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Egg Quality Assessment within Day 0 to 10 as Affected by Storage Temperature

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Authors' contributions

This work was carried out in collaboration among all authors. Authors NMS, DOO and PEE designed the study. Authors JJM, ACN, HH, SBP and ORA performed the analysis and authors DOO and ACN wrote the first draft of the manuscript. Authors NMS, DOO and PEE supervised the study and analysed the data. All the authors managed the literature search writing of the final manuscript. All authors read and approved the final manuscript.

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ABSTRACT

This experiment was conducted in the Animal Products and Processing laboratory, Department of Animal Production, University of Jos, Jos-North Local Government Area (LGA) of Plateau State. A total of 300 eggs from a battery cage and deep litter housing system were collected from the Poultry Division of National Veterinary Research Institute, Plateau State (NVRI) at once for this study. Eggs were obtained from Lohmann brown hens, at 44 weeks of age to evaluate egg quality characteristics. Out of the 300 eggs, (150 eggs from each housing system), 30 were picked at random after the following storage days (0, 5 and 10 days respectively) for determination of egg quality characteristics in a 2 x 2 Factorial arrangement in a Completely Randomized Design. The storage methods were room temperature (ambient) range from 26.6 - 29.4^{0}C and refrigeration at 5°C. External and internal quality characteristics of eggs were taken, which include egg length, egg width and weight. Data were analyzed using ANOVA at $\alpha_{0.05.}$ Result showed that egg weight loss, yolk weight, diameter, ratio, yolk:albumen index, colour and albumen length were significantly higher

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at day 10 of storage with least values obtained at day 0. As the storage days increased, Yolk height, Index, pH, Albumen weight, Height, Ratio, Index and Haugh Units decreased with highest values obtained at day 0. There were no significant differences in the interaction effect of storage time and temperature on egg external quality obtained from battery cage and deep litter systems. Yolk height was greatly affected by storage days and temperature. As the storage days increased, there was a decrease in yolk height and index while an increase was obtained in yolk diameter. Refrigerator temperature had high impact on yolk height, index and diameter from egg in deep litter system while lower values were obtained in yolk height, index and diameter from egg in battery cage system. Albumen height, length, pH, index and Haugh unit was greatly affected by storage days and temperature. As the storage days increased, there was decrease in albumen height, pH, index and Haugh unit while an increase was obtained in albumen length. Refrigerator temperature had high impact on all the albumen quality parameters measured in this study. The results obtained in this study reveals that both the storage days and temperature had great influence on the egg quality. Eggs can be kept up to day 10 in both room and refrigerator temperature without any adverse effect on the egg quality.

Keywords: Egg quality; storage time; storage temperature; housing system; Haugh unit.

1. INTRODUCTION

One of the most important consumer criteria of eggs quality is their freshness [1], which can be characterized by numerous traits related to shell or content parameters. However, characteristics of egg content can be modified by many factors. As time of storage increases, the overall egg quality as measured by conventional grading standards declines. The longer the storage time, worse will be the egg internal quality because carbon dioxide transfer through egg shell is favoured by temperature and humidity [2]. Cold storage preserves eggs for 6 to 9 months, with a particularly increased shelf life with subcooled storage at −1.5°C [3]. Packing eggs under modified atmosphere increase their internal quality up to 28 days [4].

Egg production and eggshell quality traits are affected by modified and conventional cages and deep litter systems [5,6,7]. Albumen quality is a standard measure of egg quality that is most often measured from height of the inner thick albumen or a function of this, such as the Haugh unit. Albumen quality can also be measured by the albumen pH. A high pH value is a reflection of lower albumen quality [8,9]. The factors that will influence albumen height are strain and age of the laying hen, storage time, storage conditions, environmental temperature, feeding stuffs, egg size and water consumption [10-14]. The albumen height of all eggs is at maximum when the egg is laid and decreases with storage length [9,15]. Hence, this study seeks to evaluate the egg quality changes in storage time 0 to 10 days with different temperature.

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2. MATERIALS AND METHODS

This experiment was conducted at the Animal Products and Processing laboratory, Department of Animal Production, University of Jos, Jos-North Local Government Area (LGA) of Plateau State. It is situated at the extreme North of the State and located between latitude 9^0E55' North of the Greenwich meridian and longitude 8^0E54' East of the Equator [16].

2.1 Collection of Experimental Material

A total of 300 eggs from battery cage and deep litter housing system were collected from Poultry Division of National Veterinary Research Institute, Plateau State (NVRI) at once for this study. Eggs were obtained from Lohmann brown hen, at 44 weeks of age to evaluate egg quality characteristics. Out of the 300 eggs (150 eggs from each housing system), 30 were picked at random after the following storage time (0, 5 and 10 days respectively) for determination of egg quality characteristics. The storage methods were room temperature (ambient) range from 26.6 - 29.4^{0}C and refrigeration at 5°C.

