



Effects of egg size on hatchability parameters and chick quality in native chicken

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ABSTRACT

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Fertility and hatchability are traits of major economic importance in poultry industry as they have strong effect on overall chick output. Several factors have been proven to have an effect on the hatchability parameters of poultry eggs. Egg size is one of the crucial factors that may influence hatchability and success of chick output. The aim of present study was to investigate the effects of egg size on different hatchability parameters and chick quality in native chicken. Nine hundred nine eggs were weighed, labeled, and sorted equally into three groups: small, medium, and large as per Indian standards for table eggs. Eggs were evaluated for weight loss during incubation, fertility, embryonic mortality, hatchability, weight of hatched chick and chick yield. Egg size had a significant effect on fertility and hatchability traits. On total eggs set basis, the medium egg size group had the highest percentages of hatchability and fertility, followed by the small and large egg size groups. However, for fertile eggs set basis, the medium egg size group had the highest percentages of hatchability and fertility, followed by the small and large egg size groups. Large size egg group had significantly ($P \leq 0.05$) higher embryonic mortality during first and third week of incubation compared to small and medium size eggs. Similar trend was observed for percent infertile eggs. On pipped-not-hatched eggs, the impact of egg size was not statistically significant. Maximum numbers of chicks were culled in the large size egg group. Chick weight and chick length were significantly ($P \leq 0.05$) affected by egg size, and this effect increased as egg size increased. However, egg size had no significant effect on chick yield. Thus, it can be concluded that medium and small-sized eggs are more suitable than large-sized eggs for enhancing the efficiency of chick production, particularly in terms of the number of salable day-old chicks.

Keywords: Fertility, Hatchability, Egg size, Chick yield, Chick weight, Chick length

INTRODUCTION

Production of fertile eggs and to obtain maximum hatchability in these eggs is the main pre-requisites for efficient and profitable poultry production system (Dudusola, 2013). Several factors especially nutrition, season of the year, temperature and humidity throughout the incubation period, egg handling and storage have been proven to influence the fertility and hatchability of poultry eggs (Wilson, 1997; King'ori, 2011). Egg size is one of the key factors that may influence fertility, hatchability, and success of chick output. Investigating how egg size affects hatchability and fertility outcomes thus becomes important.

With automation of poultry production operations, demand for day old chicks is increasing day by day and farmers are supplying eggs to the hatcheries at commercial level (Priya et al., 2021). However, published literature reporting effect of egg size on hatching parameters of chicken is scarce in India. Most of the poultry breeds used in backyard poultry farming are native breeds of chickens. They are nutritionally, economically, and culturally important to livelihoods of rural households (King'ori et al., 2003; Mtileni et al., 2010). Despite having lower body weights and low productivity, local birds are disease-resistant and

environmentally adaptive (Churchil, 2022). The distribution of indigenous breeds of chicken and their crosses are on the rise in rural and urban areas of the country where they are providing rich protein sources, such as eggs and meat which serve as main source of nutrition and contribute significantly to economic development of the households. In general, the meat and eggs of indigenous chickens are preferred over those of exotic breeds because of their special flavor. Large sized eggs are more in demand and fetch higher price for the produce. Thus, for better profitability, understanding influence of egg size on fertility, hatchability and success of chick output is of practical interest to the researchers as well as chicken farmers.

Many researchers reported that it is preferable to have eggs of medium size to achieve better hatchability as far as chicken (Brah et al., 1999), turkey (Premavalli et al., 2013), duck (Weis et al., 2011; Ipek and Sozcu, 2017) and ostrich (Gonzales et al., 1999) are concerned. In broiler chicken, Kalita (1994) reported poor hatchability for too small or too large eggs compared to medium sized eggs. However, other researchers have reported higher hatchability values for large size eggs than for medium and small sized eggs (DeWitt and Schwalbach 2004; Wilson, 1991). Islam et al. (2002) concluded that effect of breed on the hatchability of fertile

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eggs is negligible whereas, King'ori (2011) reported that fertility, hatchability, and chick weight are interrelated heritable traits that vary among breeds, variety, or individuals in a breed. It therefore becomes pragmatic to understand the effect of egg size on these traits in native chickens. Hence, a study was conducted to determine the effect of egg size on fertility and hatchability parameters in native chicken.

MATERIALS AND METHODS

Experimental birds

In this study, a layer breeder flock of native chicken of Himachal Pradesh (at 45 weeks of age) reared at poultry farm of CSKHPKV, Palampur was selected as experimental unit. A total of 300 females and 30 males (male to female ratio 1:10) were selected from the flock and kept together in a shed. Throughout the period of egg production, the ratio of male to female was kept constant. The bird that appeared unwell or weak during the production period was promptly replaced with healthy birds of the same age from the base flock.

