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RESEARCH MARKETING STANDARDS FOR CHICKEN EGG QUALITY PARAMETERS INTENDED FOR CONSUMPTION

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Abstract

Egg quality is a critical factor influencing consumer preference and market value, primarily affected by freshness, storage conditions, and production practices. This study compared the quality parameters of fresh and market chicken eggs. A total of 2000 eggs (both market and fresh) were analyzed following USDA Egg Grading Manual protocols. Parameters evaluated included egg weight, eggshell weight, yolk and egg white weight, specific gravity, Haugh units (HU), air cell size, yolk color (RYCF), eggshell thickness, length, and width. Results revealed significant differences, with fresh eggs demonstrating superior quality across multiple parameters. The results revealed significant differences, with fresh eggs exhibiting superior quality across several parameters. Fresh eggs had a higher mean weight (65.89 g vs. 62.30 g; $P = 0.0001$) and shell weight (7.97 g vs. 7.35 g; $P = 0.0186$), although no significant difference was observed in shell thickness ($P = 0.1626$). Fresh eggs also showed higher yolk weight (15.31 g vs. 14.37 g; $P = 0.021$) and more intense yolk color (RYCF: 12.35 vs. 11.45; $P = 0.0259$). Notably, Haugh unit values were significantly higher in fresh eggs (88.46) compared to market eggs (76.57; $P = 0.0006$), indicating better freshness. The air cell size was smaller in fresh eggs (3.47 mm vs. 4.78 mm; $P = 0.0044$), qualifying them as "extra" class under quality standards. Based on the findings, fresh eggs met the criteria for superior quality, being classified as "L" class based on weight and "extra" class due to their smaller air cell size. Conversely, market eggs tended to fall into lower quality classes, such as "M" class, due to their lower weight and larger air cell size. However, both types of eggs are deemed suitable for consumption according to established guidelines. Continuous research is essential to refine egg quality standards and align with consumer expectations.

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Introduction

The production and consumption of chicken eggs are constantly increasing, with eggs serving as a significant source of protein and essential nutrients for billions of people worldwide (DILAWAR et al. 2021, FAOSTAT 2022, KOCETKOVS et al. 2022, KUANG et al 2018, MIRANDA et al. 2015, PAL and MOLNAR 2021, PAPANIKOLAOU and FULGONI 2021, RATH et al. 2015). A significant portion of this production is used in the secondary processing industry (AHMAD et al., 2021). Kosovo's poultry industry saw significant growth in 2020, with 366 million eggs produced, meeting 99% of demand, though per capita consumption lags a little behind the EU average (MAFRD 2021, HORNE 2018).

Ensuring high physical quality parameters of chicken eggs is crucial for meeting consumer expectations and regulatory standards. Consumers prioritize freshness and nutritional value when assessing egg quality (GRASHORN et al. 2016, HARNSOONGNOEN and JAROENSUK 2021, RATH et al. 2015). Consumer preferences are influenced by intrinsic and extrinsic characteristics, as well as socio-cultural factors (RONDONI et al. 2020, ZAHEER 2015).

Numerous studies have investigated egg quality, elucidating factors that influence it, such as environmental and genetic influences, dietary supplements, chicken age, stress levels, temperature, lighting conditions, medications, diseases, management practices, and growth systems (ADAMSKI et al. 2017, DILAWAR et al. 2021, HARNSOONGNOEN and JAROENSUK 2021, KOCETKOVS et al. 2022, RATH et al. 2015, SOKOŁOWICZ et al. 2018, SENBETA et al. 2015). A study by RODRÍGUEZ-HERNÁNDEZ et al. (2024) found that hens from cage-free housing systems yield eggs of higher quality, with improvements in albumen height, egg weight, yolk color, eggshell thickness, and Haugh units. While, GRASHORN et al. (2016) emphasized genetic factors' influence on albumin quality, with minimal influence from nutrition, while adding calcium, phosphorus, and vitamin D to hen diets improved shell resistance. Stable storage conditions, as highlighted by RATH et al. (2015) and GRASHORN et al. (2016), enhance egg quality, underscoring the importance of production practices.

Size uniformity is a crucial aspect of egg marketing standards. Regulatory bodies in Kosovo, such as Ministry of Agriculture, Forestry and Rural Development (MAFRD, have set guidelines (AD Nr. 17/2008) for classifying and labeling eggs based on factors like size and shell cleanliness. This ensures transparency for consumers and consistency in packaging. Based on these standards, eggs are categorized into size groups, ranging from small to large.

