RESEARCH ARTICLE

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A Comparative Study on the Laying Performance and Egg Quality of Four Available Strains in Bangladesh

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ABSTRACT

Among all the sub-sectors of the livestock sector in Bangladesh, poultry stands as one of the most important ones. To evaluate the production performances and egg quality of four commercial layer strains in Bangladesh, a total of 128 laying pullets including NOVOgen brown, ISA brown, Hy-line brown, and Bovans brown were randomly allocated at 4 different treated groups (one individual strain treated as separate treatment) having 4 replications and 8 birds in each replication. The birds aged 20 weeks were considered for the experiment and continued until 35 weeks of age. A commercial layer diet purchased from Kazi Farms Group was fed to the experimental birds. Identical management was provided to the birds irrespective of their strains. Data on feed intake, egg production and body weight were recorded and thereafter egg mass and feed efficiency were calculated. Eggs were collected from the respective treatments and subjected to external and internal egg quality analysis. The results revealed that Hy-Line brown had significantly ($p<0.001$) lower feed intake compared to other strains. On the other hand, NOVOgen Brown had the significantly ($p<0.05$) higher shell thickness among others. Other laying performances such as hen-day egg production, average egg weight, egg mass and egg quality parameters such as shape index, Haugh unit, albumen index, and yolk color score did not affect significantly ($p<0.05$). Taken together, it may be concluded that there were almost no statistical differences in relation to laying performance and egg quality among the strains compared in this study and the strains are highly compatible to the local climatic condition.

Keywords: comparative study, egg production, egg quality, Haugh unit, layer strains.

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I. Introduction

In Bangladesh, poultry is the largest livestock group, with an estimated 375.6 million birds, including 311.8 million hens providing major protein products in the form of eggs and meat [1]. According to the report of Bangladesh Poultry Industries Central Council, Bangladesh requires 40 million eggs daily [2]. In 2020–21, the yearly egg production in Bangladesh was 23.35 billion [1], which was 7.3 billion in the 2011–12 fiscal year. Therefore, the rapid growth of 3.2 times increases in egg production was observed over the last decades. According to the Food and Agricultural Organization, a minimum annual per capita consumption of 104 eggs for least-developed countries. Nonetheless, Bangladesh is already moving forward to become a middle-income country from a least-developed country by 2026 and become a developed-rich country by 2041. Therefore a per capita consumption of 200 eggs is one of the criteria for being a middle-income-based country even though

Bangladesh already fulfilled the egg consumption demand according to FAO with an average yearly consumption of 136.01 eggs [1]. Many high-yielding strains of commercial layers have been developed to meet daily egg consumption demands. The major commercial layer strains currently available at the field level in Bangladesh are ISA Brown, Hy-line White, Hy-Line Brown, Shavar-579 Brown, NOVOgen Brown, Hy-sex White, Hy-sex Brown. The white strains generate white shelled eggs while the brown strains produce brown shelled.

II. Materials and Method

A. Experimental Layout, Birds, and Dietary Treatment

This experiment was conducted with 128 pullets of 20 weeks age, 32 pullets from each of NOVOgen Brown, ISA Brown, Hy-Line Brown, and Bovans Brown for a period of 16 weeks at Bangladesh Agricultural University (BAU) Poultry Farm, Mymensingh in order to compare the production performance and egg quality of four commonly available layer strains in Bangladesh in pyramid-type three-tier layer cage in an open-sided shed type house. Four treatments were used, each with four replications and eight birds per replication. The first treatment (T1) was NOVOgen Brown, and other treatment groups comprised of ISA Brown (T 2), Hy- Line Brown (T3), and Bovans Brown (T4). All birds were fed with diets of similar composition, manufactured by Kazi Farms Limited and provided with the same care and management up to 35 weeks of age. Strict sanitary measures were maintained during the experimental period.

B. Record Keeping

Various data linked to the goal of the current experiment, such as body weight, hen-day egg production, feed intake, egg weight, egg mass output, feed efficiency and egg quality characteristics were collected and evaluated from 20 weeks to 35 weeks. Temperature and humidity were recorded twice a day, in the morning and the afternoon. Egg quality characteristics were measured three times during the experimental period; 24th, 29th, and 34th weeks of the age. The temperature and humidity in the egg storage room were kept at an optimum level of 12 °C to 14 °C. The most generally accessible brown layer strains in Bangladesh are NOVOgen Brown, ISA Brown, Hy-Line Brown, and Bovans Brown, which are thought to be well adapted to the climatic conditions of Bangladesh. Many studies observed variations in egg production performance for various strains of chicken [3]. With the aging of layers, typical changes in eggs occur, such as an increase in yolk weight and yolk proportion but a decrease in albumen percentage [4]– [6]. However, the egg production of the birds decreases with age of the birds. Egg quality is clearly defined as a very important characteristic for consumers [7]. Egg quality has a genetic basis, and the parameters of egg quality differ between strains of hens [8]. Not all strains produce eggs of the same quality at the same time. There is a variation in the quantity and quality of eggs produced by different layer strains. Better management of layer birds is required to achieve optimum growth and egg production from different commercial layer strains [9]. A few studies were only conducted with individual and multi strains in the literature. To the best of the authors' knowledge, no comparative study has been conducted on the four most available brown layer strains found in Bangladesh. Considering the situation and the scarcity of information, an effort was made to track and compare the production performance and egg quality of four commercially available brown layer strains in Bangladesh.

