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INFLUENCE OF STORAGE ENVIRONMENT ON THE PHYSICAL AND INTERNAL QUALITY PARAMETERS OF EGGS FROM TWO HYBRID LINES

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Abstract: *This study examined quality changes in eggs from two hybrid lines, ISA Brown (brown shell) and De Calb (white shell), stored at room temperature (13–22 °C) and refrigeration (0–4 °C). Eggs were analyzed immediately after laying and on days 10, 21, and 40. The shape index remained stable across all conditions, with ISA Brown eggs showing slightly higher but more variable values. Both egg white and yolk weights decreased significantly during storage, especially in brown eggs at room temperature, while refrigeration delayed but did not prevent weight loss. Eggshell weight also declined, more so in white eggs due to thinner shells. The air cell size increased over time, with sizes above 8 mm indicating reduced freshness. Different storage temperatures have a significant impact on preserving egg quality over time, which is important for ensuring consumer safety and satisfaction. Additionally, understanding the differences in quality changes between brown and white eggs allows for better adjustment of storage and handling methods, aiming to reduce waste and economic losses in the poultry industry*.

Keywords: *poultry, quality, brown shell eggs, white shell eggs, consumer safety*

1. Introduction

Consumer eggs are among the most perishable food products, and unfavorable storage conditions contribute significantly to the rapid deterioration of both their external and internal quality. To preserve the nutritional value and taste of eggs, proper collection immediately after laying and appropriate storage (temperature and relative humidity) until distribution to consumers are essential. It is particularly important that eggs reach consumers with minimal physical and chemical changes in quality.

1.1 External changes in eggs

Over time or during aging, eggs undergo significant changes that affect both the composition and properties of their contents as well as their external appearance. One of the most notable changes during egg storage is the size of the air cell. Immediately after laying, the size of the air cell is between 1.0 and 1.9 mm [1, 2, 3]. As water evaporates from the egg, the air cell increases in size. The rate of water evaporation is significantly influenced by temperature and relative humidity. The size of the air cell can also be affected by protective shell coatings. Changes in egg weight depend on temperature, with greater weight loss occurring when eggs are stored at higher temperatures. External changes include the egg shape index. A study by [4] over a 12-week refrigeration period observed changes in quality based on the rearing system. The results showed that weight, egg height, Haugh units, and yolk quality were highest on the first day and lowest after 12 weeks of storage ($p < 0.05$).

1.2 Internal changes in eggs

Depending on storage conditions, changes in the composition and properties of eggs are pronounced. The speed of these changes is influenced by temperature, relative humidity, and storage methods. The most noticeable changes are in the egg

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components. Initially, water loss occurs primarily from the albumen, while yolk mass begins to decrease significantly later [5]. As storage temperature increases, the internal temperature of the egg also rises, leading to the breakdown of albumen structure. The degradation of the thick albumen layer allows some parts to pass through the membrane into the yolk, causing pigment separation and color changes in the yolk [6].

Study of [7] report that yolk color remained stable at 4 °C but became lighter after 30 days of storage at 22 °C, with a reduction in yolk color intensity (from 9.91 to 8.33). This dilution of yolk pigments is due to water loss. [8] Also note that storage duration significantly affects yolk color and albumen texture.

The physical and chemical properties of eggs also change during storage, primarily due to water evaporation and CO_2 loss. Prolonged storage leads to protein degradation.

2. 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 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 °C), and half were stored in a refrigerator (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.

Seven eggs from each hybrid line were sampled for physical-chemical analysis immediately after laying, on the 10th, 21st, and 40th days.

2.1 Separation and Mass Determination of Egg Components

Each whole egg was weighed individually using the analytical balance and the total mass was recorded as the whole egg mass. Separation of egg components: While wearing sterile gloves, each egg was carefully cracked over a clean bowl to avoid cross-contamination between components. The egg white (albumen) was allowed to drain into the first bowl while the egg yolk was retained in the shell halves or transferred gently between halves to complete the separation. The egg yolk was then transferred into a second bowl using gentle tipping. Care was taken to avoid rupturing the yolk membrane. The eggshells, including both halves and any fragments, were collected in a third bowl. Each component-egg white, yolk, and shell were weighed separately using the analytical balance. Taring was performed with an identical, empty container before each measurement. If any component stuck to the container walls, a clean spatula was used to transfer the entire sample for accurate mass determination.

All masses were recorded to the nearest 0.01g. This procedure was repeated for each individual egg.

2.2 Measuring the size of the gas chamber in eggs

Traditional candling is often used for the visual assessment of the size of the air cell. Then, image segmentation is used to determine the size of the gas chamber relative to the egg.