2.2 Sampling Procedure

2.2.1 Sampling and storing of egg

Immediately after egg collection, the eggs were labelled and numbered using a non-harmful permanent marker. Eggs were weighed at day 0 using sensitive scale. To study the effect of storage days on egg quality parameters, eggs were stored in refrigerator at 5°C, ambient

(room) temperature of 26.6 - 29.4^{0}C for 0, 5 and 10 days, and humidity was 55 - 60% for all treatments. The stored eggs were identified and analyzed at each corresponding storage days and temperature.

2.2.2 Evaluation of egg quality

External quality characteristics of eggs were taken, which are the egg length and egg width (cm) measured with a digital vernier caliper, egg weight was measured by weighing egg individually using a sensitive scale, and its shell weight was taken as the weight of the oven dried egg shell. The shell thickness which is the thickness of the dried egg shell was measured with a micrometer screw gauge (mean of the three points- narrow, broad and middle). After this process, eggs were carefully cracked with a spoon in a flat plate on a table without breaking the vitelline membrane, in order to measure the internal quality characteristics. The parameters were then taken immediately. The internal parameters measured were:

Yolk Width: Measured as the widest horizontal circumference with a vernier caliper.

Yolk Height: Measured as the height of the yolk at mid-point with a tripod micrometer.

Albumen Height: Measured as the height of the thick albumen.

Albumen Width: Measured as the widest horizontal circumference and,

Albumen Weight: Calculated as the difference in weight of the egg and weight of the yolk plus shell.

Yolk Index: Calculated as the yolk height divided by the yolk width (cm).

Albumen Index: calculated as the ratio of the albumen height to egg width.

Haugh unit was determined using the formula below:

$$HU = 100\log (H + 7.5 - 1.7W \wedge 0.35)$$

Where

HU= Haugh unit
H= Height of the thick albumen (mm)
W= Egg weight (grams)

2.3 Experimental Design

A 3 x 2 Factorial arrangement in a Completely Randomized Design was used.

Factor A: storage time with level of 0, 5 and 10 days.

Factor B: temperature with level of ambient and refrigerator with 20 replications.

2.4 Statistical Analysis

Data collected were analyzed using Assistat version 7.7 where statistical variations were observed, means were separated using Tukeys.

3. RESULTS

The main effects of storage days on external and internal egg qualities are shown in Table 1. Significant differences were obtained as the storage days increased for some egg qualities while the storage days had no effect on others egg qualities. Egg weight loss, Yolk weight, Diameter, ratio, Yolk:Albumen index, Colour and Albumen length were significantly higher at day 10 of storage with least values obtained at day 0. The yolk height, index, pH, albumen weight. Height, ratio, index and haugh units were all affected by the storage days. As the storage days increased, Yolk height, Index, pH, Albumen weight, Height, Ratio, Index and Haugh Units decreased with highest values obtained at day 0. The storage time did not affect egg weight, length, width, shape index and egg surface area.

Table 2 shows the main effect of storage temperature on external egg qualities. It was observed that storage temperature had no effect on the external egg qualities.

The main effect of storage temperature on egg yolk qualities is presented on Table 3. Yolk weight was affected by housing system. The deep litter had the highest yolk weight than the battery cage while Yolk height and index were greatly affected by refrigerator temperature with higher values obtained than those that were stored at room temperature for both eggs obtained from battery cage and deep litter systems.

Table 1. Main effects of storage days on external and internal egg qualities

Parameters	DAY 0	DAY 5	DAY 10	SEM
Egg weight (g)	58.25	58.25	58.25	2.63
Weight loss (%)	0.00^{c}	0.57^{b}	2.58^{a}	0.01
Egg length (mm)	54.55	53.5	55.23	2.60
Egg width (mm)	42.95	42.9	43.33	0.88
Shape index (%)	78.77	78.39	78.52	1.54
Yolk weight (g)	13.58^{b}	13.40^{b}	14.15^{a}	0.57
Yolk height (mm)	14.45^{a}	14.28^{a}	13.53^{b}	0.56
Yolk diameter (mm)	35.75^{b}	36.25^{b}	38.55^{a}	1.14
Yolk ratio (%)	22.78^{b}	23.58^{ab}	24.35^{a}	1.26
Yolk index (%)	40.61^{a}	39.57^{a}	35.73^{b}	2.13
Yolk:Albumen ratio	0.38^{b}	0.38^{b}	0.43^{a}	0.01
Yolk colour	7.10^{ab}	6.63^{b}	7.20^{a}	0.53
Yolk pH	6.41^{a}	6.19^{b}	6.14^{b}	0.17
Albumen weight (g)	36.55^{a}	35.18^{ab}	33.48^{b}	2.25
Albumen height (mm)	8.45^{a}	6.78^{b}	5.75^{c}	0.54
Albumen length (mm)	74.85^{b}	81.23^{a}	84.65^{a}	3.82
Albumen pH	8.14	8.10	7.79	0.40
Albumen ratio	62.61^{a}	59.73^{ab}	57.69^{b}	2.89
Albumen index (%)	11.37^{a}	8.53^{b}	7.21^{c}	0.87
Haugh unit (%)	92.14^{a}	81.69^{b}	73.37^{c}	3.30
Egg surface area	466.65	472.86	466.65	21.04

