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EVALUATING THE RELATIONSHIP BETWEEN EGG WEIGHT AND VILLAGE CHICKEN EGG QUALITY IN SRI LANKA

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Abstract

This study aimed to investigate how egg weight affects the internal and external quality of the eggs in village chickens. A total of 335 eggs were obtained from 28-week-old Naked Neck and Central Poultry Research Station (CPRS) crossbreed village chickens. The eggs were weighed and categorized into four weight groups: large (56-65g), medium (49-56g), small (42-49g), and peewee (30-42g). Data pertaining to external egg quality characteristics (including egg weight, egg length, egg width, shape index, shell weight, and shell thickness) and internal egg quality characteristics (comprising egg internal weight, yolk weight, albumen weight, albumen pH, yolk length, albumen height, yolk height, and Haugh unit) were gathered. These data were subjected to analysis using SPSS version 25. The results showed that egg weight significantly ($p<0.05$) influenced egg length, egg width, shell weight, shell thickness, egg internal weight, yolk weight, albumen weight, albumen pH, yolk length, yolk color, albumen height, yolk height, and Haugh unit. However, specific gravity and shape index were not significantly ($p<0.05$) affected by egg weight. The analysis revealed positive correlations ($p<0.05$) between egg weight and egg length, egg width, shape index, shell weight, yolk weight, albumen weight, yolk length, albumen height, and yolk height. In conclusion, this study underscores the pivotal role of egg weight in determining the quality of both external and internal characteristics of village chicken eggs.

Keywords
CPRS crossbreed, Egg weight, Egg external quality, Egg internal quality, Naked Neck, village chicken

1. Introduction

"Poultry" is a term used to describe commercially significant species raised for meat and egg or entertainment. Some poultry species include chickens, turkeys, quail, ducks, geese, and guinea. Nearly all rural and peri-urban families keep household poultry in the developing world. However, village chickens are widely grown in developing countries around the world (Alemayehu *et al*. 2018). Nevertheless, policymakers neglect backyard chickens (Kondombo *et al.* 2003). In several developing countries, poultry developmental approaches targeted the introduction of exotic chickens as they produce additional eggs, and weight gain is far quicker (Chebo *et al.* 2022). Similarly, the village chicken population in Sri Lanka is about 1.3 million birds. Therefore, village poultry is mainly reared for egg production (Manjula *et al.* 2018). Therefore, it is worth noting that the village chicken populations in other Southeast Asian countries, such as Cambodia, Thailand, and Vietnam, represent a significant proportion, constituting 90%, 10%, and 70% of the chicken populations in their respective nations (Silva *et al.,* 2016). Sri Lanka village chicken contributes to 15% of the egg production in the country (Silva *et al.* 2016). The total egg production reached 2586.78 million, with a per capita availability of 117.6 eggs per human population growth (DAPH 2020). Sri Lanka's egg industry produces enough eggs to fulfil the country's daily demand of 6.5 million eggs and more than 7 million eggs during the festive season. Village chicken uniquely contributes to food security (Desta, 2021). Village chicken eggs have a particular market than commercial chicken eggs due to their high-quality eggs (Kumar *et al.* 2021). The quality of egg traits is vital for egg consumption—the quality characteristics influence the consumer's acceptance of it (Hisasaga *et al.* 2020). As a result, in today's production-oriented industry, continuous genetic evaluation of different egg quality traits has become necessary to maintain dominance in overall egg quality (Abo Ghanima *et al.* 2020). Egg quality is determined by consumer acceptance concerning several characteristics, including cleanliness, freshness, outside area, communion, volume and coefficient of packaging, and egg internal and external quality (Duman *et al.* 2016). Some researchers studied the chicken egg's quality from different perspectives. It has been reported that the quality of the chicken egg is influenced by several factors, including age and genetics of the hen, nutrition, type of rearing system, and the time of oviposition (Yang *et al.* 2014). The microstructure, thickness, and loading rate of an eggshell and its specific gravity, mass, volume, surface area, and shell percentage all influence its strength (Muszyński *et al.*2022). Thick egg white is the most significant indicator of egg freshness when it comes to the consistency characteristics of the inner egg (Kumari *et al.* 2020). Long-term storage of eggs will result in a loss of egg white, making the white egg watery (Messeret 2010), and the colour of the yolk is also a consideration for consumers. According to Alabi *et al.* (2012) medium-sized eggs can be used for better hatchability, whereas large-sized eggs can be used if growth capacity is the most crucial factor. Some studies examined the relationship

between egg size and quality (Sarica *et al.* 2012). Further, there was a lack of investigation on Village chicken eggs' external and internal quality characteristics based on egg weight category. Therefore, this study aimed to examine the effect of egg weight internal and external egg quality characteristics in village chickens.

