Research Article

A Systematic Review of the Association Between Egg Weight and Egg Quality Traits

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Abstract | Egg quality traits encompass external and internal traits that determine the suitability of eggs for consumption. However, the correlation between the egg weight and characteristics determining egg quality is inconclusive. According to the author's knowledge, no systematic review has been conducted to consolidate findings on this relationship between egg weight and egg quality traits. The main goal was to systematically review the literature published on phenotypic correlation between egg weight and egg quality characteristics in chickens. Databases, namely Google Scholar, Web of Science, ScienceDirect, and PubMed, were used to search for literature. A total of five (n = 5) eligible articles were found published between 2005 and 2023 in China, Canada, USA, Europe, and Indonesia. The results revealed that egg weight and various egg quality characteristics, such as yolk weight (r = 0.45 - 0.68), albumen weight (r = 0.84 - 0.87), and shell weight (r = 0.53 - 0.67), were highly phenotypically correlated ($p < 0.01$). Furthermore, the results indicated that shell thickness (r = 0.32) and shell strength (r = 0.02) were phenotypically correlated with egg weight at ($p < 0.05$). These findings emphasize that certain traits, particularly albumen and shell weight, are consistently linked to egg weight, offering practical insights for breeding and grading strategies. One of the drawbacks of the study is that not all egg quality traits were studied in relation to egg weight in chickens, which makes it difficult to have enough information about the phenotypic correlations of all egg quality traits. The systematic review concluded that shell weight, yolk weight, albumen weight, shell thickness, and shell strength were phenotypically correlated with egg weight. However, more studies need to include many egg quality traits.

Keywords | Association, Albumen weight, Shell thickness, Yolk weight, Shell strength

Received | April 03, 2025; **Accepted** | June 29, 2025; **Published** | October 20, 2025
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Citation | Sathekge LJ, Tyasi TL (2025). A systematic review of the association between egg weight and egg quality traits. J. Anim. Health Prod. 13(4): 1002-1007.
DOI | https://dx.doi.org/10.17582/journal.jahp/2025/13.4.1002.1007
ISSN (Online) | 2308-2801

INTRODUCTION

Egg weight in chickens significantly influences various egg quality traits, making it a critical factor in poultry production (Wolc *et al.*, 2012). Egg weight is a key determinant of market value, so low egg weight affects consumers preferences (Inca *et al.*, 2022). Egg quality plays a crucial role not only in consumer satisfaction but also in hatchability, shell strength, and transportability, all of which directly affect profitability in both the table egg and breeder sectors (Roberts, 2004; Monira *et al.*, 2003). Different approaches, including selective breeding, have been used to improve productivity, with key selection criteria focusing on crucial factors like egg weight (Tribudi *et al.*, 2023).

Phenotypic correlations of egg weight with albumen and yolk dimensions show that an elevation in egg weight has a minimal effect on albumen and yolk dimensions (Inca *et al.*, 2022). Furthermore, depending only on phenotypic

correlations fails to consider the intricate interactions among genetic, environmental, and management factors that affect egg quality traits (Chen *et al*., 2024). This issue is especially critical for enhancing grading standards and achieving production uniformity, which are becoming more important in commercial operations that utilize automated egg handling and sorting systems (Mertens *et al*., 2011).

ccording to the author's knowledge, there is no comprehensive systematic review on the association between egg weight and egg quality traits. Therefore, this study will assist in indicating the egg quality traits that are associated with egg weight. Hence, the objective of this study was to systematically review the publications on the correlation between egg weight and attributes that define egg quality. The systematic review outcome will benefit poultry farmers, breeders, and the egg industry by providing insights into how egg weight affects quality traits, helping to improve breeding strategies, optimizing production, enhancing egg grading standards, and maximizing economic returns.

MATERIALS AND METHODS

Eligibility criteria

The components of the Population, Exposure, and Outcomes (PEO) framework were identified for this systematic review. The "Chicken" was defined as the study population, "egg weight" as an intervention, and "egg quality traits" as the outcome. Before proceeding with the study, a preliminary search of the PEO elements was conducted on Web of Science. Studies were eligible if they were peer-reviewed, focused on the relationship between egg weight and egg quality traits, and provided empirical data. Studies not written in English or not accessible in full-text format were excluded.

Searched strategy

A scientific literature search was conducted by two investigators using databases including Web of Science, PubMed, Google Scholar, and ScienceDirect. The search employed the following keyword combinations: association OR relationship OR linkage OR correlation, "egg weight"," and "egg quality characterisctics" OR "egg characteristics" OR "egg quality parameters". The keywords were explored in various combinations, and only studies published in English were included in the review.