$^{a, b, c, d}$ *means with different superscripts on the same column differ Significantly (P<0.05); SEM - Standard Error of Mean*

Table 2. Main effect of storage temperature on external egg qualities

Parameters	Battery cage		Deep litter		SEM
	Room Temperature	Refrigerator Temperature	Room Temperature	Refrigerator Temperature	
Egg weight (g)	58.8	56.73	58.6	59.9	3.33
Weight loss (%)	1.33	0.95	1.06	0.87	0.05
Egg length (mm)	54.63	52.77	54.8	55.5	3.3
Egg width (mm)	43.13	42.77	43.2	43.13	1.12
Shape index (%)	78.98	78.61	78.85	77.8	1.94

SEM - Standard Error of Mean

Table 3. Main effect of storage temperature on egg yolk qualities

Parameters	Battery cage		Deep litter		SEM
	Room Temperature	Refrigerator Temperature	Room Temperature	Refrigerator Temperature	
Yolk weight (g)	13.17^{b}	12.90^{b}	14.30^{a}	14.47^{a}	0.72
Yolk height (mm)	13.17^{b}	14.57^{a}	13.77^{b}	14.83^{a}	0.71
Yolk diameter (mm)	37.83^{ab}	34.37^{c}	38.73^{a}	36.47^{b}	1.45
Yolk ratio (%)	22.56^{c}	22.85^{bc}	24.50^{a}	24.26^{ab}	1.6
Yolk index (%)	35.09^{b}	42.61^{a}	36.10^{b}	40.74^{a}	2.71
Yolk:Albumen ratio	0.38^{bc}	0.37^{c}	0.41^{ab}	0.43^{a}	0.01
Yolk colour	7.17^{a}	7.46^{a}	6.37^{b}	6.90^{ab}	0.61
Yolk pH	6.21	6.27	6.27	6.11	0.21

$^{a, b, c, d}$ *means with different superscripts on the same column differ significantly (P<0.05); SEM - Standard Error of Mean*

Table 4 shows the main effect of storage temperature on egg albumen qualities. Storage temperature had no effect on albumen weight for both eggs obtained from battery cage and deep litter systems while albumen height. Index and Haugh Unit was significantly influenced by refrigerator temperature for both eggs obtained from battery cage and deep litter systems. Albumen pH and length was favoured by room temperature than refrigerator temperature for both eggs obtained from battery cage and deep litter systems.

The interaction effect of storage days and temperature on egg external quality obtained from battery cage and deep litter systems is presented on Table 5. There were no significant differences in the interaction effect of storage days and temperature on egg external quality obtained from both the battery cage and deep litter systems.

Table 4. Main effect of storage temperature on egg albumen qualities

Parameters	Battery cage		Deep litter		SEM
	Room Temperature	Refrigerator Temperature	Room Temperature	Refrigerator Temperature	
Albumen weight (g)	35.63	35.43	35.17	34.03	2.84
Albumen height (mm)	6.30^{b}	8.10a	5.97^{b}	7.60a	0.7
Albumen length (mm)	85.70^{a}	72.37^{c}	85.47^{a}	77.40^{b}	4.84
Albumen pH	8.58^{a}	7.65^{b}	8.28^{a}	7.53^{b}	0.51
Albumen ratio	60.51^{ab}	62.51^{a}	59.93^{ab}	57.10^{b}	3.67
Albumen index (%)	7.70^{c}	11.25^{a}	7.20^{c}	10.00^{b}	0.1
Haugh unit (%)	77.05^{b}	90.60^{a}	72.25^{b}	86.70^{a}	4.19
Egg surface area	471.05^{a}	454.5	463.45	479.87	26.69

$^{a, b, c, d}$ means with different superscripts on the same column differ significantly (P<0.05); SEM means: standard error of mean

