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Influence of Temperature and Storage Time on the Quality of Quail Eggs

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ABSTRACT

Background: The factors influencing the quality of quail eggs have been little studied despite their consumption having increased worldwide. **Aim.** To evaluate the influence of temperature and storage time on the quality of quail eggs. **Materials and methods:** 130 commercial eggs of *Coturnix coturnix* were subjected to a 2x5 design with a univariate general linear model, with the predictor variables being: temperature (room temperature and refrigeration) and storage time (1 day; 1, 2, 3 weeks and between 4-6 weeks); the dependent variables were, Yolk Height (YH), Yolk Diameter (YD), Thick Albumen Height (TAH), Albumen Volume (AV), Yolk pH (YpH), Albumen pH (ApH), and Haugh Units (HU); buoyancy was investigated by chi-square tests (refrigerated eggs vs. room temperature eggs). **Results:** There was an interaction between temperature and storage time in the parameters YH ($p<0.05$) and YD ($p<0.001$); there was also a difference in TAH, YH, YD, and HU ($p<0.001$) between eggs stored at room temperature and in refrigeration. The ApH and YpH varied from the first and third weeks, respectively, while the TAH varied from the third week ($p<0.001$). There were substantial differences in buoyancy percentages between eggs kept at room temperature and those refrigerated ($p<0.001$). **Conclusions:** The quality of commercial quail eggs was influenced by temperature and storage time.

Keywords: conservation, *Coturnix coturnix*, factors, fresh eggs (*Source: AGROVOC*)

INTRODUCTION

The quality of commercial eggs is defined by a set of external and internal characteristics that determine their acceptability by consumers and their shelf life; preserving the indices that define it during commercial circulation is crucial for the product's market value. Factors such as

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temperature, storage time, and handling influence these qualities (Brito *et al.*, 2020; Erensoy *et al.*, 2021).

Carvalho *et al.* (2021) state that eggs, being a nutrient-rich food, provide ideal conditions for bacterial proliferation, including pathogenic species that can impact human health. Shelf life can be understood as the storage period during which eggs remain viable for consumption under optimal temperature, light, relative humidity, and handling conditions.

Cavalcante and Querino (2019) report that the organic nature of eggs makes them highly perishable, and their internal properties are modified if measures to slow this process are not taken. Preserving quality requires appropriate storage conditions, taking into account that between laying and marketing, the components of the albumen and yolk can be significantly altered.

Time and temperature have demonstrated to be important factors that must be controlled during the storage period (Sousa *et al.*, 2016). In this regard, de Oliveira Carvalho *et al.* (2022), as well as Wlazlak *et al.* (2024), evidenced the influence of both factors on quality parameters in chicken and duck eggs. Portilla *et al.* (2023) demonstrated the significance of correct storage temperature and the time elapsed since laying in people's possible appreciation of the quality of this food.

Moreover, global production of this commodity has grown in recent years. Although the predominant consumption continues to be chicken eggs, duck, goose, and quail eggs are appreciated in some countries, and their commercial levels have also increased. However, information related to quality parameters in these species is still relatively scarce (Wijedasa *et al.*, 2020).

Quail eggs are known to possess superior nutritional characteristics compared to other species due to their higher contents of proteins, phosphorus, iron, and vitamins B1 and B2, which can play an important role in meeting food demand (Talukdar *et al.*, 2020). Accordingly, the aim of this study is to evaluate the influence of temperature and storage time on the quality of commercial eggs of this species.

MATERIALS AND METHODS

Research Site and Experimental Procedure

The study was conducted in the anatomy laboratory of the Department of Agricultural Sciences, Environment, and Fisheries at the Higher Polytechnic, in Cuanza Sul, Sumbe, Republic of Angola, during the months of June and July. Procedures followed the recommendations of Cavalcante and Querino (2019). Commercial quail eggs from the Aldeamento 1 unit, Waku-Kungo city, Cela province, Republic of Angola (n=130), were subjected to a 2x6 factorial design;

2 storage temperatures (room temperature with an average of 23°C and refrigeration at 8.9°C) and five storage periods (1 day; 1, 2, 3 weeks and between 4-6 weeks). The experimental period began 4 days after reception; storage was performed in 30-unit carton trays for chicken eggs. An analysis of variance was previously conducted to ensure no significant differences between the weights of each group.