2. Material and Methodology

2.1 Experimental site and birds

The eggs used in this study were collected from a cross breed of Naked Neck and CPRS breed strain kept on a deep litter system at an integrated model farm in Mandur, Batticaloa, Sri Lanka (7°28'54.7"N 81°45'33.8"E), which is located in the dry zone of Sri Lanka. Batticaloa's annual rainfall is 1349 mm. The temperature was varied between 24 °C and 32 °C. Three hundred and thirty-five (335) eggs were collected from the farm and returned to the Animal and Aquatic Science and Technology Laboratory of the Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka, for egg internal quality measurement on the same day collection.

2.2 Data collection

2.2.1 External egg quality

The eggs were first weighed and then categorized into four groups: peewee (30-42g), small (42-49g), medium (49-56g), and large (56-65g) as described by Adebayo (2021). Egg weight was determined using a precise digital weighing balance with an accuracy of 0.001 g. Egg length and width were measured using a Vernier caliper, while the oblong circumference of each egg was measured with a measuring tape. To determine eggshell weight, the egg was cracked open, and its contents were transferred to a separate container. The eggshells were subsequently air-dried at room temperature and weighed using a digital electronic weighing balance. Eggshell thickness (in mm) was measured using a micrometer screw gauge, with three measurements taken at the egg's broad end, middle, and tapering end, and the average was then calculated as the eggshell thickness. Specific gravity and shape index were computed using the equations provided by Ewonetu and Negassi (2016).

$$Shape\ Index = \frac{Egg\ width}{Egg\ length} \times 100$$

$$Specific\ Gravity = \frac{Egg\ weight\ in\ air}{Egg\ weight\ in\ air - Egg\ weight\ in\ water}$$

2.2.2 Internal Egg quality

The weight of the egg's internal contents and the albumen weight were measured using a precise digital weighing balance (PFB 300-3, German) with a precision of 0.001 g. The height of each egg and the diameter of the yolk were determined using a Vernier caliper. The yolk color was assessed using the DSM Roche Yolk Color Fan Chart. Albumen height was also measured using a micrometer screw gauge, while the pH of the albumen was determined using a pH Meter (HI-98190, Italy). The Haugh Unit (HU) score was computed following the formula originally proposed by Haugh in 1937.

2.2.3 Statistical Data Analysis

Analysis of variance was done for all recorded parameters using SPSS software to determine the influence of egg weight on egg quality parameters by distributive statistics and Correlation. Using one-way ANOVA, these data were compared using mean and standard deviation (SD). The following model was used for ANOVA. $Y_{ij} = \mu + W_i + e_{ij}$ Where; Y_{ij} = jth observation in the ith egg weight group, μ = population mean, W_i = effect of the ith egg weight (i=1, 2, 3,4); Peewee small, medium and large egg weight groups and e_{ij} = error term with the usual properties.

3. Results

The descriptive statistics of the effect of egg weight on external egg quality traits is show in table 1

Table 1: Effect of egg weight on external egg quality characteristics in different egg weight group

Egg Characteristics	Egg Weight Group				Sem
	Large	Medium	Small	Peewee	
Specific Gravity	13.92	14.31	15.01	12.59	0.51
Egg Length	55.92^{c}	53.18^{b}	$51.41^{a,B}$	50.24^{a}	0.228
Egg Width	42.22^{b}	$40.08^{a,B}$	38.75^{a}	38.19^{a}	0.247
Shape Index	75.70	75.51	75.57	76.59	0.269
Shell Weight	6.70^{c}	5.96^{b}	$5.53^{a,B}$	5.36^{a}	0.515
Shell Thickness	$0.36^{a,B}$	$0.35^{a,B}$	0.38^{c}	0.34^{a}	0.905

$^{a, b, c}$: means in the same row with different superscripts are significantly ($p < 0.05$) different. SEM: standard error of the mean.

