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Effect of different genetic groups and rearing systems on chicken egg quality parameters

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Abstract

A total of 60 freshly laid eggs were collected randomly from Kamrupa and indigenous chickens of Assam reared under three different systems of management viz. intensive, semi-intensive and free-range systems (10 eggs from 3 rearing systems=30 x 2 varieties=60 eggs) and were sent to the post-graduate laboratory of Department of Poultry Science, AAU, Khanapara, Guwahati-781022 to assess different egg quality characteristics. The results indicated that the overall egg weights (gm) of Kamrupa chicken were significantly (P<0.05) higher than that of indigenous chicken in different management systems. Yolk weights of indigenous chicken under different rearing systems showed no significant difference, while the corresponding values in Kamrupa chicken were significantly (P<0.05) lower in the free-range system than other two systems. The albumen weights were significantly (P<0.05) varied across genetic groups and rearing systems. The shape indices recorded in the intensive and free-range system of indigenous chicken were comparable but significantly (P<0.05) higher than the semi-intensive system. In indigenous chicken, the yolk index was significantly (P<0.05) higher in the semi-intensive system than other two systems of rearing, while in Kamrupa, the values were significantly higher in the intensive and semi-intensive than free-range system. In both the genetic groups, the albumen indices were significantly (P<0.05) higher in the intensive system than in the other two systems. The Haugh unit scores were also significantly (P<0.05) higher in intensive systems of rearing than other systems in both the genetic groups. Therefore, it may be concluded that both genetic groups and the rearing system could influence the egg quality characteristics.

Keywords: *Egg quality parameters, Kamrupa chicken, indigenous chicken, intensive, semi-intensive, free-range system*

Indigenous chicken farming under free-range system is an age-old practice among the resource poor rural people particularly among rural tribal people in India (Islam *et al*., 2022). However, due to lower production potential less attention has been paid to indigenous chicken (Tajane and Vasulkar, 2014). The eggs and meat produced from the indigenous chicken variety always fetch a premium price than their commercial counterparts due to their taste and better acceptability among consumers (Islam *et al.,* 2022). *Kamrupa* is an improved dual-type backyard chicken developed by

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Assam Agricultural University, Guwahati during the year 2016 and has been gaining popularity across north-eastern states of India due to its higher production potential, better adaptability under local environmental conditions, disease resistance and escape predation.

Egg quality is an important characteristic that influences grading, price, consumer preference, hatchability and chick weight (King'ori, 2012). Most of the internal and external quality of eggs varies with genotype, season, temperature and relative humidity. Opinions on egg quality are ambiguous. Rossi (2007) observed higher Haugh unit values of eggs from hens that were housed in cages, whereas Minelli *et al*. (2007) reported higher Haugh units from hens under organic or free-range systems. An egg produced in the farm has to pass through many physical barriers (handling, transportation, environmental conditions, etc.) before it reaches the consumer. Consumers prefer an egg in which the albumen is firm, the yolk has a dense colour, is appropriate size with an intact shell, and is free from pathogens (Samiullah *et al*., 2014). It is also to be mentioned that the quality of an egg is of utmost importance among today's health-conscious consumers. Hence, the present study was undertaken to assess the egg quality characteristics (internal and external) of two different genotypes under different rearing systems.

Materials and methods

A total of 60 freshly laid eggs were collected from two different genetic groups (30 from each *Kamrupa* (KC) and indigenous chicken (IC)) and were sent to the post-graduate Laboratory under the Department of Poultry Science, College of Veterinary Science, Guwahati to assess different egg quality characteristics. The birds were reared under three different rearing systems *viz*. intensive (INT), semi-intensive (SINT) and free-range (FR) systems and 10 eggs from each rearing system were used for the study. The birds reared under intensive and semi-intensive systems were maintained at the Instructional Poultry Farm, Biswanath College of Agriculture (BNCA), Biswanath Chariali, while the birds under the free-range system were maintained at the nearby village of the said institute. In the intensive system, the birds were fed with commercial chick starter (0-8 weeks), grower (9-20 weeks) and layer (21-72 weeks) feed as per their requirements. In semi-intensive system, both KC and IC were offered @50% of their actual requirement of commercial feeds (according to their age), while in free-range system, birds were let loose for the whole day in search of feed and often provided with supplemental feed like broken rice, fallen grains, paddy, etc. and sheltered at night. The routine deworming and vaccination were done as per the standard schedule for all the birds. The eggs were collected as follows:

The eggs thus collected during 52nd week were examined for quality characteristics in the laboratory within 24 hours of collection. After weighing the eggs with a digital weighing balance, the length and width of the eggs were measured by using a digital calliper with 0.01mm precision (Mitutoyo, 300mm, Neus, Germany) to calculate the shape index (Reddy *et al.,* 1979). The eggs were broken to obtain the albumen and yolk, and then the yolk weight was measured with 0.01 g precision. The eggshells were cleaned by washing process and then put in an oven at 105^{o}C (Nuve FN-500, Ankara, Turkey) for the drying process for 24 h. Then, the eggshell weight was determined with 0.01 g precision. Albumen weight was calculated by subtracting yolk and shell weight from total egg weight. Eggshell thickness was taken as the average of measurements at three different points of the eggshell, specifically the air cell, sharp end, and equator region, by using a digital calliper with 0.01 mm precision. The yolk diameter (YD), albumen length (AL) and albumen width (AW) were determined by using a digital calliper with 0.01 mm precision (Mitutoyo, 300 mm, Neuss, Germany). Albumen height (AH) and yolk height (YH) were measured by using a tripod micrometer. The egg yolk index (YI), albumen index (AI) and Haugh unit (HU) were calculated using the formulas given by Funk (1948), Heiman and Carver (1936) and Haugh (1937), respectively.

$$YI = \frac{\textit{Yolk height}}{\textit{Yolk diameter}} \times 100$$

$$AI = \frac{\textit{Albumen height}}{\textit{(Albumen length + Albumen width)/2}} \times 100$$

$$HU=100 \times \log[(\text{Albumen height}+7.57)-(1.7 \times \text{Egg weight}^{0.37})]$$

Yolk colour was determined with a Roche yolk colour fan with a 15-point scale (Roche Ltd., Basel, Switzerland), according to the pigmentation degree from the lightest (score 1) to the darkest colour (score 15).

Egg quality parameters *viz*. egg weight, yolk weight, yolk colour, albumen weight, shell weight, shell thickness, shape index, yolk index, albumen index and HU score data were analysed using JMP ® Pro16.0.0. Performing Fit model analysis, based on genotype and rearing type of birds, the Least squares (LS) mean values and standard error values of the said parameters of egg quality were computed and presented in Table 1. To find out the Least squares mean differences of genotypes, the student's t-test was followed and for the interaction (of genotype*rearing type), Tukey's Honestly Significant Difference (HSD) tests for all pairwise differences method was followed.