Table 5. Interaction effect of storage days and temperature on egg external quality obtained from battery cage and deep litter systems

Parameter	Days	Battery cage		Deep litter		SEM
		Room Temperature	Refrigerator Temperature	Room Temperature	Refrigerator Temperature	
Egg weight (g)	0	60.20	56.70	57.20	58.90	0.84
	5	59.00	57.00	59.50	60.60	0.87
	10	57.20	56.60	59.10	60.00	0.60
	SEM	1.05	0.81	0.77	0.89	
Weight loss (%)	0	0.00	0.00	0.00	0.00	0.00
	5	0.67	0.69	0.81	0.13	0.14
	10	3.32	0.91	2.36	1.65	0.33
	SEM	0.30	0.31	0.22	0.21	
Egg length (mm)	0	54.50	54.40	54.40	54.90	0.32
	5	55.00	48.80	54.60	55.60	1.29
	10	54.46	55.10	54.40	56.00	0.32
	SEM	0.37	1.69	0.28	0.43	
Egg width (mm)	0	43.60	43.20	42.30	42.70	0.24
	5	42.00	42.40	43.30	43.10	0.22
	10	43.00	42.70	44.00	43.60	0.31
	SEM	0.26	0.29	0.22	0.15	
Shape index (%)	0	80.02	79.44	77.82	77.82	0.40
	5	77.84	78.83	79.30	77.57	0.30
	10	79.08	77.56	79.44	77.98	0.61
	SEM	0.34	0.68	0.73	0.48	

SEM - Standard Error of Mean

From Table 6, the Interaction effect of storage days and temperature on egg yolk quality obtained from battery cage and deep litter systems shows that Yolk height was greatly affected by storage days and temperature. As the storage days increased, there was decrease in yolk height and index while an increase was obtained in yolk diameter. Refrigerator temperature had high impact on yolk height, index and diameter from egg in deep litter system while lower values were obtained in yolk height, index and diameter from egg in battery cage system.

Table 7 represents an Interaction effect of storage days and temperature on egg albumen quality obtained from battery cage and deep litter systems. It shows that Albumen height, length, pH, index and haugh unit were greatly affected by storage days and temperature. As the storage days increased, there was decrease in albumen height, pH, Index and Haugh Unit while increase was obtained in albumen length. Refrigerator temperature had high impact on all the albumen qualities parameters measured in this study.

Table 6. Interaction effect of storage days and temperature on egg yolk quality obtained from battery cage and deep litter systems

Parameter	Days	Battery cage		Deep litter		SEM
		Room Temperature	Refrigerator Temperature	Room Temperature	Refrigerator Temperature	
Yolk weight (g)	0	12.80	13.10	14.10	14.30	0.20
	5	13.20	12.50	14.00	13.90	0.21
	10	13.50	13.10	14.06	15.20	0.18
	SEM	0.22	0.19	0.19	0.20	
Yolk height (mm)	0	13.70^{aj}	14.70^{aij}	14.40^{aij}	15.00^{ai}	0.16
	5	13.40^{abj}	14.00^{aij}	14.40^{aij}	14.90^{ai}	0.20
	10	12.40^{bj}	14.60^{aj}	12.30^{bj}	14.60^{aj}	0.24
	SEM	0.23	0.18	0.25	0.17	
Yolk diameter (mm)	0	35.30^{bi}	34.70^{ai}	37.00^{bi}	36.00^{ai}	0.39
	5	37.20^{bi}	34.40^{aj}	37.20^{bi}	36.20^{aij}	0.35
	10	41.00^{ai}	34.00^{ak}	42.00^{ai}	37.20^{aj}	0.60
	SEM	0.53	0.4	0.69	0.24	
Yolk ratio (%)	0	21.65	23.33	24.71	24.33	0.48
	5	22.41	21.94	23.66	23.1	0.34
	10	23.63	23.78	25.13	23.33	0.33
	SEM	0.49	0.44	0.41	0.41	
yolk index	0	38.95^{ai}	42.40^{ai}	39.37^{ai}	41.72^{ai}	0.62
	5	36.05^{aj}	41.97^{aj}	39.07^{aij}	41.17^{ai}	0.73
	10	30.27^{bj}	43.47^{ai}	29.84^{bj}	39.32^{ai}	1.12
	SEM	0.92	0.78	1.19	0.54	
Yolk**:** Albumen ratio	0	0.35	0.36	0.4	0.4	0.01
	5	0.36	0.38	0.39	0.41	0.01
	10	0.42	0.37	0.44	0.48	0.01
	SEM	0.01	0.01	0.01	0.01	
Yolk colour	0	7.40	7.90	6.40	6.20	0.19
	5	7.00	6.50	6.00	7.00	0.15
	10	7.10	8.00	6.70	7.00	0.16
	SEM	0.19	0.20	0.16	0.20	
Yolk pH	0	6.49	6.38	6.53	6.22	0.03
	5	6.06	6.13	6.15	6.04	0.05
	10	6.07	6.31	6.10	6.06	0.03
	SEM	0.05	0.08	0.06	0.03	