Inclusion criteria

All retrieved articles were screened for eligibility based on several criteria and considered for inclusion if they met the requirements. Articles had to report at least one statistical measure of correlation between egg weight and another egg quality trait. Only original research studies were considered.

Exclusion criteria

Articles were excluded if the requirements were not met, such as duplicate records, abstracts not including the keywords, and articles not containing anything regarding the keywords. Additionally, non-peer-reviewed materials were excluded.

Data extraction

To ensure consistency, a calibrated exercise was conducted before full extraction, in which both reviewers independently reviewed and discussed a small sample of articles to ensure uniform understanding of the criteria. Any disagreements during the screening process were resolved through discussion of the abstracts, ultimately reaching a consensus. The extracted information from each article included the first author, year.

RESULTS

Figure 1 presents a flowchart outlining the step-by-step process of identifying and selecting studies for inclusion in the systematic review. During the initial search, forty-one articles (n = 41) were retrieved. Eighteen articles (n = 18) were removed as duplicates, and twenty-three articles (n = 23) remained. The twenty-three articles (n = 23) were screened for title, and none of them were removed because they had keywords. During the abstract screening, sixteen articles (n = 16) were removed because their abstracts did not include the relationship between egg quality traits of chickens. We had 7 articles (n = 7) that we assessed for eligibility, and two articles (n = 2) were removed because they did not contain anything regarding the correlation between egg quality traits of chickens in the results section. A total of five articles (n = 5) were included in the systematic review.

Characteristics of included studies

A total of five articles (n = 5) were accessed and selected as meeting the criteria for inclusion in the review, as shown in Table 1. Out of the five articles (n = 5), three articles (n = 3) (Wolanski *et al*., 2007; Inca *et al*., 2022; Tribudi *et al*., 2023) were specific on the breed however two articles (n = 2) (Zhang *et al*., 2005; Kraus *et al*., 2020) were not specific on the breed.

Publication by year

All the articles that were included in the systematic review were published between 2005 and 2023, as shown in Figure 2. The two articles (n = 2) were published between the years 2005 and 2007 (Zhang *et al*., 2005; Wolanski *et al*., 2007). Two articles (n = 2) were both published in the year 2020 (Inca *et al*., 2022; Kraus *et al*., 2020).

Table 1: Characterization of included studies.

Authors	Year	Country	Journal name	Chicken breed
Kraus *et al.*,	2020	Europe	Acta Universitatis Agriculture et Silviculturae Mendelianae Brunensis	Brown and White Egg Laying Hens
Inca *et al.*,	2020	USA	International Journal Poultry Science	Hy-line Brown Laying Hens
Zhang *et al.*,	2005	China	Poultry Science	Brown-egg dwarf layers
Wolanski *et al.*,	2007	Canada	Poultry Science	Broiler
Tribudi *et al.*,	2023	Indonesia	BIO Web of Conference	Tukong Chickens

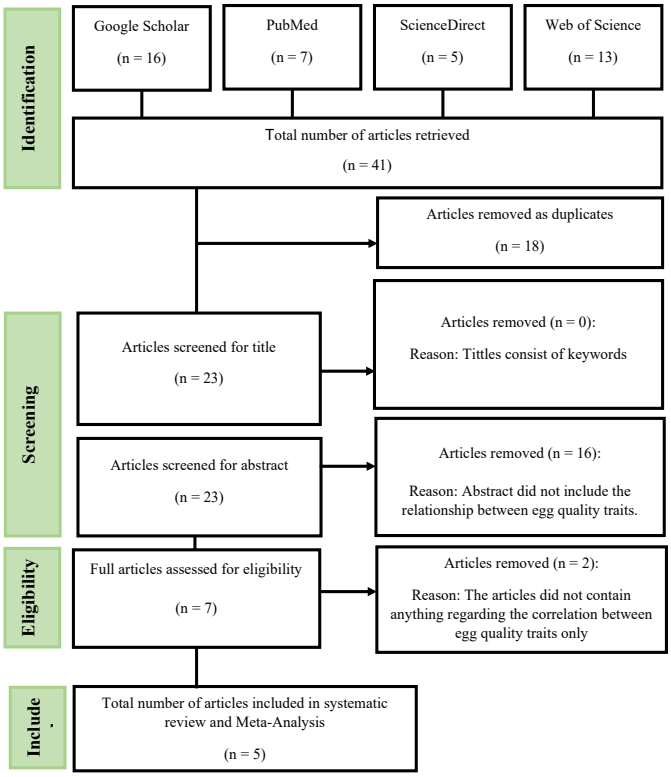

Figure 1: Flow chart of identification and selection of studies for systematic review.