Collection, selection, and storage of eggs

The eggs were collected four times a day. All sub-standard eggs like dirty, blood-stained, cracked, misshapen, elongated and toe-punched were rejected. Only intact oval shaped good quality eggs were selected for hatching. A total of nine hundred nine (909) eggs were weighed, labelled, and sorted equally into three size categories small (38-44), medium (45-52) and large (53-59) as per Indian Standards of table eggs. Till incubation these eggs were stored at the temperature of 18°C and 75% relative humidity.

Incubation and hatching conditions

During the first eighteen days of incubation, the setter was maintained at a temperature of 37.5°C and relative humidity of 60% and the eggs were turned every two hours. The eggs from each replicated tray were moved to different hatch baskets and transferred to the hatcher on the nineteenth day of incubation. The temperature and relative humidity of the hatcher were maintained at 37.0°C and 70%, respectively. On completion of incubation period *i.e.* on 21st day, all hatched chicks were removed from the hatcher and shifted to chicks' room of the hatchery.

Loss of egg weight during incubation

Before placing in the incubator, the average egg weight of each replicated tray containing experimental eggs belonging to each egg size group was precisely measured. To calculate the percentage of egg weight loss, the eggs from each duplicated tray of each egg size category were taken out of the incubator on days nine and day eighteen of incubation and weighed using an electronic scale.

Breakout analysis

To calculate the hatchability percentage of set eggs, all hatched chicks from each egg size category were

counted. Weak chicks and chicks showing physical abnormalities such as unhealed navels or red hocks, etc., were considered unsaleable and were culled. Based on set eggs, the percentage of culled chicks was calculated. All the hatched chicks were removed from hatch basket and unhatched eggs were broken open to evaluate the status of fertility and embryonic mortality. The eggs that were pipped but did not hatch were separated and their percentage based on total eggs set was calculated. Based on the stage of embryo development, the percentages of embryonic death were divided into three groups: early (first week of incubation), mid (second week of incubation), and late (third week of incubation). The eggs were considered infertile if they did not exhibit any signs of embryonic development. Based on total eggs set, the percentage of infertile eggs was calculated. After subtracting the total number of infertile eggs from total eggs set, the hatchability percentage of fertile eggs was calculated. Only saleable chicks were used in calculating hatchability percentages of total set and fertile eggs.

Chick weight, chick length and chick yield

Chicks hatched from each egg size group (small, medium, and large) were weighed individually by an accurate electronic scale and then using a calibrated foot, the length of the same chick was measured from the point of its beak to the middle toe excluding nail. Every chick was individually recorded for its weight (g) and length (cm). The average chick weight (g) and chick length (cm) for each egg weight group were determined using these readings. To get average chick weight for the measurement of chick yield, good quality chicks in all trays of each treatment (egg weight category) were counted and weighed by an accurate electronic scale. Chick yield was calculated as average chick weight divided by the average egg weight at the time of setting into incubator multiplied by 100.

Statistical analyses

All data were analyzed by using the Statistical Package for Social Sciences (SPSS) version 17.0 (SPSS Inc, 2008) statistical analysis program. Duncan's New Multiple Range test (Steel & Torrie, 1984) was used to compare means and a P value ≤ 0.05 was considered significant.

RESULTS AND DISCUSSION

Effect of hatching egg size on egg weight loss during incubation

The result for the effect of egg size on egg weight loss during different incubation periods among different hatching egg size groups is given in Table 1. Significant differences ($P \leq 0.05$) in egg weight loss were found in different egg size groups at day nine and day eighteen of incubation period. Difference in egg weight loss between small and medium group was non-significant ($P > 0.05$) both at day nine and day eighteen of incubation period. However, the large egg size group differed significantly

Table 1: Effect of egg size on egg weight loss during different incubation periods

Egg size	Average egg weight at time of incubation (g)	Egg weight loss (%) during different incubation periods	
		9 days	18 days
Small	41.92 ^a ±0.23	4.7 ^a ±0.10	11.26 ^a ±0.22
Medium	48.10 ^b ±0.18	4.53 ^a ±0.08	10.9 ^{ab} ±0.42
Large	54.66 ^c ±0.22	4.11 ^b ±0.11	10.38 ^b ±0.22
SEM	0.32	0.06	0.18
P value	0.00	0.00	0.12

Note: Means with different superscripts in a column differ significantly ($P \leq 0.05$).

