52) 374 97 63, e-mail: adamski@utp.edu.pl

Abstrakt

Celem badań było określenie zmian cech jakościowych jaj w zależności od warunków przechowywania. Materiał badawczy stanowiło 360 jaj konsumpcyjnych zniesionych przez 52-tygodniowe kury nieśne Tetra SL będące w szczycie nieśności. Jaja przechowywano w temperaturze 4 i 23°C. Ocenę jakości jaj przeprowadzano w 1., 7., 14., 21., i 28. dniu, analizując po 40 jaj z każdej grupy. Stwierdzono, że warunki przechowywania miały istotny wpływ na ubytek masy jaja i białka gęstego oraz zwiększenie wartości pH. Temperatura 23°C miała większy wpływ na dynamikę tych zmian, natomiast jaja przechowywane w temperaturze 4°C nawet po 28-dniowym przechowywaniu cechowały się dobrą jakością i świeżością. Długoterminowe przechowywanie nie miało istotnego wpływu na masę skorupy, jej grubość oraz elastyczne odkształcenie i wytrzymałość na zgniecenie.

Introduction

Egg quality is conditional on many genetic and environmental factors, among other things bird's origin, its age and stage of egg production period (BASMACIOGLU and ERGUL 2005, TRAVEL et al. 2010, KRAWCZYK 2009, CALIK 2011, GUGOŁEK et. al. 2013). Moreover, formation of quality traits of egg content and shell is also affected by nutrition, housing system and environmental conditions of rearing, i.e. temperature and humidity as well as CO_2 content in buildings (DE RUE et al. 2008, BIESIADA-DRZAZGA and JANOCHA 2009).

The requirements for the commercial quality of table eggs are presented in the PN-A-86503/AZ1 standard. The most important quality trait of table eggs is their freshness condition, evaluated, among other things, based on the degree of thinning of albumen, pH value and size of the air cell (CAMPO et al. 2000, HALAJ et al. 2000, KRAWCZYK and CALIK 2006). Intensity of changes during egg storage is caused largely by mechanical damage and the effect of temperature, humidity and sunlight. Under PN-A-8650: 1998 eggs should be stored in a clean and dry warehouse at the temperature of 8 to 13°C. During storage eggs should also be protected against weather conditions. The requirements for storage of eggs presented in the standard are met most frequently in egg warehouses. However, the majority of points of sale do not meet the requirements for the correct storage of eggs. Egg storage leads to decrease in its nutritive value and culinary and processing usefulness (RIZK et al. 2001, SILVERSIDES and BUDGELL 2004).

The aim of the studies was determination of changes in quality traits of eggs depending on their storage conditions.

Methods

Research material were 360 table eggs laid by 52 weeks of age laying hens, Tetra SL, in their peak of egg production period. The hens were kept in the cage system, according to the Council Directive 99/74/WE of 19 July 1999, which established their minimum welfare. The birds were fed *ad libitum* with a standard mixture for layers according to the obliging recommendations (LEESON and SUMMERS 2005).

In order to evaluate variation in quality traits of eggs depending on storage conditions, half of the eggs were stored at a temperature of 4°C, and the second half at 23°C and relative humidity of 45–50%. The evaluation of egg quality was carried out on the 1st, 7th, 14th, 21st, and 28th day of storage, evaluating 36 eggs from each group, taking into consideration the weight of: egg [g], yolk [g] and albumen divided into a thick and thin fraction [g]. Elastic deformation of shell was tested [μm cm^{-2}] with the use of an N.V. Marius-Utrecht device, as well as its resistance to crushing [kg cm^{-2}] with the use of Egg Force Reader™ manufactured by Orka Food Technology Ltd. pH value of yolk and albumen was determined with the use of pH-meter Elmetron CP-411. With the use of QCD apparatus from TSS, height of thick albumen was measured [mm], which along with egg weight (W) allowed to calculate Haugh units [HU] according to the formula (WILLIAMS 1992): $HU = 100 \log (H + 7.57\text{-}1.7\ W^{0.37})$.

Thick albumen was isolated by removing thin albumen with a glass pipette. Inner thin albumen was removed by cutting thick albumen. The weight of thin albumen in the egg was determined by subtracting the weight of yolk, albumen and dried shell from the total weight of the egg. For this reason, the number of eggs with damaged thick albumen was not determined. The above activities were repeated on set dates of egg quality assessment. Thin albumen created as a result of hydration of thick albumen caused by storage was also removed. Eggshells were dried for three hours at a temperature of 105°C in a dryer SUP 100 M. Next, shell weight was evaluated [g] as well as its thickness [mm] at theequator of the egg with the use of an electronic micrometer screw.