This study aims to assess a number of exterior and internal quality parameters of fresh and market chicken eggs, such as egg weight, eggshell weight, yolk and white weight, specific gravity, Haugh units (HU), air cell size, yolk color (RYCF), eggshell thickness, length and width. The results will be compared with the standards and guidelines outlined in Administrative Directive AD No. 17/2008, which defines the criteria for evaluating the external and internal quality of chicken eggs in Kosovo. For the benefit of both producers and consumers, regular monitoring of these variables is essential to preserving the safety and freshness of eggs. To improve egg quality standards and deepen our understanding, this sector requires ongoing research.

Materials and Methods

In this study, a total of 2,000 eggs were collected from various municipalities in Kosovo (Ferizaj, Gjilan, Prizren, Gjakovë, Istog, Lipjan, Podujevë, and Prishtinë). In the supermarkets of the municipalities of Ferizaj, Gjilan, Gjakovë, Istog, Lipjan, and Podujevë, a total of 200 eggs were collected from two different local producers (100 eggs from each producer). Meanwhile, in the municipality of Prizren, 300 eggs were collected from three different producers (100 eggs from each producer). In the municipality of Prishtina, 400 eggs were collected from four different producers (100 eggs from each producer). Additionally, 100 fresh eggs were collected as control samples from a farm in the Pristina region. Based on the label information, the eggs found on the market were classified as "Class A" eggs intended for consumption. The results of all samples were compared with the standards and guidelines specified in Administrative Instruction UA No. 17/2008, which sets criteria for assessing the external and internal quality of chicken eggs in Kosovo. According to this administrative instruction, eggs are classified into two groups to determine their quality for consumption: fresh class "A" eggs and class "B" eggs intended for industrial processing. Class "A" eggs are further divided and labeled as follows: "XL" – very large eggs weighing 73 g and above, "L" – large eggs weighing between 63 g and 73 g, "M" – medium-sized eggs weighing between 53 g and 63 g, and "S" – small eggs weighing less than 53 g. For class "A" eggs, the air cell should not exceed 6 mm, while for extra class eggs, the air cell should not exceed 4 mm, as specified in the same Administrative Instruction. Various criteria were used to evaluate egg quality, including egg weight, eggshell weight, egg yolk weight, egg white weight, specific gravity, Haugh units (HU), air cell size, intensity of yolk color (RYCF), eggshell thickness, egg length, and egg width. The weights of eggs, along with their shells, yolks, and egg whites, were measured using

the Electronic Analytical Balances, BA-W2004 Series, China. The air cell size was determined using the official egg air cell gauge FORM PY-35 (5-1-74), following USDA Egg Grading Manual. Specific gravity (SW) was calculated by immersing the eggs in saline solutions until they reached their floating point. Various NaCl solutions with specific weights ranging from 1.050 to 1.100 in increments of 0.005 g/cm^3 were created in order to ascertain the specific weight of the eggs (Hydrometer precision, 1.000 to 1.100 g/cm^3, Greiner-Glasinstrumente, Germany). Haugh Units (HU) were measured with a Haugh meter (Haugh unit micrometer, B C Ames Co, Waltham, Massachusetts, USA), following USDA Egg Grading Manual. Yolk color density was visually assessed using a Yolk Color Fan 1–15 scales (Roche & Company Ltd., Switzerland), following the methodology outlined by JOUBRANE et al. (2019). Eggshell thickness, length, and width were evaluated using a Digital Traceable Calipers, model 3415CC (Webster-Texas, USA). This meticulous approach ensured a robust assessment of egg quality, providing valuable insights into the characteristics of eggs available in the market from various regions and producers in Kosovo.

Statistical analysis. Descriptive statistics were conducted using the Statistical Package for the Social Sciences (SPSS) (IBM Version 28.0, Armonk, NY). The t-test was utilized to determine if there was a significant difference between the means of various parameters. A P-value of ≤ 0.05 was considered statistically significant, indicating a notable difference between the means of the parameters.

Study limitations. Research primarily focuses on the physical characteristics of hens' eggs, overlooking other factors affecting egg quality like breed, feeding, production techniques, storage temperature and genetics. Additionally, the study's limited sample size and geographic scope in Kosovo may hinder generalization. It fails to consider varied chicken housing systems (caged or free-range), which can influence egg quality. Furthermore, the research neglects to examine the impact of handling practices, hygiene, transport, and specific storage conditions on egg quality.

