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Impact of egg size on the quality of eggs, chicks, and post hatch overview of offspring during the mid stage of yield (45th week) in Hubbard broiler breeders

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Abstract

Background: The most significant component in influencing the performance of the laying flock is egg size. Though commercial broiler farming is in operation, little is known about how breeder hatching egg weight during middle (45th week) phase of yield production effects on qualities of egg & chick and post-hatch Hubbard broiler growth performance.

Methods: At 45 weeks of age, hatching eggs (n=930) from a commercial broiler breeder flock were gathered as well as classified into 3 groups of egg weight: short (60.25±0.25g), medium (65.10 ± 0.31g), and large (70.07 ± 0.61g). These eggs more classified into 2 groups i.e., egg quality parameters and incubation & post hatch performance metrics. Eggs for performance measures related to incubation and post hatch as well as eggs for quality factors are two further categories into which these eggs are divided.

Result: The proportion of shell weight was higher in the eggs obtained from small egg group. The size of the eggs had an effect on the shape index and specific gravity, with larger eggs having lower values. Both male and female chicks' weight and length were significantly influenced by egg size. Data of the body weight gain indicated that as broilers age increases, impact of egg weight on post-hatch performance of chicks' decreases. Up until age 21, female chicks' body weight gain was highly influenced by egg size. The female chicks' feed conversion ratio at day 21 of life was considerably impacted by various egg-weight categories, while it had no effect on male and female chicks at day 35.

Conclusion: Egg size favorably influenced the features of the chicks (weight and length) but without any impact on feed consumption, conversion ratio & mortality or ultimate overall live weight of the broilers.

Introduction

Production of healthy day-old chicks is the main goal of all contemporary hatcheries worldwide [1]. A number of variables have an impact on the quality of the chicks and their subsequent growth performance. Evidence suggests that egg size has an impact on the productivity of layer and broiler chickens in the future [2,3]. Egg size generally has a favorable, linear impact on broiler growth [4]. It is common knowledge that the size of broiler breeder hens' eggs grew larger with age. Though there is evidence that the impact of egg size decreases as birds become older [5]. Since the turn of the last century, research has focused on any impact that egg size may have on the post-hatch performance of broiler chicks [6]. Even though there is a strong association between egg size and hatching weights, broiler market weights and post-hatching growth are not always affected. The broiler chicks performance to market weight have shown to be significantly influenced by egg size in certain studies [7,8], however other studies displayed that all advantages of post-hatched chicks from bigger eggs quickly vanished [6,9]. In addition, Hearn[10] suggested that segregation of hatching eggs according to weight before incubation and separate rearing of day-old chicks of various weights resulted in optimum growth and minimum variability of final market weight in broiler chicks. A study [11] showed that Potchefstroom Koekkoek chick hatched from big-sized eggs gained higher daily BW up to age of 7 weeks than those hatchlings obtained from eggs of medium and small size. Furthermore, hatchlings acquired from eggs of medium size gained greater daily body weight than those chicks obtained from small-sized eggs. With regard to each bird's daily feed consumption, a similar pattern was seen. Despite the fact that the feed conversion ratio (FCR) in birds having eggs of large and medium size was similar, birds produced from eggs of large size exhibited a superior FCR as compared to birds obtained from eggs of small size. Males grow more quickly in response to egg weight compared to females [12]. Tufft and Jesen [13] reported that independent of the breeders' age from whence the eggs were taken, the size of the eggs had no impact on the broiler's body weight till market age. It was found that the performance of broilers varied depending on the stages of the growth period and the age of the broiler breeders [14]. Moreover, results showed that market live weight of broilers from 51-week-old broiler breeders were significantly higher than that of broilers from 63week old breeders. In growing broilers, the feed conversion ratio did not seem to be directly connected to the size of the parent egg. Birds that lay large eggs may put on weight, some of which may be attributed to their increased feed consumption [6].

Due to lack of information on quality of egg, chick as well as post-hatching performance of Hubbard broiler breeder, the current trial is intended to find out the impact of small (S), medium (M) and large (L) egg size on traits of egg as well as post hatching production of broiler breeder (Hubbard Classic strain) during mid production stage (week 45).