3.1 Specific gravity

The mean specific gravity of eggs in different weight groups showed no significant difference (*p>0.05*). However, small-weight group eggs exhibited slightly better specific gravity than those in the peewee, medium, and large weight groups (Table 1).

3.2 Egg length

There was a noticeable discrepancy (p<0.05) in egg length among the four categories of egg weight. It was observed that egg length exhibited an increasing trend with rising egg weight, aligning with the findings of Ukwu *et al.* (2017) for light, medium, and heavy egg weight categories. The average egg length values in this investigation surpassed those documented by Ukwu *et al.* (2017) for Isa Brown egg layers (52.5 mm) and Rajkumar et al. (2009) for 28-week-old Naked Neck hens (54.68 mm) (Table 1).

3.3 Egg width

Conversely, there were notable distinctions (p<0.05) in egg width across the various egg weight categories. It was evident that egg width exhibited an increasing pattern with the elevation of egg weight, a trend consistent with the findings of Ukwu *et al.* (2017) for light, medium, and heavy egg weight groupings. Nevertheless, the average egg width noted in this study exceeded the measurements (39.9 mm) reported by Ukwu *et al.* (2017) for Isa Brown egg layers and Rajkumar *et al.* (2009)

for 28-week-old Naked Neck hens (41.72 mm) (refer to Table 1)

3.4 Shape index

Based on the gathered data, it was determined that egg weight did not exert a significant impact on the mean shape index of the distinct egg weight categories (p>0.05). Nevertheless, it was notable that eggs in the peewee egg weight category displayed a superior shape index (76.59%) compared to the other egg groups (see Table 1). This discovery contradicts the findings of Ukwu *et al.* (2017), who documented a negative alteration in the shape index among the light, medium, and heavy egg weight groups. Additionally, the shape index recorded in thisstudy (76.59%) surpassed the figure (76.36%) reported by Ukwu *et al.* (2017) for the Isa Brown egg layer.

3.5 Shell weight

In terms of shell weight, there were significant differences *(p<0.05)* in shell weight among the different egg weight groups. The results also showed that shell weight increased as the egg weight increased among the different groups. This finding is contrary to the findings of Rajkumar *et al.* (2009), who observed a negative change in shell weight among light, medium, and heavy egg weight groups. However, the mean shell weight recorded in this study was higher than the values (5.12) reported by Rajkumar *et al.* (2009) for the Naked Nack hen (Table 1).

3.6 Shell thickness

Moreover, the shell thickness was found to significantly differ among the peewee, small, medium, and large egg weight groups *(p<0.05)*. The small egg-weight group had the highest shell thickness (0.38 mm). However, the shell thickness had the lowest value (0.45 mm) compared to Rajkumar *et al.* (2009) for the 28 weeks of age Naked Neck hen. The influence of egg weight on internal egg quality characteristics is detailed in Table 2. Table 3 presents the phenotypic correlations between egg weight and external egg quality traits, whereas Table 4 illustrates the correlations between egg weight and internal egg quality traits.

Table 2: Effect of egg weight on internal egg quality characteristics in different egg weight groups

Egg characteristics	Egg weight group				Sem
	Large	Medium	Small	Peewee	
Egg internal weight	54.25^{c}	46.20^{b}	40.50^{a}	37.81^{a}	0.128
Yolk weight	15.84^{c}	14.21^{b}	13.21^{a}	13.13^{a}	0.891
Albumen weight	36.88^{c}	31.21^{b}	26.71^{a}	24.65^{a}	0.228
Albumen ph	8.55^{a}	8.73^{a,b}	8.95^{b}	8.46^{a}	0.724
Yolk length	41.58^{b}	40.06^{a}	40.46^{a,b}	38.71^{a}	0.057
Yolk color	9.31^{b}	8.5^{a}	8.05^{a}	8.05^{a}	0.224
Albumen height	8.65^{b}	7.91^{a,b}	7.34^{a}	6.62^{a}	0.146
Yolk height	15.23^{b}	14.24^{a,b}	12.65^{a}	10.92^{a}	0.189
Haugh unit	92.32^{a}	90.58^{a}	89.81^{a}	106.99^{b}	0.376

[a, b, c]: means in the same row with different superscripts are significantly ($P < 0.05$) different. SEM: standard error of the mean.