Refrigeration was done using a Hisense 70 W equipment; temperature was measured using the Mi Temperature and Humidity Monitor 2 sensor attached to a mobile phone with a range of 0-60°C. Approximately one hour was allowed for the refrigerated eggs to reach room temperature before starting the procedures. Each egg was considered an experimental unit. Weighing was done on a Digital Scale brand digital balance with a sensitivity of 0.01 g, using a small plastic cup (fig. 1). Buoyancy was determined in a 500 ml beaker with room temperature water (fig. 2). Eggs were then opened at the greater diameter with a 12-inch hacksaw blade and a small pair of scissors (figs. 3 and 4). The contents were poured onto a 20x10 cm glass plate and the Yolk Diameter (YD) and Yolk Height (YH) were measured using a 0.05 mm precision manual gauge caliper (figs. 5 and 6). At approximately 5 mm from the edge of the yolk, the Thick Albumen Height (TAH) was determined. Subsequently, using a plastic spoon, the albumen was deposited in a 10 ml glass graduated cylinder to measure the Albumen Volume (AV) (fig. 7), then transferred to a 10 cm wide tube, while the yolk was poured into a 30 ml porcelain crucible and homogenized with a plastic spoon to determine the Albumen pH (ApH) and Yolk pH (YpH) using a Mettler Toledo FG2-basic five go portable digital pH meter with ± 0.01 precision (fig. 8); all procedures were done by the same person. The Haugh Units (HU) were calculated using the Haugh Unit Bröring IT mobile application with the formula $HU = 100 \log (TAH + 7.57 - 1.7 W^{0.37})$, where TAH is the Thick Albumen Height in mm and W is the egg weight in g.



Figure 1 Weighing the eggs



Figure 2. Determination of buoyancy



Figure 3. Cutting the shell with the hacksaw blade

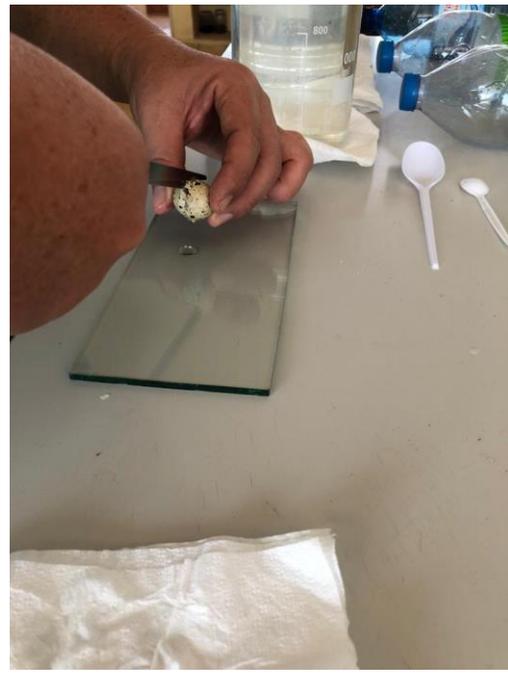


Figure 4. Completing the shell cut with scissors



Figure 5. Measuring the YD



Figure 6. Measuring the YH



Figure 7. Determination of the AV



Figure 8. Portable pH meter

Variables Studied and Statistical Analysis

The dependent variables were TAH, YH, YD, AV, YpH, ApH, and HU; while the predictor variables were temperature and storage time. The analysis was performed through a univariate general linear model structured as follows:

$Y_{ijk} = \mu + T_i + A_j + T A_{ij} + e_{ijk}$ where:

Y_{ijk}: response variable, individual observation of TAH, YH, YD, AV, YpH, ApH, and HU as a function of temperature (i) and storage time (j)

μ: overall mean

T_i: effect of storage temperature

A_j: effect of storage time

T A_{ij}: interaction effect of storage temperature with storage time

e_{ijk}: random error associated with Y_{ij}

Dunnet's multiple comparison test was used, with the first day taken as the control category to determine from which week the parameters varied. For buoyancy, the egg state (float/sink) was considered, regarding storage temperature (room/refrigeration), using Chi-square tests with

directional measures (Lambda, Goodman and Kruskal's Tau, uncertainty coefficient) and symmetric measures (Phi, Cramer's V, contingency coefficient, Pearson's R). In all cases, a significance level of $p \leq 0.05$ was considered using SPSS 15 version 15.0.1 (2006).