Obtained results were subjected to analysis of variance, and significance of differences was determined with Duncan's test, with the use of a statistical package SAS Enterprise Guide 4.3.

Results

Table 1 presents mean egg weight depending on temperature (4 and 23°C) and on the storage time (1st, 7th, 14th, 21st, 28th day). Egg weight loss was observed on all days of evaluation, irrespective of storage conditions.

The biggest loss was observed after 28 days of storage at 23°C. However, the differences between the initial and final egg weight were not statistically significant. Percentage of weight loss in eggs during storage increased significantly ($P < 0.001$), at a temperature of 4°C by: 0.64%; 1.30%; 1.61%; 2.12%, respectively and by 2.11%; 3.58%; 5.73%; 7.97% at a temperature of 23°C.

While storing eggs at a temperature of 23°C, significant differences were indicated ($P < 0.001$) within the thick albumen weight and HU (Table 2). Irrespective of the temperature of storage it was observed that after 28 days

Table 1

Quality traits of eggs during storage depending on temperature

Temp.	The period of storage	Number of eggs [pcs]	Weight [g]					Proportion per egg [%]		
			eggs		shell	yolk	albumen	shell	yolk	albumen
			"0"	on the day of testing						
4°C	1	36	63.48	.	5.87	17.13	40.47	9.27	27.10	63.63^{a}
	7	36	62.84	62.44	5.88	17.21	39.35	9.46	27.69	62.85^{ab}
	14	36	63.57	62.76	5.85	17.17	39.74	9.36	27.53	63.11^{ab}
	21	36	63.17	62.16	5.99	17.04	39.13	9.65	27.57	62.78^{ab}
	28	36	62.99	61.66	5.92	17.37	38.37	9.64	28.22	62.14^{b}
23°C	1	36	63.48	.	5.87	17.13	40.47^{a}	9.27^{b}	27.10^{c}	63.63^{a}
	7	36	62.90	61.57	5.79	17.02	38.76^{ab}	9.46^{b}	27.69^{c}	61.53^{b}
	14	36	62.89	60.65	5.98	16.85	37.83^{ab}	9.95^{a}	27.99^{c}	59.85^{c}
	21	36	63.65	60.02	6.12	17.46	36.44^{bc}	10.23^{a}	29.29^{b}	57.02^{d}
	28	36	63.70	58.63	5.91	17.88	34.84^{c}	10.12^{a}	30.65^{a}	54.51^{e}

$^{a, b, c}$ – mean trait values in columns in particular weeks of storage denoted with different letters differ statistically significantly ($p \leq 0.05$)

Table 2

Quality traits of albumen depending on storage conditions

Temp.	Day of analysis	Number of eggs [pcs]	Thick albumen weight		Albumen height [mm]	Haugh units	pH
			[g]	[%]			
4°C	1	36	21.46^{a}	33.95^{a}	5.75	72.27	7.54^{d}
	7	36	19.92^{ab}	31.85^{b}	5.42	70.71	7.90^{c}
	14	36	18.26^{b}	29.05^{c}	5.73	72.72	8.05^{b}
	21	36	19.66^{b}	31.54^{b}	5.49	70.67	8.22^{a}
	28	36	18.55^{b}	30.07^{bc}	5.56	71.60	8.26^{a}
23°C	1	36	21.46^{a}	33.95^{a}	5.75^{a}	72.27^{a}	7.54^{c}
	7	36	19.60^{b}	31.57^{b}	4.24^{b}	59.48^{b}	8.31^{b}
	14	36	14.91^{c}	24.67^{c}	2.89^{c}	39.56^{c}	8.56^{a}
	21	36	7.85^{d}	13.19^{d}	2.57^{cd}	36.12^{c}	8.52^{a}
	28	36	5.27^{e}	9.12^{e}	2.28^{d}	32.66^{c}	8.54^{a}

$^{a, b, c}$ – mean trait values in columns in particular weeks of storage denoted with different letters differ statistically significantly ($p \leq 0.05$)

the weight of albumen decreased significantly statistically. In the group of eggs stored at 23°C, there was a decrease in the weight of albumen by 9.12% as compared to the weight in a fresh egg. In the group with eggs where the temperature was maintained at the level of 4°C, there was a 1.49% decrease in the weight of albumen.