The egg shape index was calculated using [9] formula:

Egg shape index = (egg width / egg length) × 100 **Eq. (1)**

2.3 Statistical Analysis

Statistical data processing involved calculating mean values and their standard deviations. Differences between eggs stored at room temperature and in the refrigerator were analyzed using an F-test performed with the IBM SPSS Statistics software (p<0.05 and p<0.01). This F-test helped determine whether the variations between the two storage conditions were statistically significant, indicating the effect of temperature on egg quality. The results are presented in tables and graphs for clear visualization of differences and trends. This analysis provided insight into how storage conditions influence parameters such as weight loss, albumen quality, and yolk index over time.

3. Results and discussion

The egg shape index is an important parameter related to the external quality of eggs. The results for the average values of the shape index over seven consecutive measurements are presented in Table 1. The average values of the shape index for eggs from hens laying white-shelled eggs stored at room temperature ranged from 73.95% to 77.57%, while those stored in a refrigerator ranged from 73.95% to 77.21%. No statistically significant differences (p>0.05) were observed depending on the hybrid line. For brown-shelled eggs stored at room temperature, the shape index ranged from 76.92% to 80.95%, while those stored in a refrigerator ranged from 76.92% to 80.75%. Similarly, no statistically significant differences (p>0.05) were observed based on the hybrid line. Depending on the storage method, the eggs from ISA Brown hens showed higher shape index values throughout the storage period at both room temperature and in a refrigerator. However, greater variations in the values were observed during storage. For white-shelled eggs, the values of this parameter remained constant with minimal variation during the entire storage period [10]. Examining some quality properties of eggs from the Lohmann Brown hybrid line and determined that the egg shape index ranges from 77.25% to 76.72%. The egg white constitutes the main part of the egg, containing a high amount of water and proteins. During storage, water evaporation from the egg white occurs, leading to a proportional decrease in its weight.

Table 1

Eggs shape index during the storage period (%)

Method of storage	Hybrid line	**Parameters**	**Storage period (days)**			
			0	**10**	**21**	**40**
Average room temperature (16 °C)	White-shelled eggs	$\bar{x}$	**73.95**	**76.53**	**77.18**	**77.57**
		min	67.79	71.66	76.78	73.68
		max	77.78	81.48	78.18	83.02
	Brown-shelled eggs	$\bar{x}$	**76.92**	**80.95**	**78.59**	**79.51**
		min	73.68	76.27	76.36	76.36
		max	83.33	96.49	80.77	82.35
Refrigerator (4 °C)	White-shelled eggs	$\bar{x}$	**73.95**	**78.03**	**75.53**	**77.21**
		min	67.79	74.14	71.67	69.49
		max	77.78	81.82	79.25	84.31
	Brown-shelled eggs	$\bar{x}$	**76.92**	**80.75**	**79.32**	**78.84**
		min	72.88	77.19	75.86	78.18
		max	83.33	83.33	83.01	79.24

Table 2 presents the average values for the weight of the egg white in white and brown-shelled eggs stored at room temperature and in a refrigerator. The total weight reduction of the egg white over the storage period was 47.68% for white eggs and 54.29% for brown eggs stored at an average room temperature. This reduction is attributed to the low relative humidity in the storage area, while the higher reduction in brown eggs is due to their greater initial mass and shell porosity. For eggs stored in a refrigerator at 4 °C, weight reduction of the egg white was also observed starting from the 10th day and continuing until the 40th day, with a significant drop on the 40th day. The total weight reduction for refrigerated eggs were 55.35% and 51.04%, respectively. A more evident difference in egg white weight between the two hybrid lines was observed from the 10th to the 40th day of storage (*p*<0.05) in both ambient conditions.

As the total quantity of egg white decreases, corresponding changes occur in its individual layers. These findings align with the gradual reduction in egg white weight [11,12,13,14].

Table 2

Egg white mass during the storage period (g)

Method of storage	Hybrid line	**Parameters**	**Storage period (days)**			
			0	**10**	**21**	**40**
Average room temperature (16 °C)	White-shelled eggs	$\bar{x}$	29.00±1.92	28.80±1.20	18.40±0.87	15.17±0.83
		min	22.00	27.00	16.00	13.00
		max	33.00	34.00	21.00	18.00
		Sd	4.30	2.68	1.94	1.87
		Cv	14.83	9.00	10.59	12.36
	Brown-shelled eggs	$\bar{x}$	31.40±1.71	30.80±0.86	20.80±1.02	14.35±1.67
		min	26.00	31.00	18.00	10.00
		max	36.00	36.00	24.00	19.00
		Sd	3.84	1.92	2.28	3.75
		Cv	12.25	5.69	10.96	26.15
Refrigerator (4 °C)	White-shelled eggs	$\bar{x}$	29.00±1.92	31.40±1.68	28.00±0.70	14.02±1.73
		min	22.00	29.00	26.00	9.00
		max	33.00	38.00	30.00	18.00
		Sd	4.30	3.78	1.58	3.87
		Cv	14.83	12.04	5.64	27.53
	Brown-shelled eggs	$\bar{x}$	31.40±1.71	33.40±1.46	32.80±0.66	16.35±1.32
		min	26.00	28.00	31.00	12.00
		max	36.00	36.00	35.00	19.00
		Sd	3.84	3.28	1.48	2.95
		Cv	12.25	9.83	4.52	18.05
F-test	*p*	0.311	0.151	0.022(*)	0.001(*)	0.002(*)

