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Effect of Hen Age, Storage Duration and Temperature on Egg Quality in Laying Hens

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Abstract: Eggs from two age flocks (40 and 60 wk old laying hens) in a commercial layer operation were sampled immediately after lay and used them for egg quality after periods of storage of 7, 14, 21 and 28 days at room temperature or in a refrigerator. Freshly-laid eggs from two age groups did not differ in egg weight, Haugh unit, albumen pH, albumen and yolk weights and eggshell thickness. Upon incubation at different temperature and duration of storage, age of hen did not affect egg weight loss or Haugh unit, but effected on yolk and albumen weights. Increase in storage temperature accelerated egg weight loss and reduction in albumen weight, but decreased Haugh unit and the pH of albumen. As the storage duration increased, egg weight loss, albumen pH and yolk weight were increased, but Haugh unit was lowered. Interaction between temperature and storage duration was noticed in egg weight loss, Haugh unit and albumen pH. Age of hens did not interact with either temperature or storage duration in egg quality parameters measured. It is concluded that egg quality is more affected by temperature or storage duration, but not by hen age. As the age of hens is an important contributing factor to egg quality, further study is needed to clarify no clear effect of hen age on egg quality emerged from in this study.

Key words: Egg quality, storage, temperature, age, laying hens

INTRODUCTION

It has been reported that hen age affects the eggshell quality (Odabasi *et al*., 2007; Zita *et al*., 2009) including egg weight, eggshell quality (i.e., eggshell weight, eggshell breaking strength) and albumen and yolk characteristics. In addition, environment factors such as temperature and storage duration are known to affect internal quality of eggs after lay (Sekeroglu *et al*., 2008). Akyurek and Okur (2009) reported that significant interaction between hen age and either temperature or storage duration was present in the changes in egg weight loss, egg specific gravity, pH of yolk or albumen and Haugh unit. The latter observation emphasized that eggs laid from different layer age had altered egg quality during extended storage. Thus, many previous studies focused to measure to what extents temperature and storage duration could affect egg quality. It is known that the internal quality of freshly laid eggs, as judged by albumen characteristics (albumen pH, albumen weight, or Haugh unit), starts to decline. Thus, Theron *et al*. (2003) recommended to egg industry that a cold shock of 4 h and consequent storage at 25°C will extend the egg shell life with enhanced egg quality. In a study by Mowlah and Saito (1986) with Japanese quail (*Coturnix coturnix japonica*), egg contents upon storage for 14 days at room temperature were not altered, but contamination with bacteria and fungi was apparent when they were stored for 21 days or longer. They also observed that, when stored more than 21 days at room temperature, separation of the yolk from albumen was not done well, probably due to the collapse of the yolk membrane or adhesion of the yolk to shell membrane. Overall, storage temperature and duration are thus considered when it comes to optimizing egg quality from the farm to table.

It was gained our attention that most studies (Scott and Silversides, 2000; Samli *et al*., 2005) employed storage duration at a maximum of 10 days and moreover collected eggs over the laying period from single layer flock to examine the age effect on egg quality. In this study, we sampled eggs from two age flocks of laying hens which had identical layer diet (CP 17%) and subjected to equal management. This sampling was made possible that current commercial layer operations utilized multiple-age flock. In addition, freshly-laid eggs were stored to a maximum of 28 days in a refrigerator or under room temperature.

MATERIALS AND METHODS

Animals and experimental design: Eggs were obtained from Hy-Line Brown hens in a commercial layer operation, located in Chungbuk, Korea. Two flocks aged either 40 or 60 weeks were selected for egg sampling and all layers were fed a commercially

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available iso-energetic and iso-nitrogenous (CP 17%) diets throughout the entire laying period and subjected to identical environmental conditions. And, all layers were housed at environmentally controlled facility with room temperature of 22°C, exposed to 16 hours of light per day and diet and water were provided on an *ad libitum* basis. A total of 135 eggs were sampled from each age flock (n = 270) from the pre-determined cages at respective age groups.

Egg analysis: When eggs were sampled, they were weighed after collection. Initially, 15 freshly-laid eggs were analyzed for egg quality. And each of 15 eggs was stored for 7, 14, 21 and 28 days in a refrigerator or under room temperature which kept at 25°C. Egg shell thickness was evaluated by a TSS QCT shell thickness micrometer (TSS England) in equatorial region. Haugh units were calculated based on the formula using the egg weight and albumen weight. Egg yolk was weighed and albumen was used to measure pH. Eggshell was air-dried for three days, weighed and used to calculate albumin weight by subtracting yolk and shell weights from egg weight.