Temperature and storage time resulted in a change in the percentage share of yolk in the egg weight. Mean percentage share of yolk per egg during storage at 23°C increased statistically significantly by 3.55%.

Time of the storing eggs had a significant ($P < 0.001$) effect on pH value of albumen.

In both groups an increase in the pH value was observed, with accelerated dynamics of changes at a temperature of 23°C. Irrespective of the temperature of the environment, the largest increase in albumen pH was observed during the first 14 days of storage.

Long-term storage of eggs at a temperature of 4 and 23°C had no visible effect on the shell weight, its thickness, elastic deformation [μm cm^{-2}] or resistance to crushing [kg cm^{-2}]. In the whole storage period, resistance to breakage under pressure of 500 g was normal and amounted to: at a temperature of 4°C (24.11; 23.78; 25.08; 23.93; 23.32 μm, respectively) and at 23°C (24.21; 23.18; 22.36; 23.10; 24.26 μm, respectively). The lowest force causing shell breakage on the 1st and 28th day of study was: 3.18 kg and 3.17 kg (at a temperature of 4°C) and 3.18 and 3.10 kg (at a temperature of 23°C), respectively.

At a higher storage temperature, significant differences were indicated in the percentage of shell per egg between 1st–7th and 14th–28th day of evaluation, which is connected with a high water loss from the egg content.

Discussion

In our own studies an intensive decrease in egg weight was observed in the group of eggs stored at a temperature of 23°C. Similar results were observed by Gavri and Usturoi in their studies (2012). They suggested that more significant variations in egg weight within the 35 days of storage occurred in the egg group stored at a temperature of 20–25°C (4.18 g) than in those stored at the temperature of 4°C (1.05 g). While analyzing the effect of storage on variation in egg weight Jin et al. (2011) found that this trait did not change significantly during the 10-day storage period at a temperature of 5 and 21°C. Significant variations started at 29°C.

According to Jin et al. (2011) the percentage of egg weight loss significantly decreased along with an increase in temperature and storage time. Increasing storage temperature up to 29°C, caused increase in the loss of egg weight by

1.74 and 3.67%, on the 5th and 10th day of storage, respectively. These results correspond to the studies of SAMLI et al. (2005), who indicated a significant ($P < 0.001$) proportional loss of egg weight of 2.08 and 3.11%, during 5 and 10 days of storage, respectively, at a temperature of 29°C. Loss in egg weight given by AKYUREK and OKUR (2009) was also similar. Loss in the egg weight is connected with the loss of water, carbon dioxide, ammonia and hydrogen sulphide, which are produced as a result of an enzymatic breakdown of proteins and fats in the egg content (ALSOBAYEL and ALBADRY 2011, JIN et al. 2011). Dynamics of these processes increases along with an increase in temperature, therefore a lower loss in the egg weight is found in case of refrigeration, and a higher one at a room temperature.

In the evaluation of the egg content freshness, the most important indicator is quality of albumen, which should contain a large proportion of thick fraction (SCOTT and SILVERSIDES 2000). Our own studies and those of other authors (HALAJ et al. 2000, PAVLOWSKI et al. 2000, NIEMIEC et al. 2001, CALIK 2013) confirm that while storing eggs at a higher temperature, albumen structure undergoes a change through its thinning and increase in pH, whereas after breaking it, it is difficult to distinguish particular fractions in its content. Thinning of the thick albumen fraction occurs as a result of alkalisation of lysozyme complex with ovomucid. It results in a decline of interactions between proteins (TRZISZKA 2000).

The weight of thick albumen and yolk also prove lower quality and thinning of albumen. It was observed in our own studies that prolongation of the period of storage was accompanied by a decrease in thick albumen weight and an increase in yolk weight (TRZISZKA 2000).The change in the proportion of particular elements of the egg content during storage suggests diffusion of water from albumen through the vitelline membrane into the yolk, which results in a decrease in albumen weight and an increase in the volume of yolk. It was also confirmed in the studies of other authors (SCOTT and SILVERSIDES 2000, CALIK 2011, JINET al. 2011). During storage of eggs (10–21 days) at different temperatures (5–21°C) there occurred an increase in the weight of yolk per egg from 0.56% to 4.12%.