$^{a, b, c, d}$ means with different superscripts on the same column differ significantly (P<0.05);
$^{l, j, k, l}$ means along the same row with different superscripts differ significantly (P<0.05);
SEM - Standard Error of Mean

Table 7. Interaction effect of storage days and temperature on egg albumen quality obtained from battery cage and deep litter systems

Parameter	Days	Battery cage		Deep litter		SEM
		Room Temperature	Refrigerator Temperature	Room Temperature	Refrigerator Temperature	
Albumen weight (g)	0	37.80	37.10	35.50	35.80	0.83
	5	36.70	33.40	36.30	34.30	0.62
	10	32.40	35.80	33.70	32.00	0.53
	SEM	0.92	0.82	0.78	0.70	
Albumen height (mm)	0	8.40^{ai}	8.90^{ai}	8.00^{ai}	8.50^{ai}	0.17
	5	6.50^{bj}	8.10^{abi}	5.70^{bj}	6.80^{bj}	0.21
	10	4.00^{cj}	7.30^{bi}	4.20^{cj}	7.50^{abi}	0.30
		0.39	0.21	0.33	0.23	
Albumen length (mm)	0	76.50^{ci}	71.00^{ai}	77.50^{bi}	74.20^{ai}	0.84
	5	85.40^{bi}	73.50^{aj}	85.70^{ai}	80.30^{aij}	1.37
	10	95.20^{ai}	72.50^{aj}	93.20^{ai}	77.00^{aj}	2.05
	SEM	1.97	0.99	1.81	1.40	
Albumen pH	0	8.40^{ai}	7.95^{ai}	8.80^{ai}	8.40^{ai}	0.05
	5	8.52^{ai}	7.65^{ai}	8.47^{ai}	7.77^{ai}	0.07
	10	8.83^{ai}	7.35^{ajk}	8.20^{aij}	7.55^{bk}	0.23
		0.05	0.07	0.06	0.27	
Albumen ratio	0	62.62	65.12	61.92	60.70	0.89
	5	62.17	58.68	60.9	57.17	0.80
	10	56.73	36.72	56.96	53.36	1.08
	SEM	0.88	1.19	0.88	1.29	
Albumen index (%)	0	11.11^{aij}	12.56^{ai}	10.34^{aj}	11.48^{aij}	0.29
	5	7.77^{bj}	11.13^{abi}	6.67^{bj}	8.53^{bj}	0.36
	10	4.22^{cj}	10.05^{bi}	4.59^{cj}	9.99^{abi}	0.51
	SEM	0.62	0.31	0.49	0.4	
Haugh unit (%)	0	91.24^{ai}	94.91^{ai}	90.07^{ai}	92.33^{ai}	0.87
	5	79.67^{bjk}	90.55^{abi}	74.43^{bk}	82.09^{bj}	1.42
	10	60.23^{cj}	86.34^{bi}	61.24^{cj}	85.68^{bi}	2.23
	SEM	2.7	1.11	2.36	1.47	
Egg surface area	0	482.27	454.23	458.24	471.85	6.76
	5	472.66	456.63	476.66	485.47	7.00
	10	452.24	452.63	473.46	482.27	4.80
	SEM	8.38	6.53	6.14	7.11	

$^{a, b, c, d}$ means with different superscripts on the same column differ significantly (P<0.05);
$^{I, j, k, l}$ means along the same row with different superscripts differ significantly (P<0.05);
SEM - Standard Error of Mean

4. DISCUSSION

Egg weight is primarily affected by layer genotype [17]. Moreover, laying performance is an important factor contributing to egg weight. Egg weight is one of the basic indicators of egg quality [18]. Although, there were no significant differences in the main and interaction effect in egg weight between housing system, storage days and temperature in the present study but as the storage days increased the egg weight decreased which corresponds with the findings of Vlcková et al. [18], Dikmen et al. [19].