Methods

This trial was permitted through the Animal Ethic Committee which nominated by PMAS, University of Arid Agriculture Rawalpindi, Pakistan, as well as it was carried according to Directive 2010/63/EU's International Guidelines for Research Involving Animals.

Eggs anthology and choosing

From the Hubbard classic broiler breeder house, eggs hatched during 4- to 8-h light intervals were taken away every hour. 930 fertile eggs of roaster breeder group (45wk old) were selected based on weight, shape (oval), and quality for hatching. Eighty eggs were randomly chosen and weighed during every assortment occasion to find out the mean egg weight for the age of the flock. 310 eggs were weighed as well as distributed into three weight groups i.e., S, M, and L, according to the typical weight of eggs. According to Ulmer-Franco and coworkers [15], eggs were divided into three categories: S fertile eggs found as 3.0-6.0 g lighter as compared to the M, however, L fertile eggs recoded as 3.0-6.0 g heavier compared to the M, and M eggs noted about 1.5g of the mean weight of eggs. Eggs regarding every treatment were followed by separated into two subgroups: 300 eggs were used for the incubation as well as post hatch performance of the chicks, and 10 eggs were used for quality measures. In addition, the eggs chosen for incubation and post-hatch chick performance were divided into three replicates, each with 100 eggs.

Egg character indicators

This experiment was carried out for determining the traits of eggs criteria of 10fertile eggs relating to every egg group during the first twenty four hours after the eggs were placed. The Archimedes method was applied on the day of egg laying to determine an egg relative density of every group of egg size employing modus operandi according to explained through Hampe and others [16]. To assess egg quality criteria, eggs from every group weighed separately using digital scale before being cracked. In order to analyze the shell weight percentages of the eggs, cracked egg shells made thoroughly rinsed, dried in air, after that determined weight into gram. Egg thickness of every egg of every size category evaluated devoid of membrane with a digital calliper with 0.001 mm sensitivity at the fertile egg's pointed end, equator, and broader end. Next, the typical thickness of egg was measured. To determine the yolk weight %, eggs were separated and weighed separately. Wet yolk and shell weight were subtracted from the weight of each individual egg to compute albumen weight. The yolk to albumen ratio in % was computed using the yolk and albumen weights. The shape index of an egg also determined with breadth divided by height of egg then multiplied by hundred.

Chick quality parameters

Eggs of each category were distributed into three replicates containing hundred eggs every group. The eggs were given the similar development circumstances. Fertile eggs were chosen from every group as well as moved toward the commercial hatchery, which is close to Khannapul in Islamabad, Pakistan. These eggs were stored at 20 celsius as well as 75 percent moisture for three days. Individually labeled ovum was placed in several trays at random. Eggs of Double-yolked, misshapen, poor shell- quality and unclean was not taken into consideration for hatching. At a dry bulb temperature of 37.5°C and a wet bulb temperature of 29.4°C, all eggs were incubated for 18 days. All eggs were taken out of the incubator after 18 days of incubation, each one weighed separately, and then moved into Hatcher part. Moreover, 3.5 days were spent incubating the eggs at 29celsius (wet-bulb temp) and 35celsius (dry bulb temp). The average weight of a chick in grams was determined by weighing all male and female hatchlings from each egg group (S, M, and L) using digital balance (Hatchability: 85-89percent; ratio between male to female: 53:47). The weight of chicks that had hatched during that hour was then measured at 1-hour intervals. Using a ruler and each chick, the length was determined from beak's tip to center toe (nail omitted). Each individual chick's weight (g) and length (cm) were noted. For each egg weight category, the mean weight as well as length of chicks were computed from these readings. Chick yield was determined by multiplying the mean weight of egg during setting in the incubator with 100 and dividing that result by the average chick weight on the day of hatching. For each egg weight treatment, grade-A chicks were counted, weighed, and vent-sexed using an accurate digital weighing scale to obtain the average chick weight that would be used to compute the number of eggs produced.