A decrease in the value of the HU units in our own studies was connected with the temperature of air because a significant decrease in the value was observed only in the group of eggs stored at a temperature of 23°C. Similar relationship was observed by JIN et al. (2011) who noted that only at a temperature of 21 and 29°C the values of HU decreased, whereas no decrease was observed at a temperature of 5°C, which was in contrast with the results of JONES and MUSGROVE (2005) who at the temperature 4°C observed a decrease in the HU value from 82.59 to 67.43 in the 10th week of storage. Whereas TAYEB (2012) writes that during storage at a temperature of 20°C, the HU units

decreased from 72.68 to 52.11.These results correspond with other studies (TONA et al. 2004, KEENER et al. 2006, AKYURET and OKUR 2009, RAJI et al. 2009), which proved a negative effect of storage on the HU value.

In our own studies it was observed that, irrespective of the temperature, there was an increase in the pH value of the egg content. Our results are in accordance with the data presented by other authors (SCOTT and SILVERSIDES 2000, SAMLI et al. 2005, AKYUREL and OKUR 2009, JIN et al. 2012, CALIK 2013) who observed in their studies variations in the pH value within the range of 7.34 and 9.77. In the cited studies, the time of storage resulted in an increase in the pH value of albumen (OKUR 2009, JIN et al. 2012, CALIK 2013). According to CALIK (2013), the optimum pH of albumen ranges from 7.5 to 8.00. At higher pH values there occur series of adverse changes in the egg content: shrinkage of ovomucin and shifting of the yolk.

Lack of changes in physical characteristics and the shell weight during storage suggest that mineral compounds contained in the eggshell provide a long-term stability and mechanical resistance to deformation. This was confirmed by the obtained results which showed that a long-term storage of eggs at a temperature of 4°C and 23°C had no influence on the weight of shell, its thickness or elastic deformation [μm], as well as on resistance to crushing [kg cm^{-2}]. Similar results were obtained by JONES and MUSGROVE (2005). Both in our own and in the studies of the authors mentioned above only a percentage increase in the egg tightness was observed during storage. These results correspond with the data presented by other researchers (SCOTT and SILVERSIDES 2000, TAYEB 2012) who observed the effect of the time of storage on the percentage share of the shell in egg.

Conclusions

In conclusion, it was found that storage conditions had a significant effect on the loss in egg weight and in thick albumen as well as on an increase in pH value. All changes related to the storage of eggs contribute to a gradual loss of freshness, thus its culinary and processing usefulness. Temperature of 23°C had an unfavorable effect on the dynamics of changes occurring in the egg storage, while at a temperature of 4°C even after 28-day storage, they were characterized by a good quality and freshness.

Accepted for print 25.05.2016

References

AKYUREK H., OKUR A.A. 2009. *Effect of storage time, temperature and hen age on egg quality in free-range layer hens.* J. Anim. Vet. Adv., 8: 1953–1958.

ALSOBAYEL A.A., ALBADRY M.A. 2011. *Effect of storage period and strain of layer on internal and external quality characteristics of eggs marketed in Riyadh area.* J. Saudi. Soc. Agri. Sci., 10: 41–45.

BASMACIOGLU H., ERGUL M. 2005. *Characteristic of egg in laying hens. The effect of genotype and rearing system.* Turk. J. Vet. Anim. Sci., 29: 157–164.

BIESIADA-DRZAZGA B., JANOCHA A. 2009. *Wpływ pochodzenia i systemu utrzymania kur na jakość jaj spożywczy*ch. ŻNTJ, 3(64): 67–74.

CALIK J. 2011. *Evaluation of egg quality in six laying hen lines depending on their age.* ŻNTJ, 5(78): 85–93.

CALIK J. 2013. *Changes in quality of eggs from yellow leg partridge (Ż33) laying depending on storage conditions of egg.* ŻNTJ, 2(87): 73–79.

CAMPO J.L., GARCIA G. M., MUŃDOZ I., ALONSO M. 2000. *Effects of breed, hen age, and storage on the indirect prediction of the albumen quality.* Arch. Geflügelk, 64(3): 109–114.

GAVRIL R., USTUROI M. G. 2012. *Effects of temperature and storage time on hen eggs quality.* Lucrări Ştiinţifice Ser. Zootehnie, 56, 259–264.

GUGOŁEK A., MRÓZ E., STRYCHALSKI J., CILULKO J., STĘPIŃSKA M., KONSTANTYNOWICZ M. 2013. *A comparison of food preferences, egg quality and reproductive performance in short- and normal-beaked pigeons.* Archiv für Geflügelkunde, 77(4): 279–284.