The rate of egg weight loss best describes the ability of the egg to maintain its freshness for as long as possible during storage. Faster internal quality changes, i.e., quality of albumen and yolk, occur with higher egg weight loss [20]. The moment an egg is laid, Physico-chemical

changes known as egg ageing occur. After laying, water and gases begin to move both within the egg and between the internal and external environments of the egg [21]. Water loss is more rapid in small eggs that have more surface area in relation to volume, which corresponds with higher egg weight loss and lighter eggs in free-range hens and younger hens in the study of [21]. The loss of water from the egg will start a series of changes in its quality. These changes primarily include albumen thinning, increased pH, weakening and stretching of the vitelline membrane, increased water content of the yolk, and increased dry matter content in albumen [22]. In this study, it was observed that the egg weight losses increased as the storage day increased in the eggs stored at room temperatures. This was in agreement with the study of Vlcková et al. [18] who reported that egg weight was not significantly decreased by storage for 0 to 10 days at 5^0C. However, during storage at 21^0C, egg weight loss significantly increased to 0.65 and 1.03 g at 5 and 10 days of storage time, respectively. When storage temperature was increased to 29^0C, loss of egg weight dramatically increased to 1.30 and 1.94 g at 5 and 10 days of storage time, respectively. Also the result obtained in this study was similar to the findings of Walsh et al. [23] who reported significant (P <0.001) egg weight decrease of 0.36 and 0.57 g, respectively, within 7 and 14 days of storage. Similar weight losses have also been reported by Silversides and Villeneuve [8]. In contrast, Scott and Silversides [12] reported that for an unknown reason egg weight did not differ within 10 days storage. The results obtained could be due to the temperature, airflow and relative humidity (RH) during storage. The longer the storage period, the more critical these factors become, especially under room temperature.

Yolk weight, diameter, ratio, yolk:albumen index and colour were significantly higher at day 10 of storage with least values obtained at day 0. The yolk height, index and pH, were all affected by the storage days. As the storage days increased, yolk height, index and pH decreased with highest values obtained at day 0. Most of the yolk quality indices are greatly affected by storage temperature. The refrigerator temperature favoured the yolk weight, height, diameter, index and colour. This result obtained is in line with the report of Feddern et al. [24]. But eggs stored at room temperature did not meet 0.45 as standard reference [25] of a good yolk index. Also, according to de Oliveira and Oliveira [2], Yolk index must be 0.39 - 0.45. Once yolk index is related to height and diameter, as egg gets older, these characteristics are affected, demonstrating quality loss. Giampietro-Ganeco et al. [4] observed that yolk index decreased with increasing storage time. These authors found that control eggs presented yolk index =0.44 and along 7, 14, 21 and 28 days of storage, the values decreased to 0.38, 0.36, 0.32 and 0.32, respectively.

The influence of pH on egg quality is closely related to its freshness. It has been confirmed [26] that albumen and yolk pH increased as a function of storage time and storage temperature but this statement was in contrast to the results obtained in this study. The authors argued that alkaline pH negatively influences the vitelline membrane. Also, albumen alkaline ions can be exchanged with yolk H+ ions, leading to protein denaturation, increasing yolk viscosity. The report of Samli et al. [27] was in agreement with the result of this study, who obtained a rapid alkalinity increase in albumen, even after 2 days of storage time was observed, regardless of temperature differences and extended from 7.47 - 9.2 at 29°C during 5 days of storage. These findings are in agreement with the results reported by other researchers such as Silversides and Villeneuve [8], Scott and Silversides [12], Lapa˜o et al. [28]. In contrast, Walsh et al. [23] reported that neither temperature nor storage time influenced albumen pH. The increase in pH observed in yolk was not as large as in albumen, and it differed from 5.75 - 6.08 during 10 days of storage at 29°C.

As for the yolk colour, the storage days and temperature with both housing systems did not have any effect. This results is in line with the report of Ferrante et al. [29], Dukić-Stojčić et al. [30], Krawczyk [31].

The albumen quality indices were greatly affected by storage days, temperature and housing systems. In this study, as the storage days increased, the albumen weight, height, ratio, index and haugh unit decreased. Refrigerator temperature favoured the albumen height, index and the Haugh Unit more than room temperature. Extending storage length decreased Haugh unit index as reported by many researchers; [8,32-34]. On the other hand, Sauveur [35] had stated that Haugh unit was not affected by housing systems as observed in our study, whereas, Pavlovski et al. [36], Suto et al.

[37], Sekeroglu [38] reported that housing system had a significant effect on Haugh unit.

Although albumen length and width showed an increase with storage time, increasing storage time caused a decrease in albumen height and albumen index. During storage time height of egg albumen showed a decreasing trend [12,14].