Table 3: Correlation between egg weight and external egg quality characteristics

Egg external qualities	EW	SG	EL	EWT	SI	SW	ST
Egg weight	1						
Specific gravity	-.024	1					
Egg length (cm)	.500**	-0.028	1				
Egg width (cm)	.351**	0.043	.353**	1			
Shape index (%)	.007	0.071	-.352**	.747**	1		
Shell weight (g)	.791**	-0.204	.379**	.293*	-0.052	1	
Shell thickness (mm)	-.166	-.324*	-0.188	-0.15	0.018	0.066	1

Table 4: Correlation between egg weight and internal egg quality characteristics

Egg internal quality characteristics (28 weeks)	EW	EIW	YW	AW	APH	YL	YC	AH	YH	HU
Egg weight	1									
Egg internal weight (g)	.981**	1								
Yolk weight (g)	.684**	.681**	1							
Albumen weight (g)	.893**	.892**	.500**	1						
Albumen pH	-.265	-.262	-.490**	-.236	1					
Yolk length (cm)	.390*	.374*	.350*	.323	.226	1				
Yolk color	.401**	.372**	.503**	.257	-.582**	-.037	1			
Albumen height (mm)	.520**	.493**	.328	.457**	-.067	.407*	.324	1		
Yolk height (mm)	.513**	.483**	.657**	.373*	-.593**	.123	.451**	.394*	1	
Haugh unit	-.137	-.118	-.041	-.106	-.066	.002	.264	.521**	-.054	1

3.7 Egg internal weight

This study found significant differences *($p<0.05$)* in the internal weight of eggs across four different weight groups. The largest weight group had the highest internal weight value of 54.25 g. Moreover, there was a clear trend of increasing internal weight with egg weight (Table 2).

3.8 Yolk weight

The yolk weight also differed significantly *($p<0.05$)* between the four egg weight groups. Similar to internal weight, there was a clear trend of increasing yolk weight with egg weight (Table 2). Nonetheless, the yolk weight observed in this study was less than the figures reported by Rajkumar *et al.* (2009) for Naked Neck hens, although it deviated from the findings of Shi *et al.* (2009).

3.9 Albumen weight The study observed significant differences *($p<0.05$)* in albumen weight among the different egg-weight groups, with an increase in albumen weight as egg weight increased (Table 2). However, the mean albumen weight recorded in this study was lower than the values (37.23 g) reported by Tadesse *et al.* (2015). This result agreed with Shi *et al.* (2009), who observed a positive change in albumen weight among small, medium, and large egg weight groups.

3.10 Albumen pH

The egg weight significantly affected the mean albumen pH of the different egg weight groups *($p<0.05$)*. Eggs in the small weight group had numerically better albumen pH (8.95) than those in the large, medium, and peewee groups (Table 2). However, this result contradicted the findings of Silversides and Budgell (2004).

3.11 Yolk length

The study found significant differences *($p>0.05$)* in the mean yolk length among the different egg weight groups, with an increase in yolk length as egg weight increased. The large egg weight group had the highest numerical value of 41.5 mm yolk length (Table 2).

3.12 Yolk colour

Egg weight significantly affected yolk colour *($p>0.05$)*, with the largest weight group having the highest value of 9.31 and the smallest and peewee weight groups having the lowest value of 8.05. The mean yolk colour value observed in this study was higher than what Rajkumar *et al.* (2009) reported for Naked Neck hens (Table 2).

3.13 Albumen height

The albumen height also showed significant differences between the different egg weight groups *($p<0.05$)*, with an increase in albumen height as egg weight increased. This result was consistent with Şekeroğlu and Altuntas (2009) and agreed with Ukwu *et al.* (2017), who observed a positive change in shell weight among light, medium, and heavy egg weight groups (Table 2).

3.14 Yolk height

The study found that the four egg-weight groups had slightly different yolk heights *($p<0.05$)*, with an increase in yolk height as egg weight increased. This finding was consistent with Şekeroğlu and Altuntas (2009) and Ukwu *et al.* (2017) results, who discovered an improvement in yolk height in medium, large, and extra-large eggs. However, the mean yolk heights observed in this study were lower than those recorded by Tadesse *et al.* (2015) for Isa brown layers (17.81 mm). In addition, the values were lower than those stated by Sarica *et al.*, (2012) for whimsy.