RESULTS AND DISCUSSION

Temperature and storage time were found to have a significantly positive interaction on the parameters YH ($p < 0.05$) and YD ($p < 0.01$); as storage days decreased at refrigerated temperature, YH showed higher values, while YD decreased, indicating a positive effect on quality preservation (Table 1). Moura *et al.* (2008) observed interaction with a positive effect at lower temperatures and conservation times, although in the parameters TAH, HU, and weight; de Oliveira Carvalho *et al.* (2022) determined that increasing storage days had a linearly decreasing effect on YH in chicken eggs, with a more pronounced reduction for those stored at room temperature compared to those kept refrigerated at the end of the 30-day evaluation period. Portilla *et al.* (2023) found a deterioration in quality with greater weight loss when eggs were stored at room temperature for more days.

Table 1. Comparison of mean YH and YD for each combination of temperature and storage time

Parameters	Storage Temperature	Storage Time				
		First Day	1 Week	2 Weeks	3 Weeks	4-6 Weeks
HY (mm)	Environment	8.5	7.9	7.4	7.4	5.8
	Refrigeration	9.5	8.8	9.4	8.3	9.0
	Sig	*	*	*	*	*
DY (mm)	Environment	27.2	28.4	28.8	30.4	34.3
	Refrigeration	25.6	27.1	25.9	28.3	26.7
	Sig	***	***	***	***	***

* $p \leq 0.05$ for each combination of temperature and storage time in the same column; *** $p \leq 0.001$ for each combination of temperature and storage time in the same column, YH- Yolk Height, YD- Yolk Diameter.

Eggs kept at refrigerated temperature showed higher values in the parameters TAH, YH, YD, and HU ($p \leq 0.001$). Regarding storage time, variations in AV occurred from the 3rd week, while for ApH and YpH, differences were observed from the 1st and 3rd weeks, respectively ($p \leq 0.01$), as shown in Table 2.

Dutra *et al.* (2021) found that elevated room temperature favors physicochemical reactions resulting in albumen degradation processes due to protein denaturation, leading to fluidization and decreased height. High temperatures cause yolk membrane stretching and increased permeability, accelerating water entry due to higher osmotic pressure, resulting in loss of spherical shape, increased diameter, and decreased height.

Table 2. Effect of storage temperature and storage time on quality parameters

Parameters	Storage Temperature		Sig	Storage Time					R ²	E
	Environ.	Refrig.		First Day ^x	1 Week	2 Weeks	3 Weeks	4-6 Weeks		
TAH (mm)	2.8±0.4	3.2±0.4	***	3.0±0.70 ^a	3.0±0.47 ^a	3.0±0.43 ^a	3.0±0.37 ^a	2.9±0.51 ^a	0.28	0.17
YH (mm)	7.4±1.3	9.0±1.5	***	9.0±1 ^a	8.3±1.5 ^a	8.4±1.4 ^a	7.9±1.7 ^a	7.4±1.6 ^a	0.33	1.71
YD (mm)	29.8±3.1	26.7±2.9	***	26.4±2.4 ^a	27.8±1.8 ^a	27.3±3.0 ^a	29.3±3 ^a	30.4±4.1 ^a	0.44	5.39
AV (cm ³)	3.8±1.0	4.2±1.0	NS	4.5±0.8 ^a	4.3±0.92 ^a	4.1±0.88 ^a	3.5±1 ^b	3.4±1 ^b	0.24	0.80
ApH	9.2±0.8	9.3±0.7	NS	8.7±0.26 ^a	9.3±0.73 ^b	9.5±0.74 ^b	9.7±0.82 ^b	9.2±0.45 ^b	0.22	0.44
YpH	7.2±0.7	7.2±0.8	NS	6.9±0.99 ^a	6.9±0.55 ^a	7.0±0.69 ^a	7.6±0.67 ^b	7.6±0.72 ^b	0.25	0.48
HU	80.6±3.2	83.5±2.3	***	82.0±5 ^a	82.8±2.8 ^a	82.2±2.4 ^a	81.5±2.1 ^a	82.0±3.2 ^a	0.24	7.26

NS – not significant; *** $p \leq 0.001$; ^x – reference category for Dunnet's multiple comparison test, different superscripts in the same row indicate significant differences for $p \leq 0.01$; E – Error; TAH – Thick Albumen Height, YH – Yolk Height, YD – Yolk Diameter, AV – Albumen Volume, ApH – Albumen pH, YpH – Yolk pH, HU – Haugh Units.

