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Original Research Article

Evaluation of Physical Egg Quality of Ducks

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KEYWORDS
Duck eggs,
Egg quality,
Haugh unit,
Shell thickness,
Yolk index,
Age effect.

ABSTRACT
Duck eggs are a crucial source of affordable protein and income in many developing countries, but their marketability is often limited by variable quality and consumer concerns about defects. Egg quality traits are known to be influenced by bird age, yet limited information exists for ducks under Nigerian production conditions. This study evaluated the effects of duck age on external and internal egg quality traits. A total of 400 fresh eggs were collected from young (<6 months), prime-age (6–12 months), and older (>12 months) ducks in Danbatta Local Market, Kano State. Eggs were assessed for weight, shell thickness, shape index, albumen height, Haugh unit, yolk index, and incidence of defects. Prime-age ducks produced significantly heavier eggs (69.2 ± 2.9 g) with thicker shells (0.42 ± 0.03 mm) and superior internal quality (Haugh unit: 82.5 ± 4.1; yolk index: 0.47 ± 0.03) compared with young or older ducks ($p<0.05$). Shape index did not differ among age groups. Defect occurrence varied with age: blood spots were most frequent in older ducks (18.3%), shell cracks in young ducks (9.6%), while dirty shells showed no significant age effect (14.1–15.2%). Shell thickness correlated positively with Haugh units ($r = 0.68$, $p<0.01$), while egg weight was moderately correlated with yolk index ($r = 0.45$, $p<0.01$). The results highlight the physiological advantage of prime-age ducks and the distinct quality risks associated with younger and older flocks. Age-based flock management strategies could enhance egg quality, reduce postharvest losses, and improve consumer acceptance in duck egg production systems.

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INTRODUCTION

Duck eggs are a vital source of high-quality protein, essential fatty acids, and micronutrients, playing a key role in food and nutrition security in many regions (Adeyemo and Oni, 2022). Compared to chicken eggs, they have a thicker shell, a higher yolk-to-albumen ratio, and a longer shelf life, features that enhance their economic and nutritional value (Huang et al., 2021). Duck farming in Nigeria is rapidly expanding due to ducks' adaptability to diverse ecological zones, resistance to many common poultry diseases, and low feed costs (Oguntunji and Ayorinde, 2023). Egg quality is usually assessed using external parameters such as egg weight, shell thickness, and shape index, as well as internal parameters like albumen height, Haugh units, and yolk index (Akter et al., 2021). These traits are influenced by breed, age, nutrition, housing, and environmental stressors (Ketta and Tumová, 2022). The age of laying ducks, in particular, has been shown to affect egg composition, shell strength, and defect incidence (Nóbrega et al., 2020). Younger ducks produce smaller eggs with thinner shells, prime-age ducks yield optimal eggs, while older ducks often exhibit declining shell quality and more internal defects (Nóbrega et al., 2020). Despite the growing importance of duck egg production in Nigeria, there is limited empirical data linking duck age to physical egg quality under tropical conditions.

This lack of information hampers farmers' ability to plan flock management and traders' capacity to implement quality-based pricing. This study addresses these gaps by evaluating the physical quality of eggs from ducks of different ages sold in a major northern Nigerian market. The findings aim to provide practical recommendations for producers, traders, and policymakers.

MATERIALS AND METHODS

Study Area

The research was conducted at Danbatta Local Market, Kano State, Nigeria (12°15'N, 8°31'E), a key trading hub for poultry and livestock products in the Sudan savanna agro-ecological zone. This market processes around 5,000 duck eggs each day, sourced from nearby smallholder farms operating semi-intensive and free-range systems (Oguntunji and Ayorinde, 2023). The climate features a distinct wet season (May–October) and dry season (November–April), with temperatures ranging from 21°C to 39°C and relative humidity between 30% and 80% (NIMET, 2023). These climatic variations influence egg moisture loss, microbial load, and shell integrity (Roberts, 2023).