Housing and performance traits of broilers

The experiment was carried out in semi-controlled shed which situated at Tumair Village, Islamabad. The partitions that were used to split this shed into 18 pens (experimental units) each had measurements of 5 feet, 3 feet, and 10 feet (length × width × height). Before the day-old chicks arrived, the shed was cleaned, sanitized, and fumigated. Each pen had a layer of rice husk litter that was 2 to 3 inches deep. From each egg category (S, M & L), 45 males and 45 females were randomly chosen from the hatchery, replicated three times with 15 day-old chicks in each, then moved to semi-controlled shed. These chicks were allocated at random into the shed's 18 experimental units. All pens were carefully managed to have the same ventilation, humidity (60-70%), and temperature (68°F). Stocking density was $0.07 m^2$/bird. The chicks were raised under floor litter (wood shavings) system for 35 days with 23L:1D. At d 0 to 10, d 11 to 25, and d 26 to 35, the birds were fed commercial broiler starter, grower, and finisher rations, respectively. From d1 to 14, broilers were given a crumbled starter diet containing 23.0% crude protein as well as 3067 Kcal/kg metabolizable energy; at 15 to 28days, grower ration consisting 20.2% crude protein and 3,152 Kcal/kg metabolizable energy and at 29-41days, a crumbled finisher diet (19.0% crude protein as well as 3,196 Kcal/kg metabolizable energy). Throughout the trial, food and water were freely available to the birds. Day-old chicks were weighed using an electronic scale as soon as they arrived at the farm to determine the average day-old weight of each egg-size category's male and female broiler chicks. The average BW (g) for male and female broiler chicks of each egg-size category was determined by weighing all the chicks in each replicate at the conclusion of each week on a digital weighing scale. Every week until the end of study, the cumulative live BW (g) for every replicate was as well computed. Weekly evaluations of the chicks' feed intake in every replication group were made (total feed consumption = average daily feed intake from day 1 to day 35).

At the end of every week until the completion of the trial, cumulative feed intake (g) for every replicate was calculated. For each replicate, feed conversion ratio was also calculated. During the rearing period, each replicate also kept track of the weekly death % for broiler chicks.

Statistical analyses

The data was evaluated using one-way analysis of variance (ANOVA), and it was analysed using General Linear Model (GLM) techniques in SPSS 16.0. Means were compared using Duncan's Multiple Range tests at the 0.05 level of significance when there were significant differences.

Results

Egg quality parameters

The size of egg exhibited a substantial ($p \leq 0.05$) impact on weight of shell, form index as well as specific gravity

Traits	Size of egg*			SEM	P - Value
	S	M	L		
Egg weight (g)	60.25ᵃ±0.25	65.10ᵇ±0.31	70.07ᶜ±0.61	0.781	0.000
Weight of Shell (%)	9.99ᵃ±0.19	9.62ᵃᵇ±0.15	9.42ᵇ±0.14	0.101	0.062
Thickness of Shell (mm)	0.35±0.00	0.34±0.00	0.34±0.00	0.00406	0.232
Weight of Yolk (%)	30.79±0.34	31.13±0.27	31.57±0.48	0.21734	0.346
Weight of Albumen (%)	57.80±0.47	58.07±0.25	57.98±0.45	0.2245	0.889
Yolk : albumen	53.30±0.98	53.63±0.67	54.54±1.24	0.516	0.661
Form index	76.34ᵃ±0.62	75.84ᵃᵇ±0.36	74.81ᵇ±0.40	0.2892	0.086
Specific gravity	1.078ᵃ±0.00	1.074ᵇ±0.00	1.070ᶜ±0.00	0.000	0.000

a-c Average with various letters in rows vary substantially ($p \leq 0.05$)

*S= (Small size: 3-6g lighter compared to mean weight of egg); M= (Medium size: ±1.5g from mean weight of egg); L= (Large: 3-6g heavier compared to mean weight of egg).