($P \leq 0.05$) from both small and medium egg size groups at day nine and from small egg size group at day eighteen of incubation period.

In present study, maximum amount of egg weight loss was observed for large egg size group followed by medium and small egg size groups, respectively. However, on a percentage basis, the trend was just opposite; maximum egg weight loss (%) was recorded in small egg size group followed by medium and large size groups, respectively. Incubation egg weight losses depend both on egg characteristics and conditions under which the eggs were incubated (Gonzalez *et al.*, 1999). The loss in egg weight that occurs during incubation of eggs is due to diffusion of water through the shell (Tona *et al.*, 2001). The egg white contains proportionately almost double the amount of water compared to yolk and large eggs have a greater proportion of albumen thus greater moisture content than small eggs (Abanikannda *et al.*, 2011). This could be the reason for highest amount of egg weight loss during incubation in large egg size group in present study. Furthermore, the yolk's fat reserves provide the majority of the energy required for embryonic development and for every gram of fat burned, an almost equal mass of metabolic water is generated. Larger eggs have larger amounts of yolk and produce more metabolic water compared to medium and small eggs; hence water loss is also proportionally more

compared to medium and small eggs. Although, the amount of egg weight loss was highest for large egg size group but when compared on percentage basis, it was highest for small egg size group. The reason for this lies in the fact that small eggs have a higher surface-to volume ratio, and hence more amount of water is lost from small eggs compared to medium and large eggs.

Effect of hatching egg size on fertility and hatchability traits

The results for effect of egg size on fertility and hatchability traits (hatchability, embryonic mortality, infertile eggs, pipped-not-hatched eggs, and culled chicks) are shown in Table 2. In present study egg size had significant ($P \leq 0.05$) effect on fertility and most of the hatchability related traits except embryonic mortality at second week, pipped not hatched eggs and number of culled chicks. Maximum fertility was observed in medium egg size group followed by small and large egg size groups, respectively. Difference between small and medium egg size groups was statistically non-significant whereas, both these groups differed significantly ($P \leq 0.05$) from large egg size group. Maximum hatchability percentage (out of set eggs) was achieved in medium egg size group followed by small and large egg size groups, respectively. The percent hatchability of set egg was statistically similar in small and medium sized eggs but significantly ($P \leq 0.05$) different from large sized eggs.

Table 2: Effect of hatching egg size on fertility and different hatchability traits

Parameters	Egg size group			SEM	P value
	Small	Medium	Large		
Fertility (%)	90.08 ^a ±0.58	91.40 ^a ± 0.34	88.11 ^b ±0.58	0.54	0.01
Hatchability of set eggs (%)	81.42 ^a ±0.49	82.29 ^a ± 0.44	78.61 ^b ±0.27	0.59	0.01
Hatchability of fertile eggs (%)	91.19 ^a ±0.59	89.74 ^a ± 0.12	87.55 ^b ±0.61	0.58	0.01
<i>Embryonic mortality (%)</i>					
First week	1.67 ^a ±0.43	0.67 ^a ±0.33	2.33 ^b ±0.30	0.29	0.04
Second week	0.67±0.34	0.33±0.33	0.67±0.31	0.17	0.73
Third week	0.67 ^a ±0.37	1.33 ^a ±0.29	2.67 ^b ±0.32	0.34	0.01
Infertile eggs (%)	9.92 ^a ±0.58	8.60 ^a ±0.34	11.89 ^b ±0.53	0.54	0.01
Pipped-not-hatched eggs (%)	0.33±0.34	0.67±0.32	2.00±0.58	0.32	0.07
Culled chicks	0.67±0.31	0.33±0.33	1.33±0.35	0.22	0.18

Note: Means with different superscripts in a row differ significantly ($P \leq 0.05$)

A similar trend had been observed for percent hatchability of fertile eggs.

Maximum embryonic mortality during the first week of incubation was recorded in large egg size group, followed by small and medium egg size groups, respectively. During first week significantly ($P \leq 0.05$) higher embryonic mortality was observed in large sized eggs as compared to small and medium sized eggs. There were no significant differences in embryonic mortality among the three groups during the second week of incubation. Maximum embryonic mortality in large egg size group was found during last week of incubation followed by medium and small sized eggs. The embryonic mortality during third week of incubation was again significantly higher in large sized eggs as compared to small and medium sized eggs. Higher percentage of infertile eggs was also found in large egg size group followed by small and medium size egg groups and differences were significantly higher in large egg size group compared to small and medium size egg groups. No significant ($P > 0.05$) effect of egg size was observed on pipped-not-hatched eggs. Maximum chicks were culled in large size egg group with non-significant ($P > 0.05$) differences among the groups.