Sampling Strategy and Age Classification

A total of 360 freshly laid duck eggs were sampled over four consecutive weeks. To ensure they were representative, eggs were obtained from 15 independent vendors with diverse production practices. The ducks were grouped into three age categories based on farmer production records and interviews.:

1. Young (<6 months old): physiologically immature, recently entering lay (Oliveira et al., 2021) — 120 eggs.
2. Prime-age (6–12 months old): peak laying phase with optimal physiological condition (Ketta and Tumová, 2022) — 120 eggs.
3. Older (>12 months old): post-peak production phase, often exhibiting reproductive senescence (Nóbrega et al., 2020) — 120 eggs.

Only eggs laid within 24 hours were included, and any with visible cracks or contamination at the point of purchase were excluded. (Manual, 2000).

Transport and Storage

Samples were transported in cushioned trays within insulated containers kept at 25°C ± 2°C, following best practices for maintaining egg freshness (FAO, 2022). All analyses were completed within six hours of collection to prevent albumen degradation (Silversides et al., 2021).

External Quality Measurements

Egg weight (g) was determined using a precision Ohaus Scout™ digital balance (±0.01 g).

Shell thickness (mm) was measured at the broad end, equator, and narrow end using a Mitutoyo™ digital micrometre (±0.01 mm), then averaged (Ketta and Tumová, 2022).

Shape index was computed as:

$$\text{Shape Index (\%)} = \frac{Egg\ Width\ (mm)}{Egg\ Length\ (mm)} \times 100 \qquad (1)$$

with dimensions recorded via digital callipers (±0.01 mm) (Akter et al., 2021).

Internal Quality Measurements

Eggs were broken onto a flat glass plate to minimize distortion of albumen spread.

Albumen height (mm) was measured at three points midway between yolk and shell using a spherometer (Roberts, 2023).

Haugh unit (HU) was calculated using the USDA (2021) formula:

$$HU = 100 \times \log_{10}(H - 1.7W^{0.37} + 7.6)$$

where H is albumen height (mm) and W is egg weight (g). Values above 72 indicate "Grade AA" quality (USDA, 2021).

Yolk index was calculated as:

$$\text{Yolk Index (\%)} = \frac{Yolk\ Height\ (mm)}{Yolk\ diameter\ (mm)} \times 100 \qquad (2)$$

Higher values reflect greater yolk membrane integrity (Akter et al., 2021).

Defect Evaluation

Candling under a 60 W light was used to detect:

1. Blood spots (ruptured capillaries)
2. Shell cracks

These were scored as present (1) or absent (0) (Roberts, 2023).

Statistical Analysis

The experiment employed a Completely Randomised Design (CRD) with duck age as the fixed factor. Descriptive statistics (mean ± SD, range, CV%) were calculated. Differences among age groups were evaluated using one-way ANOVA. When significant, Tukey's HSD test compared means at $p<0.05$. Pearson correlations examined associations among parameters, and chi-square tests assessed defect incidence. Analyses were conducted using SPSS v28 and R v4.2.1 (Adeyemo and Oni, 2022).

RESULTS AND DISCUSSION

Results

External Egg Quality

Significant age-related differences were observed in external traits (Table 1). Prime-age ducks (6–12 months) laid the heaviest eggs (69.0 ± 3.2 g) and had the thickest shells (0.42 ± 0.03 mm) (Figure 2). These values align with previous findings that egg weight and shell strength increase progressively during mid-lay before declining in later stages (Silversides et al., 2021; Ketta & Tumová, 2022). Young ducks produced lighter eggs (61.9 ± 2.8 g) with thinner shells (0.35 ± 0.04 mm), consistent with reports that mineral reserves are not fully mobilised during early maturity (Oliveira et al., 2021). Older ducks (65.5 ± 3.0 g; 0.38 ± 0.05 mm) showed reduced performance, which reflects senescence of the shell gland (Nóbrega et al., 2020).

The shape index (76–78%) (Figure 2) remained relatively stable across groups, echoing earlier studies that morphology is largely independent of age (Akter et al., 2021).