Table 1: Influence of different size of egg on the traits of typical eggs

Items		Egg size*			Standard Error Mean	Probability-Value
		S	M	L		
Numbers of egg set		One hundred	One hundred	One hundred		
Weight of eggs (g)		60.03ᶜ±.05	65.01ᵇ±.04	70.01ᵃ±.05	0.99	0.00
Weight of chick (g)						
Female		40.22ᶜ±.22	43.15ᵇ±.18	47.44ᵃ ±.30	.22	0.00
Male		40.40ᶜ±.19	43.76ᵇ±.18	47.75ᵃ±.11	.22	0.00
Production of Chicks**(%)						
Female		65.78±.79	65.68±.10	66.96±.20	.400	.23
Male		67.89±.81	67.73±.41	67.29±.10	.342	.80
Length of Chick (cm)						
Female		18.85ᶜ±.04	19.30ᵇ±.03	19.48ᵃ±.09	.039	0.00
Male		18.92ᶜ±.09	19.53ᵇ±.07	19.65ᵃ±.07	.041	0.00

a-c Average with various letters in rows vary substantially ($p \leq 0.05$)

*S= (Small size: 3-6g lighter compared to mean weight of egg); M= (Medium size: ±1.5g from mean weight of egg); L= (Large: 3-6g heavier compared to mean weight of egg).

**Chick weight/set egg weight ×100

Table 2: Influence of egg size on quality of chicks (Means ± SE)

Factors	Egg size*			SEM	P-value
	S	M	L		
Day old weight (g)					
Male	41.2ᵃ±0.4	44.5ᵇ±0.4	47.6ᶜ±0.1	0.939	0.000
Female	39.9ᵃ±0.5	43.2ᵇ±0.1	47.4ᶜ±0.2	1.091	0.000
Body weight (g)					
14d					
Male	405.4±1.0	403.9±1.9	412.8±5.0	2.078	0.180
Female	397.0ᵃ±1.8	402.1ᵇ±0.8	407.2ᶜ±0.7	1.598	0.003
21d					
Male	686.7±1.7	688.7±2.7	690.3±1.9	1.187	0.519
Female	676.3ᵃ±2.4	678.8ᵃᵇ±2.5	684.8ᵇ±0.7	1.591	0.073
35d					
Male	1584.3±1.9	1578.7±2.3	1576.7±6.6	2.377	0.451
Female	1535.3±4.4	1529.0±1.5	1526.7±2.9	2.048	0.216
Feed intake (g)					
1-14d					
Male	493.2 ±2.4	495.8±3.1	498.4±1.8	1.445	0.392
Female	486.5±2.1	488.9±2.1	488.7±2.4	1.810	0.706
15-21d					
Male	935.2±1.5	939.2±3.2	942.8±1.1	1.537	0.116
Female	929.1ᵇ±1.4	931.1ᵃᵇ±4.1	938.4ᵃ±1.0	1.923	0.090
1-35d					
Male	2782.2±2.9	2796.6±7.9	2797.7±7.3	4.077	0.244
Female	2743.1±4.4	2730.8±8.8	2728.9±1.2	3.628	0.241
Feed Conversion Ratio					
1-14d					
Male	1.216±0.0	1.216±0.0	1.210±0.0	0.0033	0.412
Female	1.219±0.0	1.223±0.0	1.201±0.0	0.0048	0.272
15-21d					
Male	1.362±0.0	1.364±0.0	1.366±0.0	0.0042	0.598
Female	1.373±1.4	1.372±1.4	1.370±0.0	1.368	0.807
1-35d					
Male	1.763±0.0	1.765±0.0	1.774±0.0	0.0027	0.211
Female	1.787±0.0	1.786±0.0	1.794±0.0	0.003	0.550

a-c Average with various letters in rows vary substantially ($p \leq 0.05$)

*S= (Small size: 3-6g lighter compared to mean weight of egg); M= (Medium size: ±1.5g from mean weight of egg); L= (Large: 3-6g heavier compared to mean weight of egg).

Table 3: Influence of size of eggs on post-hatch broiler performance during middle (45 week) phase of production cycle

during middle phase of the yield cycle as shown in Table 1. Generally, as egg size increased, shell weight, shape index, and specific gravity decreased. Small eggs had the highest ($p \leq 0.05$) shell weight percentage, shape index, and specific gravity, followed by M and L egg catagories. In broiler breeders, effect of egg size on shell thickness, weights of yolk & albumen as well as yolk to albumen ratio was not significant ($p \geq 0.05$) at the midpoint of the production phase.