(*p*<0.05), * statistically significant

The difference in yolk weight between the 10th and 21st days showed a reduction of 17.45% for white eggs and 12.90% for brown eggs.

By the 40th day, the total yolk weight decreased by 68.92% in white eggs and 64.47% in brown eggs stored at an average room temperature of 16 °C. For eggs stored in a refrigerator (4 °C), a reduction in yolk weight was also observed from the 10th to the 40th day. On the 10th day of storage, the yolk weight averaged 17.90±0.97g for white eggs and 15.10±0.51g for brown eggs. By the 21st day, yolk weight had decreased by 10.39% and 8.61%, respectively, with total reductions of

68.65% and 62.98% by the end of the storage period in the refrigerator.

A more evident difference in yolk weight between the two hybrid lines was noted on the 10th, 21st, and 40th days of storage (p<0.05) in both storage conditions. The continuous decline in yolk weight for eggs rom both hybrid lines stored under both ambient conditions was significant on the last day of storage. This is attributed to internal changes occurring during storage. The gradual decrease in egg white weight confirms corresponding changes in its individual layers, further contributing to the gradual reduction in yolk weight. During storage, significant changes in eggshell weight were observed, mainly due to water evaporation through the pores.

The yolk content also undergoes significant changes during storage. Over time, the yolk weight is notably reduced. The average values for white and brown eggs stored at room temperature and in a refrigerator are shown in (Table 3).

Table. 3

Egg yolk mass during the storage period (g)

Method of storage	Hybrid line	**Parameters**	**Storage period (days)**			
			0	**10**	**21**	**40**
Average room temperature (16 °C)	White-shelled eggs	$\bar{x}$	20.40±0.67	17.20±1.02	14.20±1.23	6.34±0.37
		min	19.00	15.00	18.00	5.00
		max	22.00	21.00	25.00	7.00
		Sd	1.51	2.28	2.77	0.83
		Cv	7.43	13.25	13.73	13.10
	Brown-shelled eggs	$\bar{x}$	15.20±0.73	12.40±0.40	10.80±0.79	5.40±1.12
		min	13.00	17.00	13.00	1.00
		max	17.00	19.00	18.00	8.00
		Sd	1.64	0.89	1.78	2.50
		Cv	10.81	4.86	11.32	73.76
Refrigerator (4 °C)	White-shelled eggs	$\bar{x}$	20.40±0.67	17.90±0.97	16.04±0.74	5.61±0.68
		min	19.00	16.00	14.00	4.00
		max	22.00	20.00	18.00	8.00
		Sd	1.51	2.19	1.67	1.52
		Cv	7.43	12.44	10.20	27.14
	Brown-shelled eggs	$\bar{x}$	15.20±0.73	15.10±0.51	13.80±0.73	5.59±2.13
		min	13.00	14.00	12.00	3.00
		max	17.00	16.00	16.00	14.00
		Sd	1.64	1.14	1.64	4.78
		Cv	10.81	7.55	11.97	85.53
F-test		p	0.158	0.001(*)	0.001(*)	0.001(*)

(p<0.05), * statistically significant

During storage, significant changes in eggshell weight were observed, mainly due to water evaporation through the pores, (Table 4). The results indicate that white eggs exhibited greater shell weight reduction compared to brown eggs under both ambient conditions. A more pronounced difference in shell weight between the two hybrid lines was observed only on the last day of storage (p<0.05), favoring eggs stored in the refrigerator. This observation is justified because white eggs have thinner and more delicate shells, allowing for greater and easier water evaporation. The genetic predisposition influencing the above-mentioned results is also supported by previous studies, [15,16,17].