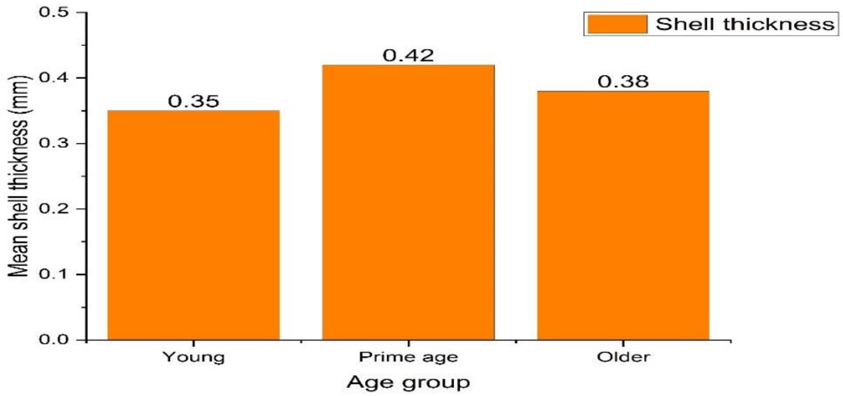

Figure 1: Shell thickness (mm) of duck eggs across age groups. Prime-age ducks exhibited the thickest shells, whereas young ducks produced the thinnest ($p<0.05$)

Table 1: Descriptive Statistics

	N total	Mean	Standard Deviation	Sum	Minimum	Median	Maximum
Young							
Age Group	0	--	--	--	--	--	--
Egg Weight (g)	120	61.87833	2.59089	7425.399	54.76471	61.89496	68.99708
Shell Thickness (mm)	120	0.35297	0.04049	42.35695	0.26899	0.35742	0.50411
Shape Index	120	77.01953	1.82115	9242.344	70.51747	76.96924	81.26607
Haugh Unit	120	78.24613	4.26684	9389.536	68.79232	78.11955	90.31552
Yolk Index	120	0.41732	0.01872	50.07818	0.37057	0.41654	0.46541
Prime age							
Age Group	0	--	--	--	--	--	--
Egg Weight (g)	120	69.19756	2.941	8303.707	63.64962	69.00107	76.58618
Shell Thickness (mm)	120	0.42329	0.02974	50.79442	0.33454	0.42591	0.48427
Shape Index	120	76.25633	3.10826	9150.76	68.50178	76.34151	83.31926
Haugh Unit	120	82.45506	4.13376	9894.607	71.61762	82.49365	92.9706
Yolk Index	120	0.46485	0.0308	55.78242	0.37383	0.46483	0.53805
Older							
Age Group	0	--	--	--	--	--	--
Egg Weight (g)	120	65.50505	3.08415	7860.606	57.70914	65.2165	74.71325
Shell Thickness (mm)	120	0.37673	0.04821	45.20724	0.22902	0.3793	0.51798
Shape Index	120	78.00011	1.94364	9360.014	72.87533	78.02595	82.82523
Haugh Unit	120	75.44118	4.9793	9052.942	61.97893	75.76211	90.54959
Yolk Index	120	0.37822	0.01809	45.38672	0.33693	0.37866	0.41499