Results and Discussions

Table 1 presents a comparative analysis of various characteristics of chicken eggs, specifically comparing market eggs with fresh (control) eggs. The descriptive statistics provide insights into parameters such as egg weight, eggshell weight, egg yolk weight, egg white weight, specific gravity, Haugh unit (HU), air cell size, intensity of yolk color (RYCF), eggshell thickness, egg length, and egg width. These parameters are crucial in evaluating the quality and nutritional content of eggs.

Table 1

Comparative analysis of chicken egg characteristics:
Market vs. Fresh eggs (descriptive statistics)

Specification		Egg weight [g]	Eggshell weight [g]	Egg yolk weight [g]	Egg white weight [g]	Specific gravity [g/cm^3]	Haugh unit [HU]	Air cell [mm]	Intensity of yolk color [RYCF]	Eggshell thickness [μm]	Egg length [mm]	Egg width [mm]
Market chicken eggs	min	56.97	6.75	13.40	36.82	1.06	62.90	3.44	9.44	0.38	49.10	38.10
	max	66.90	7.97	15.30	43.63	1.09	91.20	6.21	12.70	0.44	57.40	44.80
	mean	62.30	7.35	14.37	40.58	1.07	76.57	4.78	11.45	0.41	53.97	41.99
	SEM	1.41	0.20	0.27	0.96	0.00	3.86	0.43	0.52	0.01	1.18	0.98
	STDEV	3.44	0.49	0.66	2.34	0.01	9.45	1.04	1.26	0.03	2.88	2.40
Fresh chicken eggs (control)	min	59.58	5.88	11.84	36.76	1.07	75.50	3.20	9.00	0.32	45.77	33.77
	max	76.85	10.83	18.26	54.39	1.10	115.00	4.80	15.00	0.56	61.54	48.46
	mean	65.89	7.97	15.31	43.53	1.09	88.46	3.47	12.35	0.43	56.26	43.68
	SEM	0.64	0.16	0.29	0.71	0.00	1.34	0.10	0.23	0.01	0.48	0.40
	STDEV	3.71	0.95	1.68	4.14	0.01	7.83	0.58	1.37	0.05	2.82	2.33
P-value	–	**0.0001**	**0.0186**	**0.021**	**0.0164**	**0.0001**	**0.0006**	**0.0044**	**0.0259**	**0.1626**	**0.0124**	0.0137

Note: The statistics include minimum, maximum, mean, standard error of the mean (SEM), and standard deviation (STDEV) values for egg weight, eggshell weight, egg yolk weight, egg white weight, specific gravity, Haugh unit (HU), air cell size, intensity of yolk color (Roche Yolk Color Fan), eggshell thickness, egg length, and egg width. *P*-values indicate the level of significance for differences between the two groups, with values less than 0.05 considered statistically significant

Egg weight is a fundamental characteristic affecting marketability and consumer preference. The mean egg weight for market eggs (62.30 g) is slightly lower than that of fresh eggs (65.89 g), indicating potential differences in egg size between the two groups. Notably, market eggs have a narrower range of weights (56.97 g to 66.90 g) compared to fresh eggs (59.58 g to 76.85 g), suggesting more consistency in size among market eggs. The difference in mean egg weight between the two groups is statistically significant ($P = 0.0001$), indicating a meaningful disparity. From this we conclude that fresh eggs, which were stored at controlled temperatures, had a higher weight compared to market eggs, where the storage temperature was not controlled. The average market egg weight in the research follows the standard range (58 to 62 g) reported by RATH et al. (2015), while fresh eggs exceed the reported averages. Factors influencing egg weight, such as feed, chicken weight, genetics, environment, storage conditions, and sanitary conditions in farms, are reported by various authors (HARNSOONGNOEN and JAROENSUK 2021, KOCETKOVS et al. 2022, RATH et al. 2015, SOKOŁOWICZ et al. 2018).