Chick quality parameters

For both the male and female chicks, the egg size showed substantial impact upon the weight and length of chicks (Table 2). According to the data, body weight and length of chicks were increased with L size of eggs from the chicks of female as well as male. Though, egg size did have a non-substantial impact upon hatchling output.

Broilers production parameters

Day-old weight was considerably influenced by egg size. Additionally, the weights of female chicks at days 14 and 21 of the growth period were substantially exaggerated by egg size ($p \leq 0.05$), whereas the weight of female chicks at day 35 was not significantly different (Table 3). During the growth period, there were not considerable variations ($p \geq 0.05$) in the male chick's weight from various egg size categories. Though, the chicks obtained from eggs of S size accomplished their utmost weight numerically at 35 day of growing phase than those of chicks attained from eggs of M and L size. In the present trials, egg size had an impact on the growth of female chicks for the first three weeks, but by the fourth week, this effect vanished. The size of egg exhibited insignificant impact on feed consumption at growing phase in this experiment using 45-week-old broiler breeders, with the exception of females at growth day 21(Table 3). When the egg size at day 21 of growth increased, it was noted that feed consumption of female chicks augmented substantially ($p \leq 0.05$). The present study's results exhibited that broilers' feed consumption was unaffected by egg weight. During middle production phase, egg size exhibited no discernible influence on chick's feed conversion ratio at middle stage of production (Table 3).

Discussion

A thin mineral structure called the eggshell shields the egg's contents from mechanical damage, dehydration, and microbial contamination. Moreover, the eggshell allows gases and water that are important for the development of the chick embryo to pass through [17]. According to the current study; S size eggs were heavier in the shell than M and L size egg groupings. These findings are in line with those of Shafey [18], who found that meat and layer breeders at 42-46 wks of age had more S eggs compared to M or L eggs in terms of egg shell weight (14.1% vs. 12.5% and 11.5%, respectively). The same scientists also observed that egg size had no influence on shell thickness (0.33, 0.35 and 0.34 mm for S, M and L egg size groups, respectively). These values are comparable to results of the current study at the mid (45 weeks) stage of production period which also showed no statistically substantial variation. However, some scientists [19] reported that in the brown-egg layer strain of Lohmann chickens, M eggs (0.400 mm) had the thickest eggshells ($p \leq 0.05$) while extra L eggs (0.382 mm) had the thinnest eggshells. Similar trend was observed in this investigation, where the lowest value of this trait was observed in L egg size group. Regardless of the egg size, the egg shell's weight was about 16% of egg's weight in the present study. However, Popova-Ralcheva and colleague [20] reported that the thickness of the egg shell, which makes up 12% of the egg's weight, serves as a substitute for strength. Breeder eggs typically have an eggshell thickness of 0.30 to 0.34 mm [20] which is close to value of the current study. The data obtained on the improvement ($p \leq 0.05$) in the albumen weight with increase in egg size in this study is in accordance with the results of Finkler and others [21] who found that with increasing egg size there is an increase in the albumen weight. Shi and colleague [22] reported that albumen weight percentage increased with egg size in brown-egg layer strain of Nike. There was a strong relationship found between egg size as well as albumen weight percentage. Similarly, in this trial, albumen weight was also increased with egg size but difference was non-significant throughout the production cycle. A recent study [23] exhibited that albumen and yolk weight in eggs of Dominant Black breeder strain was found as 53.79, 56.09 and 58.37%; 32.50, 26.46 and 28.14% for S, M and L egg size groups, respectively. Similarly, these traits in Yaffa Brown breeder strain was examined as 50.33, 55.0 and 60.67%; 29.85, 25.45 and 27.98% for S, M and L egg size groups, respectively. The data showed that in both strains, egg albumen percentage increased with increase in egg size and reverse trend was observed in yolk percentage. While in this study, egg size did not effect on albumen and yolk weight might be due to breed difference from above study.

The ratio of the greatest width to length, which varies with egg size, strain, location in the clutch, and time of oviposition, is a simple way to characterize the egg shape index [24]. One study indicated that egg shape index increased until the 20 or 24 weeks of production then decreased gradually [25]. Similarly, in the present study, shape index values were decreased during early, mid and late stage of production cycle. Egg shape is also affected by heritable character as well as individual characteristics, and is determined in the oviduct. The egg shape index varies from 57 to 92; however values below 74 are thought to be a contributing factor to more cracked and broken eggs [26]. In this experiment, range from 73.0 to 78.2 which can be considered as normal values according to Narushin [26].