Statistical analysis: All data obtained in this study were evaluated by three-way ANOVA using SPSS 15.0 for Windows (SPSS Inc., Chicago, IL), with hen age, temperature and storage length as main factors. Treatment means for storage length were tested from statistically significant difference using Tukey's HSD post-hoc test in SPSS 15.0 for Windows. A value of $p<0.05$ was considered statistically significant.

RESULTS AND DISCUSSION

The average egg weight between age groups was not different, being at 64.3 and 64.0 g for 40 and 60 week-old hens (data not shown). Haugh unit, an indicator of freshness, was 86.3 and 86.9 for 40 and 60 week-old hen. The pH of albumen of fresh eggs laid from hens aged 40 or 60 weeks was 8.64 and 8.63. In addition, eggshell thickness (35.1 vs 36.2 mm/100), yolk weight (16.1 vs. 15.7 g), albumen weight (42.4 vs. 41.9 g) and eggshell weight (6.25 vs. 6.34 g) were not different between age groups (data not shown). Thus, it was seen that egg quality was not affected by hen age. Upon incubation at different temperature and duration of storage, the effect of hen age was only seen in yolk and albumen weights, being heavier in eggs of 60 vs. 40 week-old hens. Higher storage temperature led to significant increase in egg weight loss and albumen weight, but lowered Haugh unit and albumen pH. Increase in storage duration generally increased egg weight loss, albumen pH and yolk weight, but decreased Haugh unit. Interaction between temperature and storage duration was noticed in egg weight loss, Haugh unit and albumen pH. Age factor did not interact with either temperature or storage duration in any egg quality-associated parameters measured. Tentatively, it can be concluded from this study that egg quality is more affected by temperature or storage duration, but not by hen age.

Table 1: Effects of hen age, temperature and storage duration on egg weight loss, Haugh unit (HU), eggshell thickness

Age (weeks)	Temp	Duration	Weight loss, g	HU	Egg shell thickness, mm/100
40	4°C	7[d]	0.42	84.7	35.97
		14[d]	0.97	85.6	34.77
		21[d]	1.38	82.8	35.08
		28[d]	1.86	83.7	33.93
	25°C	7[d]	0.82	66.2	35.05
		14[d]	1.71	53.8	35.53
		21[d]	2.55	51.5	34.87
		28[d]	3.48	45.1	35.23
60	4°C	7[d]	0.49	84.4	34.91
		14[d]	1.07	85.1	34.06
		21[d]	1.42	81.6	34.43
		28[d]	1.93	78.2	34.54
	25°C	7[d]	0.49	70.9	35.45
		14[d]	1.07	61.7	35.50
		21[d]	1.42	52.7	34.16
		28[d]	1.93	40.5	36.20
Pooled SEM			0.114	2.319	1.021
Main factors:					
Age					
40 weeks			1.59	67.8	35.05
60 weeks			2.17	70.8	34.74
Storage temperature					
4°C			1.19[b]	83.1[a]	34.68
25°C			2.15[a]	55.4[b]	35.14
Storage duration					
7[d]			0.61[d]	76.3[a]	35.33
14[d]			1.31[c]	71.3[b]	34.91
21[d]			1.94[b]	67.1[b]	34.63
28[d]			2.50[a]	62.5[c]	34.73
p-value					
Age			NS	NS	NS
Temp			<0.001	<0.001	NS
Duration			<0.001	<0.001	NS
AgexTemp			NS	0.096	NS
AgexDuration			NS	0.074	NS
TempxDuration			<0.001	<0.001	NS
AgexTempxDuration			NS	NS	NS

[a-d]Different letters indicate significant difference among means in each column with the storage duration and temperature.
NS: Not significant.