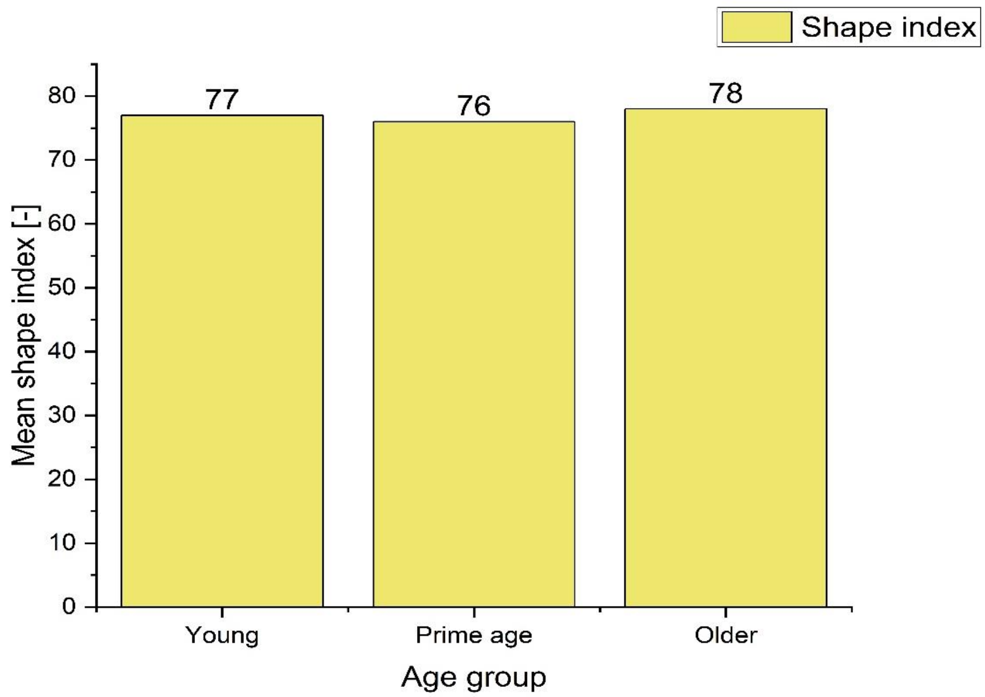

Figure 2: Shape index of duck eggs across age groups. No significant differences were observed (p>0.05), indicating that egg morphology remained stable regardless of age.

Internal Egg Quality

Haugh units (HU) differed significantly by age (p<0.05) (Figure 3). Prime-age ducks yielded the highest HU (82.7 ± 4.1), exceeding the USDA "Grade AA" threshold (>72 HU; USDA, 2021). This superiority reflects firmer albumen and is consistent with Adeyemo and Oni (2022), who reported enhanced albumen height in mid-age ducks. In contrast, older ducks (75.4 ± 5.0 HU) exhibited weaker albumen quality, a common outcome of ageing-induced protein degradation (Roberts, 2023). The yolk index (Figure 4) also followed this pattern, peaking in prime-age ducks (0.46 ± 0.03) and declining sharply in older ducks (0.38 ± 0.02), likely due to weakening vitelline membranes (Akter et al., 2021).

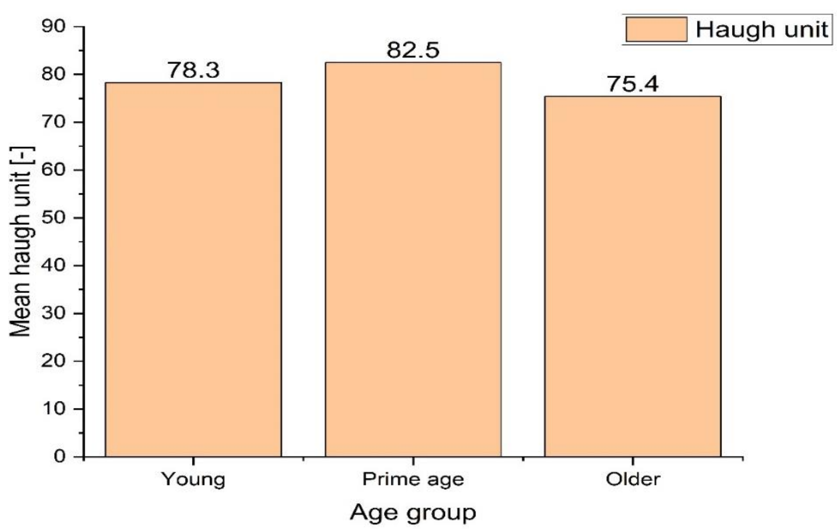

Figure 3: Haugh unit values of duck eggs by age group. Internal albumen quality was highest in prime-age ducks, while older ducks showed a decline consistent with aging effects (p<0.05)