Eggshell weight and thickness are critical for shell integrity and protection of the eggs contents. Market eggs exhibit a mean eggshell weight of 7.35 g, whereas fresh eggs have a slightly higher mean weight of 7.97 g. However, fresh eggs demonstrate a wider range of eggshell weights, indicating greater variability in shell thickness compared to market eggs. This variation could influence egg quality and susceptibility to breakage. The difference in mean eggshell weight between the two groups is statistically significant ($P = 0.0186$). In terms of eggshell characteristics, market eggs tend to have a slightly thinner eggshell, as evidenced by the mean eggshell thickness of 0.41 μm, compared to 0.43 μm for fresh eggs. However, this difference may not be statistically significant, as indicated by the *P*-value (0.1626). The results of our research align with findings from other authors regarding eggshell characteristics and influencing factors (KOCETKOVS et al. 2022, RATH et al. 2015, SOKOŁOWICZ et al. 2018). A study by RODRÍGUEZ-HERNÁNDEZ et al. (2024) concluded that cage-free housing systems yield higher quality eggs with thicker shells. Additionally, GRASHORN et al. (2016) stressed the significance of chicken diet in enhancing shell resistance. Stable storage conditions, as emphasized by RATH et al. (2015) and GRASHORN et al. (2016), contribute to improved egg quality, underscoring the importance of production practices.

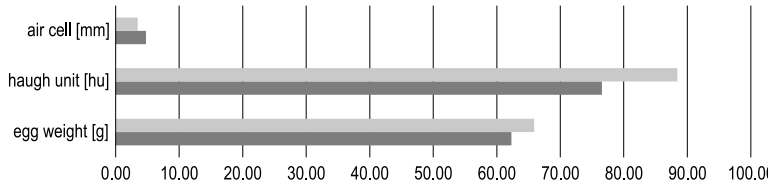
Egg yolk weight and color intensity are essential indicators of nutritional value and visual appeal. Fresh eggs exhibit a marginally higher mean yolk weight (15.31 g) compared to market eggs (14.37 g), suggesting potentially richer nutritional content in fresh eggs. The difference in mean yolk weight between the two groups is statistically significant ($P = 0.021$). Furthermore,

the intensity of yolk color, measured by the Roche Yolk Color Fan (RYCF), is significantly higher in fresh eggs (mean RYCF of 12.35) than in market eggs (mean RYCF of 11.45), indicating a deeper, more vibrant yolk color in fresh eggs. The difference in mean RYCF is statistically significant ($P = 0.0259$). Higher values of yolk weight, color index, and factors influencing weight loss have been reported by previous authors (DILAWAR et al. 2021, KOCETKOVS et al. 2022, RATH et al. 2015, SOKOŁOWICZ et al. 2018). A recent study by RODRÍGUEZ-HERNÁNDEZ et al. (2024) found that cage-free housing systems produce eggs of higher quality and weight, with a more intense yolk color.

Haugh unit (HU) values reflect the freshness and quality of eggs, with higher values indicating fresher eggs. Fresh eggs have a substantially higher mean HU value (88.46) compared to market eggs (76.57), indicating fresher and potentially higher-quality eggs in the fresh group. This discrepancy is further supported by the significant difference in air cell size between the two groups, with fresh eggs having a smaller mean air cell size (3.47 mm) compared to market eggs (4.78 mm), signifying less air infiltration and better egg freshness. The differences in mean HU and air cell size are statistically significant ($P = 0.0006$ and $P = 0.0044$, respectively). We have observed that smaller Haugh Units correlate with larger air chambers and vice versa. Previous studies have shown that the Haugh unit depends on albumen height but not on egg weight (INCA et al. 2020, JANG 2022, RAFEA 2019). Both lower and higher values of air cell in eggs, and the factors affecting the deterioration of this important parameter for egg quality in consumption and food industry use, have been discussed by previous authors (HARNSOONGNOEN and JAROENSUK 2021, RATH et. al. 2015). A recent study by RODRÍGUEZ-HERNÁNDEZ et al. (2024) found that cage-free housing systems produce higher quality eggs, with improvements in albumen height and Haugh units. Additionally, GRASHORN et al. (2016) emphasized the influence of genetic factors on albumin quality, with minimal impact from nutrition. Overall, the comparative analysis highlights significant differences in various egg characteristics between market and fresh eggs, with some parameters showing statistically significant disparities while others do not. These findings underscore the importance of considering multiple factors when assessing egg quality and consumer preferences.

Figure 1 compares egg weight, Haugh unit, and air cell size between market and fresh chicken eggs.