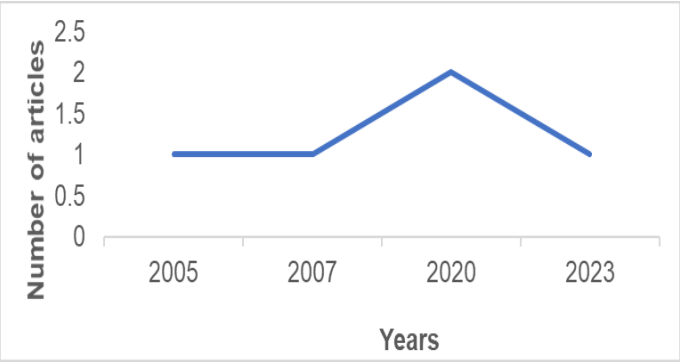

Figure 2: Publication by year.

Publication by country

The results indicated that out of the five articles (n = 5) that were included, they were conducted in different countries, as shown in Figure 3. Article (Zhang *et al.*, 2005) was published in China, article (Wolanski *et al.*, 2007) was published in Canada, article (Inca *et al.*, 2022) was published in the USA, article (Kraus *et al.*, 2020) was published in Europe and lastly article (Tribudi *et al.*, 2023) was published in Indonesia.

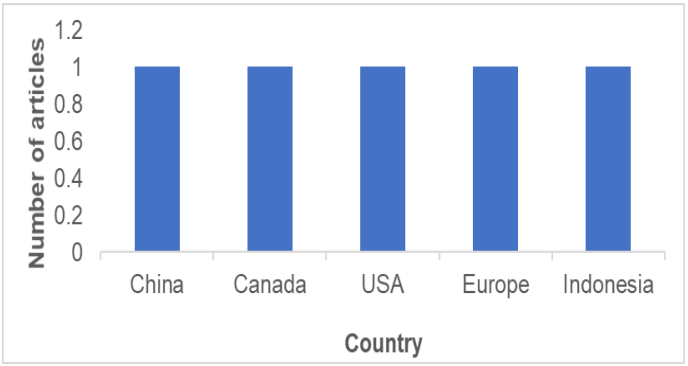

Figure 3: Publication by country.

Publication by journal

Figure 4 presents the publications by journal for the articles used in this review. The results showed that two articles (n = 2) were published in the same journal named Poultry Science (Zhang *et al.*, 2005; Wolanski *et al.*, 2007). The remaining 4 articles (n = 4) were published in different journals (Inca *et al.*, 2022; Kraus *et al.*, 2020; Tribudi *et al.*, 2023).

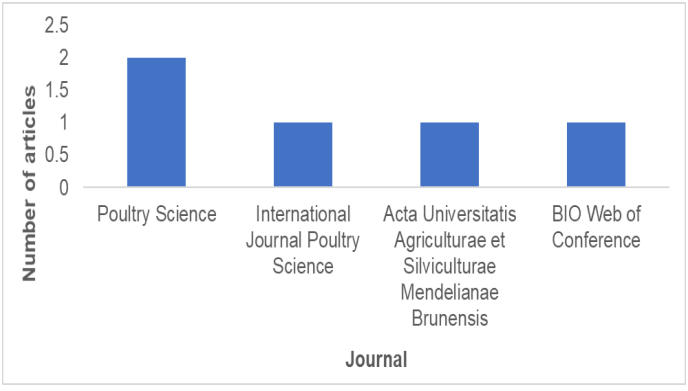

Figure 4: Publication by Journal.

Publication by breed

Publication by breed is represented in Figure 5. The results indicated that all 5 articles (n = 5) that are included in this review used different breeds.

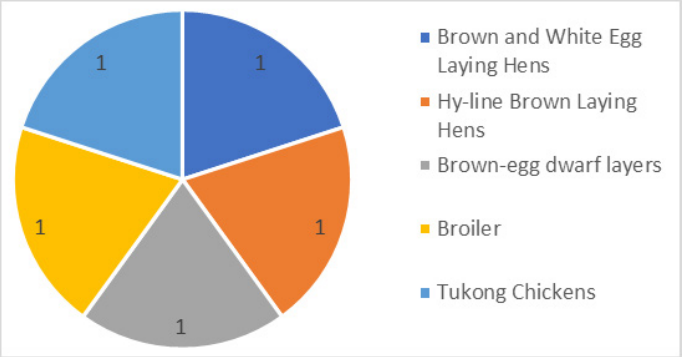

Figure 5: Publication by breed.