In contrast to our study, it was reported (Silversides and Scott, 2001; Akyurek and Okur, 2009) that hen age significantly affected various egg qualities such as egg weight loss, shell weight, shell thickness, yolk weight, albumen weight, pH of yolk and albumen, or Haugh unit. Furthermore, eggs were significantly associated with temperature or storage duration in egg qualities (Silversides and Scott, 2001; Akyurek and Okur, 2009). The former studies collected eggs from a single flock at different time points while we sampled them from two different age flocks in a commercial layer operation with multi-age flocks. In this study, we did not find any difference in egg qualities of freshly laid eggs (i.e., egg weight) between age groups whereas Akyurek and Okur (2009) found heavier egg weight laid from older vs.

Table 2: Effects of hen age, temperature and storage duration on egg components and albumen pH

Age (weeks)	Temp	Duration	Yolk wt., g	Shell wt., g	Albumen wt., g	Albumen pH
40	4°C	7[d]	16.03	6.66	39.41	8.65
		14[d]	15.86	6.31	38.70	8.67
		21[d]	15.93	6.32	36.09	8.73
		28[d]	15.86	6.26	36.48	8.79
	25°C	7[d]	15.62	6.30	38.90	8.98
		14[d]	16.11	6.46	34.20	9.07
		21[d]	15.99	6.45	33.97	9.07
		28[d]	17.06	6.21	35.12	9.06
60	4°C	7[d]	15.65	6.17	39.77	8.65
		14[d]	16.81	6.23	37.46	8.69
		21[d]	16.58	6.27	37.42	8.78
		28[d]	17.05	6.27	38.36	8.74
	25°C	7[d]	15.82	6.06	38.86	8.99
		14[d]	16.77	6.58	36.59	8.99
		21[d]	16.54	6.09	36.71	9.04
		28[d]	17.44	6.53	38.50	9.06
Pooled SEM			0.387	0.153	1.146	0.014
Main factors:						
Age						
40 weeks			16.07[b]	6.37	36.44[b]	8.91
60 weeks			16.59[a]	6.26	37.93[a]	8.86
Storage temperature						
4°C			16.28	6.30	37.92[a]	8.72[b]
25°C			16.40	6.33	36.50[b]	9.03[a]
Storage duration						
7[d]			15.77[b]	6.29	39.23[a]	8.84[b]
14[d]			16.41[ab]	6.38	36.64[b]	8.85[b]
21[d]			16.28[ab]	6.29	36.05[b]	8.92[a]
28[d]			16.85[a]	6.31	37.18[ab]	8.91[a]
p-value						
Age			0.011	NS	0.035	NS
Temp			NS	NS	0.034	<0.001
Duration			0.004	NS	0.004	<0.001
AgexTemp			NS	NS	NS	0.082
AgexDuration			NS	0.098	NS	NS
TempxDuration			NS	NS	NS	0.042
AgexTempxDuration			NS	NS	NS	0.002

[a-b]Different letters indicate significant difference among means in each column with the age of hen, storage duration and temperature.
NS: Not significant.

young hens. Thus, different observation between our study and previous studies would be raised in part by the experimental design employed. It may well be likely that initial egg weight would determine the post-storage egg quality as the eggs laid from different hen age had identical egg quality. Further study is needed to clarify this assumption.

As expected, increasing temperature or storage duration negatively affected egg quality. It is well reported that longer storage duration or higher temperature increased egg weight loss, albumen pH and decreased Haugh unit (Scott and Silversides, 2000; Samli *et al*., 2005; Jin *et al*., 2011). Especially, the latter two observations are considered the reflection of the decrease in albumen quality. And, as Khan *et al.* (2013) stated, those deterioration in albumen quality is the consequence of the evaporation of moisture and carbon dioxide, thus led to pH increase and concomitant structural change in albumen protein.

It was found that yolk weight increased with concomitant increase in storage duration. This is in agreement with studies by Silversides and Scott (2001), Jin *et al*. (2011) and Khan *et al*. (2013), but in contrast to those by Akyurek and Okur (2009) and Samli *et al.* (2005). Especially, Khan *et al*. (2013) postulated the movement of water from albumen to the yolk as the possible explanation of the increased yolk weight with storage duration.

In this study, storage temperature and duration, but not the age of hen, were found to be the major contributing factors in post-lay changes of egg quality. Our observation on no clear effect of age on egg quality upon storage is in sharp contrast to the previous reports that the age of hens is an important contributing factor to egg quality. Thus, further study is needed to clarify no clear effect of age on egg quality upon storage. This can be addressed if the weight-matched eggs sampled from different age flocks are compared.

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