Results and discussion

The present results indicated that the egg weights varied significantly (P<0.05) between genotypes and rearing systems (Table - 1). The *Kamrupa* chickens produced significantly (P<0.05) heavier eggs than the indigenous chickens, which might be due to the different genetic makeup and body weights of the birds used. The influence of genotype on the weight of eggs was also confirmed by Hammershoj and Steenfeldt (2015). Further, there were significant (P<0.05) differences of egg weights in different rearing systems and eggs were found to be heavier in the intensive system than other two systems in both genotypes, which might be due to better nutrition in the intensive system. The present findings were in good agreement with Kucukyilmaz *et al*. (2012), who also reported differences of egg weights in conventional cages from organic systems of rearing. In contrast, several earlier workers found that the housing system did not influence the egg weights (Kuhn *et al*., 2014; Lordelo *et al*., 2017; Sokolowicz *et al.*, 2018). The overall shape indices between the genotypes did not show any significant (P>0.05) differences. The shape indices both in indigenous and *Kamrupa* chicken showed inconsistent results in different rearing systems. The shape indices of indigenous chicken under the intensive system were similar to the free-range system but significantly (P<0.05) higher than the semi-intensive system. The corresponding values were comparable between intensive and semi-intensive but significantly (P<0.05) lower in the free-range system in *Kamrupa* chickens. Kucukyilmaz *et al*. (2012) also reported higher shape indices in the organic system than conventional cage system within same genotypes. However, Clerici *et al.* (2006) reported no differences in egg shape index for eggs from layers reared in an organic or conventional system. The overall mean yolk weight (g) of indigenous chicken (12.82±0.03) was significantly (P<0.05) higher than *Kamrupa* chicken (12.14±0.07) (Table 1). Krawczyk (2009) reported lower yolk weight in the eggs from native hens compared to commercial hybrids. In contrast, Sokolowicz *et al.* (2018) found that yolk weight could not be influenced by genotypes. However, the yolk weights did not vary significantly (P>0.05) across rearing systems in indigenous chickens, but the values were significantly (P<0.05) higher in intensive than free-range and were comparable to semi-intensive systems in *Kamrupa* chickens. Sokolowicz *et al.,* (2018) reported that yolk weight might be influenced by housing systems. The study also revealed that the overall albumen weights (g) of *Kamrupa* chickens (26.47±0.09) were significantly (P<0.05) higher as compared to indigenous chickens (19.03±0.11). Among rearing systems, intensive systems recorded significantly (P<0.05) higher values than other systems in both genotypes. Mugnai *et al.* (2009) reported higher albumen weights of eggs collected from hens reared under organic systems than conventional cage system. The overall mean shell weight was significantly (P<0.05) higher in *Kamrupa* chicken compared to indigenous, which might be attributed to the heavier eggs of *Kamrupa* as compared to indigenous chicken. Sokolowicz *et al.* (2018) also demonstrated that the housing system influenced egg shell weight, thickness, density and strength. The shell weights found in the intensive system were significantly (P<0.05) higher as compared to other two systems in both genotypes. The interaction between genotypes and rearing systems also showed significant (P<0.05) variations. The yolk index of indigenous chicken was significantly (P<0.05) higher in the semi-intensive system (4.09±0.04) than the intensive system (3.87±0.04) but comparable with free-range system (4.03±0.04). Similarly, the yolk index was significantly (P<0.05) higher in the intensive system (4.40±0.04) than the free-range system but comparable with the semi-intensive system (4.37±0.04) in *Kamrupa* chickens. Nayak *et al.* (2020) reported a higher yolk index in *Vanaraja* chicken reared under caged and free-range than those reared under the semi-intensive system of rearing. Dong *et al.* (2017) reported that lower yolk ratio of eggs from hens reared in free-range than those under conventional cage and flat net rearing systems. The albumen indices in both the genotypes were significantly (P<0.05) higher in the intensive system as compared to the other two systems. The overall albumen index was significantly (P<0.05) higher in *Kamrupa* chicken (10.97±0.06) as compared to indigenous chickens (9.10±0.06). Nayak *et al*. (2020) reported that the overall albumen index of eggs of *Vanaraja* layers differed significantly higher in the conventional cage than the free-range system. The overall shell thickness did not show any significant (P>0.05) differences between the genotypes. The results indicated that there were no significant differences in overall shell thickness between genotypes, however erratic results of shell thickness were observed amongst rearing systems in both genotypes. Comparatively, thicker shells were found under semi-intensive and free-range than intensive systems in indigenous chickens, while in *Kamrupa* similar thickness was recorded. Earlier studies indicated organic eggs had thicker shells as compared to the conventional system (Mugnai *et al*., 2009; Kucukyilmaz *et al*., 2012). Thicker egg shells in indigenous chicken under free-range and semi-intensive might be attributed to augmentation of minerals in the shells due to increased mineral metabolism resulting from the ingestion of tiny stones and direct exposure of hens to sunlight in the outdoor area (Rizzi *et al*., 2006). The yolk colour determines the yellowness of the egg yolk and was significantly (P<0.05) higher in the free-range system in both genotypes than in semi-intensive and intensive systems. The yolk colour score followed a diminishing trend through free-range, semi-intensive and intensive systems in both genotypes.

The present findings corroborated the findings of Sokolowicz *et al.* (2018), who found more intense egg yolk colour in hens of different breeds reared under organic and free-range systems compared to the litter floor system. The intense yolk colour could be attributed to the access of hens to an outdoor run, in which the birds could ingest grass and herbs while scavenging. It was claimed that plants ingested by hens on the free range had a positive effect on yolk colour (Horsted *et al*., 2006). Karadas *et al*. (2005) also demonstrated that eggs from free-range hens had a higher yolk carotenoid content compared to the hens without outdoor access. The overall HU score was significantly (P<0.05) higher in *Kamrupa* chicken

Table 1: Least Square (LS) mean and standard error (S.E) and LS mean difference analysis of egg quality parameters