Egg specific gravity is a veiled marker of the egg size's relationship to the egg shell quality. According to the current investigation, there was anticipated so as to values of specific gravity would correspond with %age of shell (i.e., greater shell content eggs would have greater specific gravity); nevertheless, these results conflict with those of Ulmer-Franco and colleague [15]. Overall, these findings confirmed that evaluating shell quality by specific gravity is a trustworthy method [27]. In contrast to the present results, other scientists reported that body weight at day one was higher in birds produced from eggs with lower specific gravities [8].

Chick weight parameter is generally broadly applied as marker for evaluating the day-old chick's quality [28]. According to the current study, there is a known positive link between size of eggs as well as weight of chicks in the broiler [7]. Several studies displayed that there is a strong association between egg size as well as hatchling weight within several household birds [6,29]. The heavier eggs produce heavier chicks when they hatch [15]. According to another study [30], L eggs had more nutrients than S eggs did, and as a result growing embryos from L eggs typically have more nutrients than they required for development. As hens matured, weight of eggs, yolk & albumen increased, but egg shell quality decreased [31]. This increase in chick size as a result of rising egg weight may also be related to the fact that higher egg weight contains additional material. As per latest studies, the excellent way to assess the chick's visual quality is to measure the chick's length [1,32]. Literature showed that the L egg size, as in the case of the current study, was the cause of the L chick length [33]. Egg size has a beneficial impact on chick length.

Egg size had an impact on the growth of chicks in the present trial for the first three weeks (21 days), nevertheless, by the fourth week, this impact was vanished. These findings supported earlier studies [13,34] which exhibited that as a maturing chick acquired older, the relationship between egg size and BW become weaker. This experiment disagrees with the results of other study [35] which claimed that Potchefstroom Koekoek chicks (1-7wk of age) that were obtained from L-sized eggs performed better than those chicks attained from M- and S-sized eggs in terms of body weight and body weight gain at 7wk.

The results of present trial showed that broilers' feed consumption was unaffected by egg size. These findings are consistent with another study which showed that commercial Cobb 500 broiler breeders did not find that egg size affected how much feed those consumed [15]. Likewise, a prior study [36] confirmed that egg size did not effect on bird's feed consumption. Feed consumption on daily basis improved with enhancing egg size in the Anak broilers' starter phase, however an inverse link between feed consumption as well as egg size in the finisher phase was observed [7,37]. At day 21 for female broilers, these findings are consistent with the ongoing trial; nevertheless, at all other stages, there is no statistically significant difference in feed consumption. Contrary to the aforementioned results, it has been documented that native Venda chickens [38] and Japanese quail [39] hatching from S eggs showed considerable higher feed consumption compared to those hatchlings obtained from L eggs. The breeds employed in these experiments could be the cause of these variances. Egg size did not influence on broiler's FCR [13,15] which concurs with the existing research.

At various stages in the production cycle, the chick's death %age produced from breeding group was unaffected by egg size (data not shown in Table). In spite of the strain, egg weight had no impact on broiler mortality [15]. Similar findings were achieved with the chickens of Potchefstroom Koekoek when raised for 7 wk of age [36]. On the contrary to the current trial, several investigations displayed considerable influence of egg size on the consequent broiler mortality [10,39].

In conclusion, the specific gravity, shape index, and shell weight of hatching eggs all considerably dropped as egg size increased. Egg size enhanced both weight and length of chicks while having little effect on chick yield. Egg size had an impact on the growth of the chicks during the first three weeks, however by the fourth week, this impact vanished. With the exception of day 35 of the growth phase, egg size did not effect on the amount of feed consumed by broilers. In the Hubbard broiler breeder strain, egg size had no impact on FCR or broiler mortality. Additional research is required to ascertain the impact of egg size at various ages as well as breeder strains on the performance of broilers.

Competing Interest

The authors declare that there is no conflict of interest.

Author Contributions

All authors made equal contributions.

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