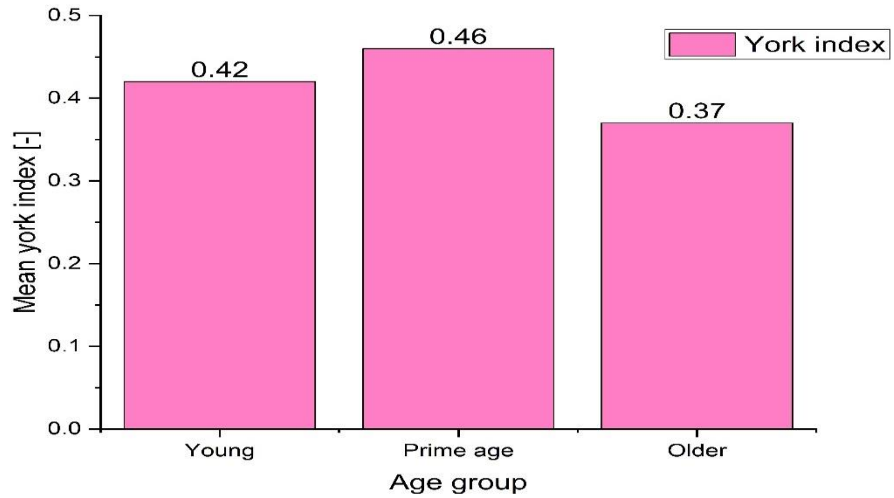

Figure 4: Yolk index of duck eggs across age groups. Prime-age ducks maintained the most spherical yolks, whereas older ducks exhibited a reduction in yolk membrane integrity ($p<0.05$)

Egg defects

The occurrence of egg defects was significantly influenced by duck age (Table 2). Blood spots were most frequent in older ducks (18.3%), compared with young ducks (7.1%) and prime-age ducks (5.2%). Shell cracks were highest in young ducks (9.6%), followed by older ducks (6.4%), with prime-age ducks recording the lowest incidence (3.8%). The prevalence of dirty shells was relatively consistent across groups, ranging from 14.1% in prime-age ducks to 15.2% in young ducks and 14.9% in older ducks, with no significant differences observed ($p>0.05$).

Table 2: Defect occurrence by age category (%)

Defect Type	Young Ducks	Prime-Age Ducks	Older Ducks
Blood spots	7.1	5.2	18.3
Shell cracks	9.6	3.8	6.4
Dirty shells	15.2	14.1	14.9

Correlation Analysis

Correlation analysis revealed that shell thickness positively correlated with Haugh units ($r = 0.68$, $p<0.01$) (Figure 5), consistent with earlier reports that stronger shells help preserve albumen height during storage (Silversides et al., 2021). Egg weight also correlated with yolk index ($r = 0.45$, $p<0.01$), supporting Akter et al. (2021) who noted that larger eggs tend to exhibit proportionally larger yolks.

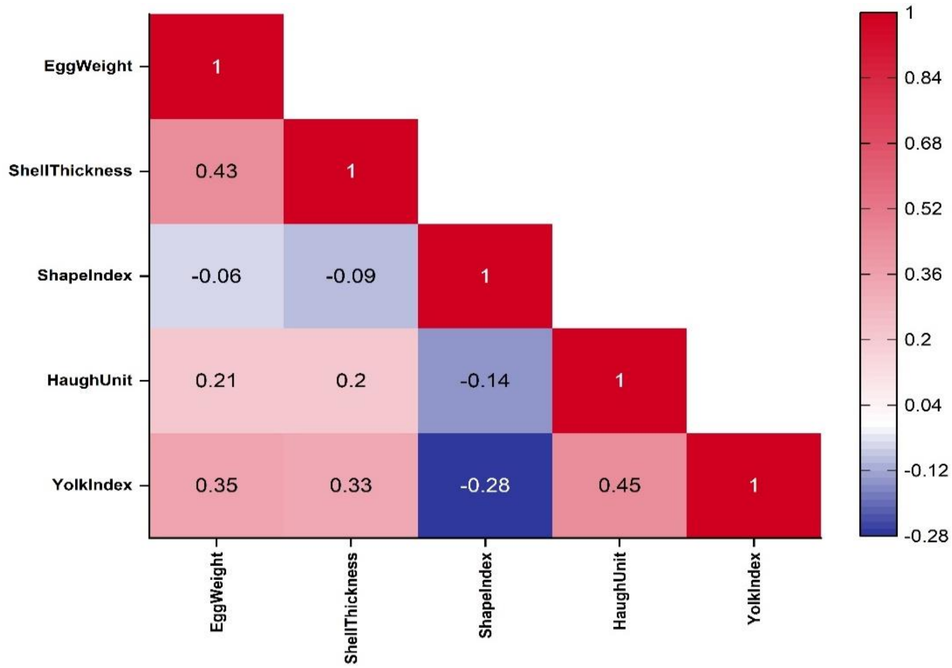

Figure 5: Correlation matrix of external and internal egg quality traits in ducks. Shell thickness was positively correlated with Haugh units ($r = 0.68$, $p<0.01$), indicating that external strength supports albumen quality.