3.15 Haugh unit

The mean Haugh unit of the different egg weight groups was significantly ($p<0.05$) influenced by egg weight. The peewee egg weight group having the highest value of 106.9, which was lower than what Tadesse *et al.* (2015) (Table 2).

4. Discussion

One of the important characteristics that help in distinguishing poultry species from other vertebrate species is the presence of feathers that provide them the ability to fly, disguise, and regulate their temperature. In addition to plumage color, eggshell and its spot colors are extremely diverse. Their results showed that eggshell color and color of spots had a significant effect on egg quality characteristics such as eggshell ratio, eggshell index, albumen index, yolk index, and Haugh unit. Other studies have focused on the impact of eggshell color changes on eggshell structure, egg weight reduction, and hatching parameters (Taha, 2011). Based on the data presented in Table 3, it was observed that there were no significant correlations between egg weight and specific gravity, shape index and shell thickness. However, there was a significant correlation ($p<0.01$) between egg weight and egg length, width, and shell weight. It was also found that egg length and width had a positive correlation with egg weight, indicating that these dimensions' increase as egg weight increases. The positive correlation between egg weight, egg length, and egg width aligns with Ukwu *et al.* (2017) and Alkan *et al.* (2015). The external egg characteristics measurements showed varying degrees of association, ranging from positive to negative. For instance, there was a highly positive and significant correlation ($p<0.01$) between egg width and shape index, indicating that egg width increases as shape index increases. There was also a low negative correlation between specific gravity and shell thickness ($p<0.05$), implying that egg specific gravity decreases as shell thickness increases. Furthermore, there was a low negative association between egg length and shape index ($p<0.01$), indicating that egg length increases as the shape index decreases. Additionally, a positive correlation was found between egg length, width, and shell weight ($p<0.01$), This result agrees with the results of Ukwu *et al.* (2017). The study revealed a significant and highly positive correlation ($p<0.01$) between egg weight and internal egg weight, yolk weight, albumen weight, yolk length, yolk colour, albumen height and yolk height (Table 4). Furthermore, yolk length had a significant correlation at ($p<0.05$). These findings suggest that an increase in egg weight corresponds to an increase in internal egg weight, yolk weight, albumen weight, yolk length, yolk colour, albumen height, and yolk height. These results support the previous findings of Alkan *et al.* (2015), which demonstrated that egg weight increases with yolk weight and albumen weight. However, albumen pH and Haugh unit were not significantly correlated with egg weight. Moreover, the study discovered positive correlations between internal egg weight and yolk weight, yolk colour, albumen height, yolk height ($p<0.01$), and yolk length ($p<0.05$). Likewise, the egg's internal weight increases with the increase in yolk weight, yolk colour, albumen height, yolk height, and yolk length. Additionally, there were low to moderate positive correlations between yolk weight and albumen weight, yolk colour, yolk height ($p<0.01$), and yolk length ($p<0.05$). The study also found that albumen weight was positively correlated with albumen height ($p<0.01$) and yolk height ($p<0.05$), which is consistent with the findings of Alkan *et al.* (2015). Furthermore, correlations among internal egg quality parameters varied from positive to negative. Specifically, negative correlations were found between the albumen pH and yolk colour and yolk height ($p<0.01$); the albumen pH increases as yolk colour and yolk height decrease. Yolk colour was positively associated with yolk height ($p<0.01$). Furthermore, correlations between albumen height and yolk height were significant ($p<0.01$). It is worth noting that the determination of the best type of eggshell colors and egg quality is controversial among the published data. In the present study, although

Yolk color positively associate with yolk height and found a positive relationship between albumen height and yolk height egg quality traits could be established.

5. Conclusion

According to the study, the weight of a 28-week-old hen's egg has a positive impact on several characteristics such as egg's length, width, shape index, and shell weight. Furthermore, the egg weight is also positively correlated with internal weight, yolk weight, albumen weight, yolk length, yolk color, albumen weight, and yolk height. However, albumen pH, Haugh unit, specific gravity, and shell thickness had a negative association with egg weight. These findings are of great significance to both poultry researchers studying egg quality characteristics and breeders working on partridge egg breeding and improvement. The study concluded that egg weight plays a crucial role in shaping the internal and external quality characteristics of eggs, which varies among different ages of village chickens. This knowledge could be beneficial to develop a selection program to improve egg quality features in the crossbreed of Naked Neck and CPRS breed egg layers.

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