The Quality Control Program of the United States Department of Agriculture (USDA) determines quality conditions of eggs that will be consumed. According to this classification, eggs may be classified as follows: Eggs of excellent quality (AA) are those that exhibit HU values of 72 or higher; eggs of high quality (A) are those with HU values between 60 and 72; and eggs of low quality (B) are those with HU values lower than 60 [39]. In this study, the HU ranged from 60.23% on day 10 at room temperature to 94.91% on day 0 at refrigerator temperature. In Vivian Feddern et al*.,* (2017) work, eggs of HU range (83 to 94) values which was classified as AA grade up to 9 weeks at refrigerated temperatures. On the contrary, eggs stored at room temperature showed fast decline up to 4th week (HU = 41), which would classify these eggs as B quality by USDA. It was recently reported that at room temperature (28°C), HU differed significantly comparing storage at day 0 (HU=66) and day 21 (HU=47). However, at refrigerated temperature (5°C) none of the studied days differed (0, 7, 14 and 21) for this parameter. According to Giampietro-Ganeco et al. [40], eggs stored at refrigerated temperatures had best quality up to 28 days of storage with HU values within the established standard. In this study, eggs can be graded into AA, A and B according to the USDA grading system. Both storage day and temperature affected the HU value obtained.

5. CONCLUSION

The results obtained in this study reveals that both the storage days and temperature had great influence on the egg quality. Eggs can be kept up to 10 days in both room and refrigerator temperature without any adverse effect on the egg quality.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Karoui R, Kemps B, Bamelis F, de Ketelaere B, Decuypere E, De Baerdemaeker J. Methods to evaluate egg freshness in research and industry: A review. Eur. Food Res. Technol. 2006;222: 727-732.
2. de Oliveira BL, Oliveira D. Qualidade e Tecnologia de Ovos. 1. ed. Lavras, MG: UFLA. 2013;223. [Links]
3. Belitz HD, Grosch W, Schieberle P. Food Chemistry. 4. ed. Berlin, Heidelberg: Springer Berlin Heidelberg. 2009;1070. [Links]
4. Giampietro-Ganeco A, et al. Quality assessment of eggs packed under modified atmosphere. Ciência e Agrotecnologia. 2015;39(1):82-88. [Links]
5. Abrahamsson P, Tauson R. Aviary systems and conventional cages for laying hens effects on production, egg quality, health and bird location in 3 hybri. Acta Agriculture Scandinavica Section A-Animal Science. 1995;45:191-203.
6. Abrahamsson P, Tauson R, Appleby MC. Performance of 4 hybrids of laying hens modified and conventional cages. Acta Agriculture Scandınavıca Section A-Animal Science. 1995;45:286-296.
7. Abrahamsson P, Tauson R. Performance of egg quality of laying hens in aviary system. J. Applied Poultry Res. 1998;7: 225-232.
8. Silversides FG, Villeneuve P. Is the Haugh unit correction for egg weight valid for eggs stored at room temperature? Poult. Sci. 1994;73:50–55.
9. Silversides FG, Scott TA. Effect of storage and layer age on quality of eggs from two lines of hens. Poultry Sci. 2001;80:1240-1245.
10. Williams KC. Some factors affecting albumen quality with particular reference to Haugh Unit score. World's Poultry Sci. J. 1992;48:5-16.
11. Jacob JP, Milles RD, Mather FB. Egg quality. University of Florida extension,