Fresh eggs surpass market eggs in several aspects: they have higher egg weight (fresh: 65.89 g, market: 62.30 g) and Haugh unit (fresh: 88.46, market: 76.57). Moreover, fresh eggs display a smaller air cell compared to market eggs (fresh: 3.47 mm, market: 4.78 mm). The mean weight of fresh eggs (65.89 g) classifies them in the large egg category according to Administrative Instruction No. 17/2008, which stipulates that eggs with a mean weight



	Egg weight [g]	Haugh unit [hu]	Air cell [mm]
fresh chicken eggs (control) mean	65.89	88.46	3.47
market chicken eggs mean	62.30	76.57	4.78

fresh chicken eggs (control) mean market chicken eggs mean

Fig. 1. Comparison of mean egg characteristics, key quality parameters, between Market and Fresh chicken eggs

of 63–73 g are classified as large class "L" eggs. On the other hand, market eggs with a mean weight of 62.30 g fall into the medium egg category "M" (53–63 g). However, according to this administrative instruction, both fresh and market eggs are categorized as "A" class eggs, which are suitable for consumption. Regarding the air cell measurements from the study, both groups of eggs fall into the "A" class. However, fresh eggs are classified as "extra" because they do not exceed the 4 mm limit set in the administrative guidelines for this parameter. The administrative instructions stipulate that the air cell should not exceed 6 mm, and eggs classified as "extra" should

Table 2

Percentage change in chicken egg characteristics compared to mean values: Fresh eggs vs. Market

Parameters	Fresh chicken eggs (control)	Market chicken eggs	Percentage difference [%]
Egg weight [g]	65.89	62.30	-5.76
Eggshell weight [g]	7.97	7.34	-8.58
Egg yolk weight [g]	15.31	14.37	-6.54
Egg white weight [g]	43.53	40.57	-7.30
Specific gravity [g/cm^3]	1.090	1.073	-1.58
Haugh unit [HU]	88.46	76.56	-15.54
Air cell [mm]	3.47	4.78	27.41
Intensity of yolk color (Roche yolk color fan)	12.35	11.45	-7.86
Egg shell thickness [μm]	0.43	0.41	-4.88
Egg length [mm]	56.26	53.96	-4.26
Egg width [mm]	43.68	41.99	-4.02

Note: Negative values in the Percentage Difference [%] column indicate a decrease in the measured parameter for Market compared to Fresh Chicken Eggs

have an air cell size not exceeding 4 mm. These disparities imply superior quality and freshness in fresh eggs, possibly influenced by factors like storage temperature, diet, and handling. Further investigation is required to fully comprehend the implications of these distinctions.

Fresh eggs, serving as the control group, demonstrate significant advantages over market eggs in several key parameters. Firstly, fresh eggs exhibit a higher egg weight by 5.76% compared to market eggs. This weight disparity suggests potential differences in nutritional content and overall egg quality. Secondly, fresh eggs display an 8.58% increase in eggshell weight compared to market eggs. A thicker eggshell often correlates with better egg protection and durability. Furthermore, fresh eggs boast a higher Haugh unit (HU), indicating superior freshness and quality. The Haugh unit is a vital metric in assessing egg quality, with higher values indicating fresher eggs. Additionally, fresh eggs have a substantially smaller air cell size, with a 27.41% decrease compared to market eggs. A smaller air cell suggests fresher eggs, as air cell size increases with egg aging. In summary, the comparison underscores the superiority of fresh eggs over market eggs in terms of weight, eggshell thickness, Haugh unit, and air cell size. These differences are crucial for consumers and egg producers alike, emphasizing the importance of considering egg freshness and quality when making purchasing decisions. Loss of egg weight, significant decline in albumen height and HU, as well as yolk index, has been documented by various authors. Additionally, degradation in shell characteristics such as thickness, width, and height has been observed. Factors influencing these changes include storage duration and temperature, chicken age, diet, and eggshell attributes (GRASHORN et al. 2016, HARNSOONGNOEN and JAROENSUK 2021, KOCETKOVS et al. 2022, RATH et al. 2015)

Conclusion

This study provides a comprehensive evaluation of the external and internal quality parameters of chicken eggs available in the market compared to fresh eggs sourced directly from farms. The findings highlight significant differences in key external quality parameters, such weight, shell thickness, Haugh Unit, and air cell size. Fresh eggs consistently outperformed market eggs in these metrics, emphasizing their superior quality. When compared to the criteria outlined in Administrative Instruction UA No. 17/2008, which sets standards for assessing the external and internal quality of chicken eggs in Kosovo, both market and fresh eggs meet the basic requirements for consumer safety and marketability. However, the superior performance of fresh eggs suggests that stricter adherence to storage and production

practices could further enhance the quality of market eggs. Future studies should consider expanding the sample size and geographic scope, alongside exploring factors such as chicken breed, diet, housing systems, and storage conditions. Such efforts are essential for refining marketing standards and aligning them with evolving consumer expectations. By doing so, stakeholders can improve product quality, increase market competitiveness, and support informed consumer choices.

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