Table 4

Eggshell mass during the storage period (g)

Method of storage	Hybrid line	Parameters	Storage period (days)			
			0	**10**	**21**	**40**
Average room temperature (16 °C)	White-shelled eggs	$\bar{x}$	8.20±0.86	6.20±0.73	7.90±0.73	6.74±0.26
		min	6.00	8.00	11.00	7.00
		max	11.00	11.00	15.00	8.00
		Sd	1.92	1.64	1.64	0.59
		Cv	23.45	17.86	13.46	7.64
	Brown-shelled eggs	$\bar{x}$	8.40±0.92	6.40±0.51	7.40±0.51	6.92±0.73
		min	7.00	7.00	6.00	6.00
		max	12.00	10.00	9.00	10.00
		Sd	2.07	1.14	1.14	1.63
		Cv	24.68	13.57	15.40	20.63
Refrigerator (4 °C)	White-shelled eggs	$\bar{x}$	8.20±0.86	6.80±1.20	5.00±0.31	4.74±0.45
		min	6.00	6.00	8.00	7.00
		max	11.00	7.00	10.00	9.00
		Sd	1.92	0.44	0.70	1.02
		Cv	23.45	6.57	7.85	13.18
	Brown-shelled eggs	$\bar{x}$	8.40±0.92	8.80±0.49	6.60±3.95	5.12±2.94
		min	7.00	8.00	7.00	4.00
		max	12.00	10.00	21.00	21.00
		Sd	2.07	1.09	8.85	6.59
		Cv	24.68	12.44	55.2	72.31
F-test	*p*		0.086	0.093	0.015	0.001(*)

(p<0.05), *statistically significant

Table 5

Air cell dimensions of eggs during the storage period (mm)

Method of storage	Hybrid line	Parameters	Storage period (days)			
			0	**10**	**21**	**40**
Average room temperature (16 °C)	White-shelled eggs	$\bar{x}$	5.80±0.38	21.40±0.51	25.00±0.23	33.00±0.23
		min	5.00	20.00	24.00	32.00
		max	7.00	23.00	26.00	34.00
		Sd	0.84	1.14	1	1
		Cv	14.42	5.33	4	3.03
	Brown-shelled eggs	$\bar{x}$	6.40±0.51	19.60±1.68	23.40±1.68	34.40±1.57
		min	5.00	18.00	21.00	31.00
		max	8.00	21.00	25.00	40.00
		Sd	1.14	1.52	1.52	3.51
		Cv	17.82	7.74	6.48	10.20
Refrigerator (4 °C)	White-shelled eggs	$\bar{x}$	5.80±0.38	21.80±1.16	25.00±1.64	28.80±0.80
		min	5.00	19.00	21.00	36.00
		max	7.00	24.00	28.00	30.00
		Sd	0.84	2.59	3.67	1.79
		Cv	14.42	11.87	14.70	6.21
	Brown-shelled eggs	$\bar{x}$	6.40±0.51	23.80±0.97	28.60±1.63	31.60±0.40
		min	5.00	21.00	24.00	31.00
		max	8.00	27.00	34.00	33.00
		Sd	1.14	2.17	3.65	0.89
		Cv	17.82	9.11	12.75	2.83
F-test	*p*		0.001(*)	0.022(*)	0.001(*)	0.002(*)

(p<0.05), *statistically significant

The air cell is located between the shell and the egg white. The temperature of a freshly laid egg is around 41 °C, at which point the air cell is very small. As the egg cools, the membrane separates from the shell, creating the air cell. The results for changes in the air cell are presented in (Table 5). The findings show that the storage method affects the air cell size in eggs from different hybrid lines, with statistically significant differences (p<0.05) observed on the 10^{th}, 21^{st}, and 40^{th} days of storage for both hybrid lines under both ambient conditions. For a freshly laid egg, the air cell should not exceed 8mm; beyond this limit, the eggs are no longer considered fresh, [18, 19, 20].

4. Conclusion

The study results indicate that the shape index of eggs, both white- and brown-shelled, remains stable across different storage conditions (room temperature and refrigeration) and hybrid lines, with no statistically significant differences observed. Eggs from ISA Brown hens consistently showed higher shape index values throughout the storage period, although with greater variability compared to other lines. Significant weight loss occurred in both the egg white and yolk during storage, with brown eggs experiencing greater reductions at room temperature, likely due to their larger initial mass and more porous shells. Refrigeration delayed the onset of weight loss until around the 10th day but did not prevent substantial reductions by the 40th day. Differences between hybrid lines in egg white and yolk weight loss were statistically significant, suggesting genetic factors influence egg quality retention during storage. Eggshell weight also decreased significantly due to water evaporation, with white eggs showing greater shell weight reduction because of their thinner and more delicate shells. The size of the air cell increased over time and was affected by storage method and hybrid line, with air cells exceeding 8 mm indicating a loss of freshness. These findings highlight that while refrigeration helps slow quality degradation, timely consumption remains essential. Monitoring air cell size and weight loss can serve as practical indicators of egg freshness. Additionally, considering differences in shell characteristics between egg types may guide improved packaging and handling strategies to reduce moisture loss and extend shelf life.

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