Phenotypic correlation between egg weight and yolk weight

Table 2 indicates the phenotypic association between egg weight and yolk weight. The results showed that out of the five included articles (n = 5), only two articles (n = 2) (Wolanski *et al.*, 2007; Kraus *et al.*, 2020) studied the phenotypic correlation between egg weight and yolk weight. The results reported that there was a strong positive correlation between egg weight and yolk weight in both articles. This suggests a consistent trend, at least among the limited studies available, the heavier eggs tend to have proportionally larger yolks. However, both studies did not report on breed-specific responses, making it difficult to assess if this relationship varies significantly across genetic backgrounds.

Table 2: Phenotypic correlation between egg weight and yolk weight

Author	Year	Egg quality trait		Significance
Kraus *et al.*,	2020	Egg weight	Yolk weight	**
Wolanski *et al.*,	2007			**

Phenotypic correlation between egg weight and albumen weight

The phenotypic relationship between egg weight and albumen weight is summarized in Table 3. From the reviewed articles, the results indicated that two articles (n = 2) (Wolanski *et al.*, 2007; Kraus *et al.*, 2020) studied the phenotypic correlation between egg weight and albumen weight. Both articles (n = 2) (Wolanski *et al.*, 2007; Kraus *et al.*, 2020) reported a strong positive correlation between albumen weight and egg weight. This consistency reinforces the biological expectation that an increase in egg weight corresponds to greater albumen content. These findings are significant because albumen hight and volume are often linked to egg freshness and internal quality.

Phenotypic correlation between egg weight and shell weight

Table 4 presents the phenotypic correlation between egg weight and shell weight. The findings indicated that from the reviewed articles, four articles (n = 4) (Zang *et al.*, 2005; Wolanksi *et al.*, 2007; Kraus *et al.*, 2020; Inca *et al.*, 2022) out of five articles (n = 5) studied the phenotypic relationship between egg weight and shell weight. It was reported that all four articles (n = 4) (Zang *et al.*, 2005; Wolanksi *et al.*, 2007; Kraus *et al.*, 2020; Inca *et al.*, 2022) reported a highly significant correlation between egg weight and shell weight. The consistent results from four studies conducted in various countries with different breeds enhance the credibility of this finding. Nonetheless, the studies did not thoroughly address the variations in correlation strength, indicating an area for further exploration.

Table 3: Phenotypic correlation between egg weight and albumen weight

Author	Year	Egg quality trait		Significance
Kraus *et al.*,	2020	Egg weight	Albumen weight	**
Wolanski *et al.*,	2007			**

Table 4: Phenotypic correlation between egg weight and shell weight.

Author	Year	Egg quality trait		Significance
Kraus *et al.*,	2020	Egg weight	Shell weight	**
Inca *et al.*,	2020			**
Zang *et al.*,	2005			**
Wolanski *et al.*,	2007			**

Table 5: Phenotypic correlation between egg weight and shell thickness.

Author	Year	Egg quality trait		Significance
Kraus *et al.*,	2020	Egg weight	Shell thick-ness	ns
Zang *et al.*,	2005			*

Phenotypic correlation between egg weight and shell thickness

Table 5 indicates the phenotypic relationship between egg weight and shell thickness. The results showed that two articles (n = 2) (Zang *et al.*, 2005; Kraus *et al.*, 2020) out of the five reviewed articles (n = 5) investigated the phonotypic correlation between egg weight and shell thickness. The results have indicated that the article (Kraus *et al.*, 2020) had a non-significant phenotypic correlation between egg weight and shell thickness. The results also revealed a significant phenotypic correlation between egg weight and shell thickness in an article (Zang *et al.*, 2005). The results might suggest variability in how shell thickness responds to increases in egg weight across different environments or genetic conditions.

Phenotypic correlation between egg weight and shell strength

Below is Table 6, which shows the phenotypic relationship between egg weight and shell strength. Out of the five

included articles (n= 5) in the study, only two articles (n= 2) (Wolanski *et al.*, 2007; Kraus *et al.*, 2020) focused on the phenotypic correlation between egg weight and shell thickness. The finding revealed that one article (n = 1) (Kraus *et al.*, 2020) had no significant phenotypic correlation between egg weight and shell strength, and the other article (Wolanksi *et al.*, 2007) had a significant phenotypic correlation between egg weight and shell strength. As with shell thickness, this variation may stem from breed differences or differences in measurement methods.