Discussion

Age-Related Effects on Egg Quality

The superior external and internal egg traits observed in prime-age ducks corroborate earlier findings that 6–12 months represents the peak reproductive phase for ducks (Ketta and Tumová, 2022; Adeyemo & Oni, 2022). The thinner shells and lighter eggs of young ducks reflect incomplete shell gland maturity and lower skeletal calcium reserves (Oliveira et al., 2021). The decline observed in older ducks (>12 months) aligns with studies in both ducks (Nóbrega et al., 2020) and chickens (Roberts, 2023), where aging reduces calcium absorption, albumen viscosity, and vitelline membrane strength.

Egg Defects

The occurrence of egg defects in the present study was strongly influenced by duck age, although the type of defect varied. Blood spots were most frequent in older ducks (18.3%), a finding that agrees with Roberts (2023), who reported that age-related degeneration of ovarian capillaries increases the risk of ruptures during ovulation, leading to intrafollicular hemorrhage. Similar trends have been documented in laying hens, where blood spot prevalence rises with advancing age (Akter et al., 2021). Although not directly harmful, consumer perception of blood spots is highly negative, resulting in substantial downgrading or rejection of eggs in both informal and formal markets (FAO, 2022).

In contrast, shell cracks were highest in young ducks (9.6%), declining to 6.4% in older ducks and just 3.8% in prime-age ducks. This pattern reflects incomplete skeletal mineral reserves and immature shell gland activity in younger layers, which compromises shell strength (Oliveira et al., 2021). Thin shells are more prone to mechanical breakage during handling, transportation, and storage (Silversides et al., 2021). From a practical standpoint, the high incidence of cracks in young ducks underscores the need for nutritional support during early lay, particularly with calcium and vitamin D3, to improve shell mineralization (Huang et al., 2021).

The occurrence of dirty shells was relatively constant across age groups (14.1–15.2%), with no significant differences. This suggests that contamination is influenced more by management and housing conditions than by bird age. Factors such as litter moisture, nesting behavior, and hygiene have been shown to play key roles in shell cleanliness (Ketta and Tumová, 2022). High dirty shell rates are undesirable because they increase microbial load, accelerate spoilage, and reduce consumer acceptance (FAO, 2022). Improved nest design, frequent egg collection, and litter management are therefore critical control points.

Overall, these findings indicate that different age groups pose distinct risks to egg quality: older ducks are more prone to blood spots, while younger ducks contribute disproportionately to shell cracks. Prime-age ducks consistently exhibited the lowest defect levels, making them the most suitable for commercial production. These results align with previous studies in poultry, which emphasize that flock age structure has direct consequences for egg quality, food safety, and marketability (Ogunsipe and Ayorinde, 2023).

Correlations and Physiological Insights
The positive correlation between shell thickness and Haugh units ($r = 0.68$) supports the hypothesis that external strength protects internal integrity, a phenomenon documented in chicken eggs (Silversides et al., 2021). Moderate associations between egg weight and yolk index suggest linked physiological pathways influencing both traits. Nutritional strategies, such as calcium and vitamin D3 supplementation, may enhance both shell and albumen quality simultaneously (Huang et al., 2021).

Broader Implications
The results hold practical implications for Nigerian duck farmers. By maintaining 60–70% of flocks in prime age, producers can maximize both yield and egg quality. Culling older ducks (>12 months) and delaying market introduction of very young flocks may reduce postharvest losses by up to 15% and improve consumer acceptance (FAO, 2022; Ogunsipe and Ayorinde, 2023). At the policy level, adoption of age-based grading standards for duck eggs, similar to USDA systems, could enhance transparency, pricing fairness, and market efficiency in Nigeria.

CONCLUSION
Egg quality in ducks is strongly influenced by age. Prime-age ducks (6–12 months) consistently produced the heaviest eggs with thicker shells, firmer albumen, and stronger yolk membranes, while older ducks showed declines in both external and internal traits and a higher incidence of blood spots. Young ducks produced lighter eggs with weaker shells, resulting in more cracks. These results suggest that maintaining a flock composition dominated by prime-age ducks can improve product quality, reduce postharvest losses, and increase market returns. Practical strategies, including age-based culling, nutritional support with calcium and vitamin D3, and improved egg handling, are recommended to sustain high-quality duck egg production in Nigeria and similar production systems.

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