Institute of food and agricultural science. 2000;11.
12. Scott TA, Silversides FG. The effect of storage and strain of hen on egg quality. Poultry Sci. 2000;79:1725-1729.
13. Farooq M, Mian MA, Ali M, Durrani FR, Asquar A, Muqarrab AK. Egg traits of Fayomi bird under subtropical conditions. Sarad J. Agri. 2001;17:141-145.
14. Tilki M, Saatci M. Effects of storage time on external and internal characteristics in partridge *(Alectoris graeca*) eggs. Revue Med. Vet. 2004;155:561-564.
15. Tilki M, Inal S. Quality traits of goose eggs. 2. Effects of goose origin and storage time of eggs. Arch. Geflügelk. 2004;68: 230-234.
16. Haruna U, Daneji MI, Idi S. Comparative economic analysis of adopters and non-adopters in Bauchi LGA, Bauchi State. Proceedings of the 8th Annual Conference Nigerian Society for Animal Production, AESON. 2007;55-62.
17. Holt PS, Davies RH, Dewulf J, Gast RK, Huwe JK, Jones DR, Waltman D, Willian KR. The impact of different housing systems on egg safety and quality. Poult. Sci. 2011;90:251-262.
18. Vlcková J, Tumová E, Míková K, Englmaierová M, Okrouhlá M, Chodova D. Changes in the quality of eggs during storage depending on the housing system and the age of hens. Poultry Science. 2019;98:6187–6193.
Available:http://dx.doi.org/10.3382/ps/pez401
19. Dikmen YB, Ipek A, Sahan Ü, Sözcü A, Baycan SC. Impact of different housing systems and age of layers on egg quality characteristics. Turk. J. Vet. Anim. Sci. 2017;41:77–84.
20. Grashorn M. Effects of storage conditions on egg quality. Lohmann Information. 2016;50:22–27.
21. Lewko LK, Gornowicz E. Effect of housing system on egg quality in laying hens. Ann. Anim. Sci. 2011;11:607-616.
22. Caner C, Yüceer M. Efficacy of various protein-based coating on enhancing the shelf life of fresh eggs during storage. Poult. Sci. 2015;94:1665–1677.
23. Walsh TJ, Rizk RE, Brake J. Effects of temperature and carbon dioxide on albumen characteristics, weight loss, and early embryonic mortality of long stored hatching eggs. Poult. Sci. 1995;74:1403–1410.
24. Feddern V, De Pra MC, Mores R, da Silveira RN, Coldebella A, de Abreu PG. Egg quality assessment at different storage conditions, seasons and laying hen strains. Animal Science and Veterinary Ciênc. agrotec. 2017;41(3).
Available:https://doi.org/10.1590/1413-70542017413002317
25. Mertens K, et al. Advances in egg defect detection, quality assessment and automated sorting and grading. In: Nys I, Bain M, van Immerseel F. (Eds.). Improving the safety and quality of eggs and egg products. Volume 1: Egg chemistry, production and consumption. 1. ed. Cambridge: Woodhead Publishing Limited. 2011;209-241. [Links]
26. Garcia ERM, Orlandi CCB, Oliveira CAL, Cruz FK, Santos TMB, Otutumi LK. Qualidade de ovos de poedeiras semipesadas armazenados em diferentes temperaturas e períodos de estocagem. Revista Brasileira de Saúde e Produção Animal. 2010;11(2):505-518.
27. Samli HE, Agma A, Senkoylu N. Effects of storage time and temperature on egg quality in Old Laying Hens 2005. J. Appl. Poult. Res. 2005;14:548–553.
28. Lapa˜o C, Gama LT, Soares MC. Effects of broiler breeder age and length of egg storage on albumen characteristics and hatchability. Poult. Sci. 1999;78:640–645.
29. Ferrante V, Lolli S, Vezzoli G, Cavalchini LG. Effects of two different rearing systems (organic and barn) on production performance, animal welfare traits and egg quality characteristics in laying hens. Italian Journal of Animal Science. 2009; 8:165-174.
30. Dukić-Stojčić M, Perić L, Bjedov S, Milošević N. The quality of table eggs produced in different housing systems. Biotech. Anim. Husb. 2009;25:1103-1108.
31. Krawczyk J. Quality of eggs from Polish native Greenleg Partridge chicken-hens maintained in organic vs. backyard production systems. Animal Science Papers and Reports. 2009;27(3):227-235.
32. Bell DD, Patterson PH, Koelkebeck KW, Anderson KE, Darre MJ, Carey JB, Kuney DR, Zeidler G. Egg marketing in national supermarkets: Egg quality- Part 1. Poultry Sci. 2001;80:383-389.
33. Adamiec J, Dolezal M, Mikova K, Davidek M. Changes in egg volatiles during storage. Czech J. Food Sci. 2002;20:79-82.

34. Tona K, Onagbesan O, De Ketelaere B, Decuypere E, Bruggeman V. Effect of age of broiler breeders and egg storage on egg quality, hatchability, chick quality, chick weight, and chick post hatch growth to Floury-two days. J. Appl. Poult. Res. 2004; 13:10-18.
35. Sauveur B. Effect of method of rearing of fowls on egg characters. Production Animales. 1991;4:123-130.
36. Pavlovski Z, Hopic S, Uracar S, Masic B. The effect of housing system on internal egg quality in small layer flocks. Biotech. u Stocarstvu. 1994a;10:37-43.
37. Suto Z, Horn P, Ujvari J. The effect of different housing systems on production and egg quality traits of brown and leghorn type layers. Acta Agraria Kaposvariensis. 1997;1:29-35.
38. Sekeroglu A. The effects of free range system on egg productions and egg quality of Brown and White Layer genotypes. Gaziosmanpasa University, Institute of Science, Animal Science Department, PhD Thesis (Unpublished); 2002.
39. USDA. Unites States Department of Agriculture. Egg-Grading Manual. 2000;56. Available:https://www.ams.usda.gov/publications/content/egg-grading-manual Access in: 28 April 2017. [Links]
40. Giampietro-Ganeco A, et al. Comparative study of quality characteristics of egg stored in domestic refrigerators. Ars Veterinaria. 2012;28(2):100-104. [Links]

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