HALAJ M., HALAJ P., GOLIAN J., VALAŚEK F, MORAVIĆIK F., MELEN M. 2000. *The influence of storage time and temperature on weight loss in eggs and yolk pigmentation*. Acta Fytotechnica et Zootechnica, 3(2): 52–54.

JIN Y.H., LEE K.T., LEE W.I., HAN Y.K. 2011. *Effects of storage temperature and time on the quality of eggs from laying hens at peak production.* Asian-Aust. J. Anim. Sci., 24(2): 279–284.

JONES D.R., MUSGROVE M.T. 2005. *Effects of extended storage on egg quality factors.* Poult. Sci., 84: 1774–1777.

KEENER K.M., MCAVOY K.C., FOEGEDING J.B., CURTIS P.A., ANDERSON K.E., OSBORNE J.A. 2006. *Effect of testing temperature on internal egg quality measurements*. Poult. Sci., 85: 550–555.

KRAWCZYK J. 2009. *Effect of layer age and egg production level on changes in quality traits of eggs from hens of conservation breeds and commercial hybrids.* Ann. Anim. Sci., 9(2): 185–193.

KRAWCZYK J., CALIK J. 2006. *Egg quality in free-range hens.* Pol. J. Nat. Sci. Supl., 3(1): 433–438.

LEESON S., SUMMERS J.D. 2005. *Commercial poultry nutrition. Guelph, Ontario, Canada, University Books,* 3nd ed., pp. 163–222.

NIEMIEC J., STĘPIŃSKA M., ŚWIERCZEWSKA E., RIEDEL J., BORUTA A. 2001. *The effect of storage on egg quality and fatty acid content in PUFA-enriched eggs.* J. Anim. Feed Sci., 10(2): 267–272.

PAVLOWSKI Z., HOPIĆ S., MAŚIĆ B., LUKIVĆ M. 2000. *Effect of oviposition time and age of hens on some characteristics of egg quality*. Biotechnology in Animal Husbandy, 16(5/6): 55–62.

RAJI A.O., ALIYU J., IGWEBUIKE J.U., CHIROMA S. 2009. *Effect of storage methods and time on egg quality traits of laying hens in a hot dry climate*. ARPN J. Agric. Biol. Sci., 4: 1–7.

RIZK R.E., MORSY S.T, ISMAIL H., EL-DEREA H. 2001. *Effect of chicken breed, housing system and egg storage conditions on quality traits, chemical composition and bacterial contamination of eggs.* Proc. XIII Intern. Symp. Young Poultry men PB WPSA Kraków, 2001, p. 523.

RUE K. DE, MESSENS W., HEYNDRICKX M., RODENBURG T.B., UYTTENDAELE M., HERMAN L. 2008. *Bacterial contamination of table eggs and the influence of housing systems.* World Poul. Sci., 64: 5–19.

SAMLI H.E., AGMA A., SENKOYLU N. 2005. *Effect of storage time and temperature on eggs quality in old laying hens.* J. Appl. Poult. Res., 14: 548–553.

SCOTT T.A., SILVERSIDES F.G. 2000. *The effect of storage and strain of hen on egg quality.* Poultry Sci., 79(12): 1725–1729.

SILVERSIDES F.G., BUDGELL K. 2004. *The relationships among measures of egg albumen height, pH and whipping volume.* Poultry Sci., 83: 1619–1623.

TAYEB I.T. 2012. *Effects of storage temperature and length on egg quality parameters of laying hen*. J. Anim. Sci., 1(2): 32–36.

TONA K., ONAGBESAN O., KETELAERE B. DE, DECUYPERE E., BRUGGEMAN V. 2004. *Effect of age of broiler breeders and egg storage on egg quality, hatchability, chick quality, chick weight and chick post-hatch growth to 42 days*. J. Appl. Poult. Res., 13: 10–18.

TRAVEL A., NYS Y., LOPES E. 2010. *Physiological and environmental factors affecting egg quality*. Inra. Prod. Anim., 23: 155–166.

TRZISZKA T. 2000. *Jajczarstwo*. Wyd. Akademii Rolniczej, Wrocław.

WILLIAMS K.C. 1992. *Some factors affecting albumen quality with particular reference to Haugh unit score.* World's Poult. Sci. J., 48: 5–16.