Table 6: Phenotypic correlation between egg weight and shell strength.

Author	Year	Egg quality traits		Significance
Kraus *et al.*,	2020	Egg weight	Shell strength	ns
Wolanski *et al.*,	2007			*

DISCUSSION

It is important to consider the relationship between egg quality characteristics in order to maintain quality and address challenges such as shelf life and marketing of eggs (Inca *et al.*, 2022). This systematic review was carried out to reveal the phenotypic relationship between egg weight and egg quality traits. In total, five articles (n= 5) were included in this systematic review. The results revealed that yolk weight, albumen weight, shell thickness, shell weight, and shell strength were associated with egg weight. The findings indicated that four articles (n= 4) (Zang *et al.*, 2005; Wolanski *et al.*, 2007; Inca *et al.*, 2022; Kraus *et al.*, 2020) reported a phenotypic correlation between egg weight and shell weight, while two articles (n= 2) (Wolanski *et al.*, 2007; Kraus *et al.*, 2020) reported a correlation regarding egg weight and yolk weight, albumen weight, and shell strength. Lastly, a phenotypic correlation was noted between egg weight and shell thickness (Zang *et al.*, 2005; Kraus *et al.*, 2020).

The findings are consistent with a study by Jegede *et al.* (2024), which identified a moderate to strong positive correlation between yolk weight and egg weight in commercial layers. This aligns with the outcome of this review, indicating that heavier eggs generally contain larger yolks, thereby supporting the biological premise that yolk formation is a major contributor to overall egg mass. Additionally, Vekić et al. (2022) reported similar results, observing a significant positive correlation between egg weight and albumen weight across various chicken strains. This supports the consistent relationship identified in this review, viewing albumen content as a predictor of egg mass. The reported strong phenotypic correlation between egg weight and shell weight is supported by the findings of Supasini *et al.* (2024), who demonstrated a linear relationship between the two traits in brown egg layers under different environmental conditions. The relationship between egg weight and shell strength seems inconsistent. This is illustrated in this review and reinforced by Fu (2024) who found that while shell strength generally decline with hen age, significant factors like calcium metabolism and shell mineralization also significantly influence strength.

To the authors knowledge, this is the first systematic review reporting on the phenotypic association between egg weight and parameters of egg quality of chickens. Hence, there is no comparison with other systematic review findings on this topic. The results of this systematic review imply that egg quality traits can be leveraged to improve the egg weight of chickens. The strength of this systematic review lies in the fact that no similar review has been conducted on the relationship between egg weight and egg quality traits of chickens. This review contributes to the body of knowledge by evaluating egg quality traits to enhance the egg weight of chickens. A major constraint of this study is that other articles documented the phenotypic correlation using a limited number of egg quality traits in relation to egg weight. However, the review is limited by the small number of eligible studies and the methodological differences across them, which may affect the consistency and generalizability of the results. The review, however, is constrained by the limited number of eligible studies and the methodological variations among them, which may influence the consistency of the findings. Future research should focus on incorporating larger sample sizes, standardizing trait measurements, and investigating a wider array of internal and external egg quality factors, such as shell color, yolk index, and Haugh unit. This approach would deepen our understanding of how egg weight interacts with various quality parameters across different breeds and production environments. Ultimately, this review lays a foundation for further investigations aimed at optimizing egg quality through phenotypic trait selection and provides valuable insights for producers and breeders alike.

CONCLUSION

In conclusion, the systematic review suggests a phenotypic correlation between egg weight and egg quality traits, including yolk weight, albumen weight, and shell weight. These findings highlight potential applications in poultry breeding programs, where traits like albumen weight or shell weight could serve as indirect selection markers to enhance egg weight. Additionally, the correlations may inform improvements in egg grading systems by refining classification standards based on internal quality characteristics.

ACKNOWLEDGEMENT

The authors wish to acknowledge the Department of Agricultural Economics and Animal Production at the University of Limpopo. No funding is provided for this study. The authors declare that there is no conflict of interest.

NOVELTY STATEMENT

This study shows consistent correlations of egg weight with egg quality traits, particularly with albumen, yolk, and shell weights, providing new insights for breeding for egg weight improvement.

AUTHOR'S CONTRIBUTION

TLT: Designed the manuscripts and examined and validated the final manuscript.
SLJ: Manuscript written.

Generative AI and AI-assisted technology statement

The generative AI and AI assisted technology were not used in the creation of this manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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