Parameters	Indigenous chicken			*Kamrupa* chicken			Overall		P-Value		
	INT	SINT	FR	INT	SINT	FR	$^{\#}$IC	$^{\$}$KC	Genotype (G)	Rearing type (R)	G x R
Egg weight (g)	36.92^{d} ±0.14	35.56^{e} ±0.13	34.61^{f} ±0.16	45.80^{a} ±0.13	44.98^{b} ±0.13	43.05^{c} ±0.19	35.70^{B} ±0.13	44.61^{A} ±0.14	<.0001*	<.0001*	0.0012
Yolk weight (g)	12.76^{c} ±0.03	12.82^{c} ±0.05	12.86^{c} ±0.03	12.63^{a} ±0.06	12.47^{a} ±0.05	11.32^{b} ±0.06	12.82^{B} ±0.03	12.14^{A} ±0.07	<.0001*	<.0001*	<.0001*
Albumen weight (g)	20.09^{d} ±0.09	18.97^{e} ±0.09	18.01^{f} ±0.11	27.36^{a} ±0.10	26.57^{b} ±0.09	25.47^{c} ±0.05	19.03^{B} ±0.11	26.47^{A} ±0.09	<.0001*	<.0001*	0.1967
Shell weight (g)	3.99^{c} ±0.02	3.76^{d} ±0.02	3.75^{d} ±0.03	4.97^{a} ±0.02	4.55^{b} ±0.02	4.59^{b} ±0.02	3.83^{B} ±0.02	4.70^{A} ±0.02	<.0001*	<.0001*	0.0012
Shape index	74.72^{ab} ±0.10	73.62^{c} ±0.13	74.63^{ab} ±0.07	74.22^{b} ±0.19	74.27^{b} ±0.13	75.09^{a} ±0.11	74.32^{A} ±0.08	74.53^{A} ±0.10	0.0593	<.0001*	<.0001*
Yolk index	3.87^{c} ±0.04	4.09^{b} ±0.04	4.03^{bc} ±0.04	4.40^{a} ±0.04	4.37^{a} ±0.04	3.97^{bc} ±0.04	3.99^{B} ±0.03	4.24^{A} ±0.03	<.0001*	<.0001*	<.0001*
Albumen index	10.26^{c} ±0.96	9.18^{d} ±0.96	7.87^{e} ±0.96	11.61^{a} ±0.96	10.96^{b} ±0.96	10.35^{c} ±0.96	9.10^{B} ±0.06	10.97^{A} ±0.06	<.0001*	<.0001*	<.0001*
Shell thickness (mm)	0.30^{c} ±0.003	0.31^{a} ±0.003	0.31^{ab} ±0.003	0.31^{abc} ±0.002	0.30^{bc} ±0.003	0.31^{ab} ±0.002	0.31^{A} ±0.002	0.31^{A} ±0.002	0.3060	0.0054*	0.0020*
Yolk colour (Roche scale)	10.40^{c} ±0.07	11.46^{b} ±0.03	12.07^{a} ±0.07	9.46^{d} ±0.08	10.21^{c} ±0.06	11.86^{a} ±0.05	11.31^{A} ±0.08	10.51^{B} ±0.11	<.0001*	<.0001*	<.0001*
HU Score	80.27^{b} ±0.18	79.19^{c} ±0.18	77.28^{e} ±0.18	82.26^{a} ±0.25	79.22^{c} ±0.18	78.04^{d} ±0.17	78.91^{B} ±0.11	79.84^{A} ±0.11	<.0001*	<.0001*	<.0001*

NB: Means with different superscripts in a row differed significantly ((P<0.05)

#IC: Indigenous chicken; $^{\$}$KC: *Kamrupa* Chicken

(79.84±0.11) than in indigenous chicken (78.91±0.11). The HU scores were significantly (P<0.05) higher in the intensive system followed by semi-intensive and free-range systems in both genotypes. Similarly, Sokolowicz *et al.* (2018) observed that both genotypes and rearing systems influenced the HU score. Samiullah *et al*. (2017) reported a lower HU score for barn eggs compared to free-range eggs. Lordelo *et al.* (2017) demonstrated that the albumen from both barn and free-range eggs were characterised by similar HU scores, but were lower than in egg albumen from organic farms. In contrast, Kucukyilmaz *et al*. (2012) observed that eggs procured from brown layers reared in organic had higher HU score than that of conventional cage rearing, while eggs from white layers did not show any significant (P>0.05) differences between organic and conventional cage rearing.

Conclusion

In conclusion, both the rearing system and hen genotype had considerable effects on most of the egg quality characteristics. *Kamrupa* hens had a higher egg production rate and produced eggs with higher egg weight, better albumen quality and HU score than the native chicken. However, the yolk colour was found to be the best in indigenous chicken reared under free-range system. Further research is needed to investigate the dietary influences of pasture composition and herbal intake on nutrient utilisation and egg quality in hens reared under semi-intensive and free-range systems.

Conflict of interest

The authors declare no conflict of interest.

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