Similar processes are described by Lana *et al.* (2017) and Carvalho *et al.* (2023) regarding the decrease in albumen quality with increasing temperature; due to the denaturation of ovomucin, hydrolysis of amino acid chains occurs, CO₂ is lost, and water is released, resulting in greater fluidity, reduced viscosity, and increased dispersion when exposed on a surface. Consequently, there is lower TAH in eggs stored at room temperature and significant differences in HU values depending on storage temperature ($p \leq 0.001$) due to the direct influence of TAH on this parameter (Drabik *et al.*, 2021). Correspondingly, Saleh *et al.* (2020); Martínez *et al.* (2021) and Kim *et al.* (2024) found higher values of this parameter for eggs kept in refrigeration.

Giampietro-Ganeco *et al.* (2012) confirmed that refrigeration storage is efficient for maintaining YpH with acceptable quality values. Silva *et al.* (2020) explained that the increase in pH values during storage is related to CO₂ loss, which accelerates at high temperatures. Carbonic acid, one of the buffer system elements of albumen, dissociates into water and CO₂, which is released to the exterior through shell pores, resulting in pH increase, albumen liquefaction, and a decrease in thick albumen height. However, in this study, temperature did not significantly affect this parameter in any egg component.

AV showed a significant decrease starting from the third week ($p \leq 0.01$). Correspondingly, Silva *et al.* (2020) explained that the parameter reduction suggests dehydration through shell pores along with the loss of ammonia, sulfur gas, CO₂, and nitrogen. de Oliveira Carvalho *et al.* (2022) affirmed that the cuticle covering the shell's air pores dehydrates and begins to shrink, increasing porosity, facilitating the escape of CO₂ and water produced by biochemical reactions in the albumen, with a linear weight reduction.

Brito *et al.* (2020) investigated commercial chicken egg quality and concluded that age decisively influences pH values; the fresher the eggs, the lower the pH. For chickens, the optimal time is considered up to 25 days without substantial variations in quality. More research is needed to

establish criteria for the optimal time for quail eggs to maintain acceptable pH values based on storage time.

Limia and Cazanguie (2023) established a positive correlation of YpH with ApH in Angolan quail eggs, while it was negative with TAH and AV. Regarding these indicators, Alo *et al.* (2024) found a progressive decrease in TAH values in heavy breeding quail eggs with increasing storage time, observing significant differences from 15 days.

The buoyancy results showed that eggs stored at room temperature had higher percentages than refrigerated ones ($P < 0.001$), as shown in Table 3. These results align with those of Sert *et al.* (2011) and Akter *et al.* (2014), who determined that specific gravity decreased faster in eggs stored at room temperature than in refrigeration due to the air chamber's increase. Rosseto *et al.* (2018) and Diana *et al.* (2020) evaluated quality indicators and determined that higher temperatures result in lower density for the same reason, with simultaneous loss of component mass and weight reduction.

Table 3. Buoyancy percentages in common water based on storage temperature

Storage Temp	Floats (%)	Sinks (%)	Total (%)	Sig
Environment	63	37	100	***
Refrigeration	14	86	100	***

*** $P < 0.001$ for chi-square tests and directional (Lambda, Goodman and Kruskal's Tau, uncertainty coefficient) and symmetric (Phi, Cramer's V, contingency coefficient, Pearson's R) measures.

According to Zalapa (2016), there is a tendency for the air chamber size to increase as quality decreases due to dehydration and weight loss. This phenomenon reduces specific weight and promotes buoyancy in eggs stored at room temperature, where the mentioned changes occur more quickly.

CONCLUSION

Reducing temperature and storage time had a positive impact on most quality measuring parameters of quail eggs.

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AUTHOR CONTRIBUTION STATEMENT

Research conception and design: ECA; data analysis and interpretation: ELP; redaction of the manuscript: ELP.

CONFLICT OF INTEREST STATEMENT

The authors state there are no conflicts of interest whatsoever.