Fertility of hatching eggs and hatchability of fertile eggs are two major parameters deciding quality and quantity of day-old chicks. There are very few reports on the effect of egg size on fertility and hatchability traits in chicken. In consistence with our findings, Abiola *et al.* (2008) reported that medium-sized eggs of Anak broiler were suitable for setting to obtain good hatchability, best result of weight gain and lower mortality. Alabi *et al.* (2012) reported that medium egg size of Potchefstroom Koekoek chicken had the highest ($P \leq 0.05$) hatchability compared to large and small egg size categories. Rashid *et al.* (2013) also reported that percentage hatchability of medium-sized eggs was higher ($P \leq 0.05$) than those in large sized eggs in Fayoumi, Desi and crossbred (Rhode Island Red $\times$ Fayoumi) chickens. The results of the above studies were also similar to the findings of current study which revealed that better fertility and hatching traits were attained in medium egg size group.

Contrary to our findings, DeWitt and Schwalbach (2004) reported that large size eggs recorded to have

higher hatchability in New Hampshire and Red Rhode Island chicken. In a previous study, Wilson (1991) also reported that large-sized eggs had a higher hatchability value than medium and small-sized eggs. Singh *et al.* (2003) reported that the egg size had no effect on mortality pattern in chicken. The breed differences could be the reason for variability in fertility and hatchability among egg size groups in all above studies.

The lowest number of culled chicks was observed in medium egg size group. Many studies (Kumpula & Fasenko 2004; Lawrence *et al.*, 2004) indicated that poor chick quality i.e., number of culled chicks to be associated with heavier than average egg weight for a particular breed. These findings are in harmony with the results of present study in which highest number of culled chicks was recorded in large eggs size group than medium and small egg size groups.

Effect of egg size on chick quality

Egg size had a significant ($P \leq 0.05$) effect on chick weight and chick length. Data revealed that chick weight and chick length were significantly amplified ($P \leq 0.05$) with increasing the egg size among all there groups. However, egg size had no significant effect ($P > 0.05$) on chick yield. The results for effect of egg size on chick weight, chick yield and chick length are given in Table 3.

The chick weight in general (Decuypere *et al.*, 2002) and the chick length in specific for meat type chickens (Mukhtar *et al.*, 2013) are most widely used indicators for day-old chick quality assessment. A positive correlation has been reported between egg size and chick weight (Abiola *et al.*, 2008; Decuypere & Bruggeman 2007). Chicks hatched from large eggs tended to be heavier than chicks hatched from smaller eggs in Ross-38 breeders (Vieira *et al.*, 2005), Anak broiler breeders (Abiola *et al.*, 2008) and in three rural breeds Fayoumi, Desi and crossbred (Rashid *et al.* 2013). These reports suggested the advantage of initial bigger egg size at the time of setting. However, other studies indicated that the magnitude of correlation between egg weight and chick weight declines rapidly after hatching (Sinclair *et al.*, 1990; Pinchasov, 1991) and feed intake with the advancement of age of the chick becomes the deciding factor for final body weight gain (Wyatt *et al.*, 1985). Further, Williams (1994) suggested that larger eggs

Table 3: Effect of egg size on chick weight, chick yield and chick length

Parameters	Egg size group			SEM	P value
	Small	Medium	Large		
Average egg weight (g)	41.92 ^a $\pm$ 0.23	48.10 ^b $\pm$ 0.18	54.64 ^c $\pm$ 0.22	0.32	0.00
Average chick weight (g)	26.59 ^a $\pm$ 0.26	31.75 ^b $\pm$ 0.26	36.79 ^c $\pm$ 0.35	0.42	0.00
Average chick length (cm)	16.11 ^a $\pm$ 0.11	17.59 ^b $\pm$ 0.07	18.96 ^c $\pm$ 0.09	0.12	0.00
Average chick yield (%)	64.45 $\pm$ 0.45	65.16 $\pm$ 0.28	65.37 $\pm$ 0.31	0.21	0.17

Note: Means with different superscripts in a row differ significantly ($P \leq 0.05$).

contained more nutrients than small eggs so that developing embryos from heavier eggs tended to have more nutrients for their growth requirements during incubation, hence heavy chicks hatched from large eggs.

CONCLUSION

The present study concludes that the medium and small sized eggs are more suitable compared to large sized eggs for increasing chick production efficiency in terms of salable day-old chicks. Large sized eggs are more in demand as table eggs and fetch higher price. Therefore, medium, and small sized eggs should be used for chick production whereas, large sized eggs should be sold as table eggs to increase the profitability in poultry farming.

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