Data was taken from the stored eggs on the 2nd day after collection. Eight eggs per treatment (2 eggs per replication) were selected randomly from the egg-laying nest (cage) at one time and used for analysis. Egg weight was measured by using a digital egg weighing balance. The length of the egg was measured by a slide caliper. In every case, the mean of three records for each variable was considered for the length of a particular egg. The width of the egg was evaluated by a slide caliper. The measurements were taken from three points (small end, large end, and waist region of the egg). The meaning of three measurements was considered as the width of a particular egg. The eggs were then carefully broken on a glass plate (30 cm × 21 cm) to measure both external and internal egg quality characteristics. The external egg quality characteristics were measured by estimating shape index and eggshell thickness. The internal egg quality characteristics were determined by estimating egg albumen weight, yolk weight, shell weight, albumen index, yolk index, yolk color score, and Haugh Unit.

C. Statistical Analyses

Data for different variables were subjected to analysis of variance (ANOVA) in a completely randomized design (CRD) employing IBM SPSS Statistics 20. Differences with p-values<0.05 or better were considered to be significant. The mean values between treatments were separated by DMRT [10].

III. Results

A. Overall Laying Performance

1) Age at sexual maturity

No significant (p>0.05) difference in age at sexual maturity among the strains compared in the study was observed in the Table I. Generally, brown egg-producing strains, on average, reach sexual maturity earlier (132.07 days) than white egg producing strains (137.8 days) [11]. The NOVOgen Brown, ISA Brown, Hy-Line Brown, and Bovans Brown groups were the late matured pullets because they laid their first eggs after 132 days in this experiment. During the experiment, birds were facing environmental stresses due to higher temperature and humidity. These adverse climatic conditions might be the cause of late sexual maturity in our experiment.

2) Age at 50% egg production

No significant (p>0.05) difference in age of 50% egg production among the strains compared in the study was observed (Table I). According to the management guidance, the age at 50% egg production for NOVOgen Brown, ISA Brown, Hy-Line Brown, and Bovans Brown groups is 144 days, 145 days, 140 days, and 143 days, respectively [12]. As a result, it might be said that the age at 50% egg

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TABLE I: OVERALL PRODUCTION PERFORMANCES OF FOUR COMMERCIAL BROWN LAYER STRAINS DURING 20–35 WEEKS OF AGE

Parameter	NOVOgen Brown	ISA Brown	Hy-Line Brown	Bovans Brown	P-value	LS
Age at Sexual Maturity(days)	135.25±0.47	135.75±0.85	136.75±0.47	136.75±0.47	0.395	NS
Age at 50% production(days)	153.25±2.17	156.50±4.87	153.0±2.55	153.75±5.69	0.925	NS
Age at Peak Production(days)	200.0±10.71	196.75±11.67	187.75±11.92	211.0±10.84	0.558	NS
HDEP (%)	80.08±2.69	77.44±4.05	80.73±1.71	72.92±4.56	0.403	NS
Average Egg Weight (g)	55.35±0.73	53.91±0.50	54.90±0.26	54.66±0.35	0.269	NS
Feed Intake (g/b/d)	105.48^{a}±0.09	103.99^{b}±0.05	102.07^{d}±0.05	103.58^{c}±0.06	0.000	**
EMO (g/b/d)	44.32±1.50	41.71±1.96	44.32±0.82	39.84±2.37	0.257	NS
FE	2.38±0.08	2.50±0.12	2.30±0.04	2.62±0.15	0.229	NS
Body weight at 5% Egg Production (kg)	1.64±42.39	1.60±44.67	1.58±54.36	1.61±53.83	0.875	NS
Body weight at 50% Egg Production (kg)	1.76±76.14	1.78±42.93	1.73±29.62	1.77±34.79	0.896	NS
Cumulative feed intake (kg)	11.81^{a}±11.05	11.64^{b}±6.66	11.43^{d}±6.48	11.60^{c}±7.42	0.000	**
Total Cost (BDT/b)	635.04^{a}±0.59	626.02^{b}±0.35	614.48^{d}±0.34	623.58^{c}±0.39	0.000	**

*The experimental period was August-November/2021: the feed price may vary throughout the year. Here per kg feed price was 43tk.
Where, ^{a,b,c} means with different superscripts within the same row differ significantly, value indicate: Mean ± Standard Error (SE); **= Significant (P<0.05), LS= Level of Significance.

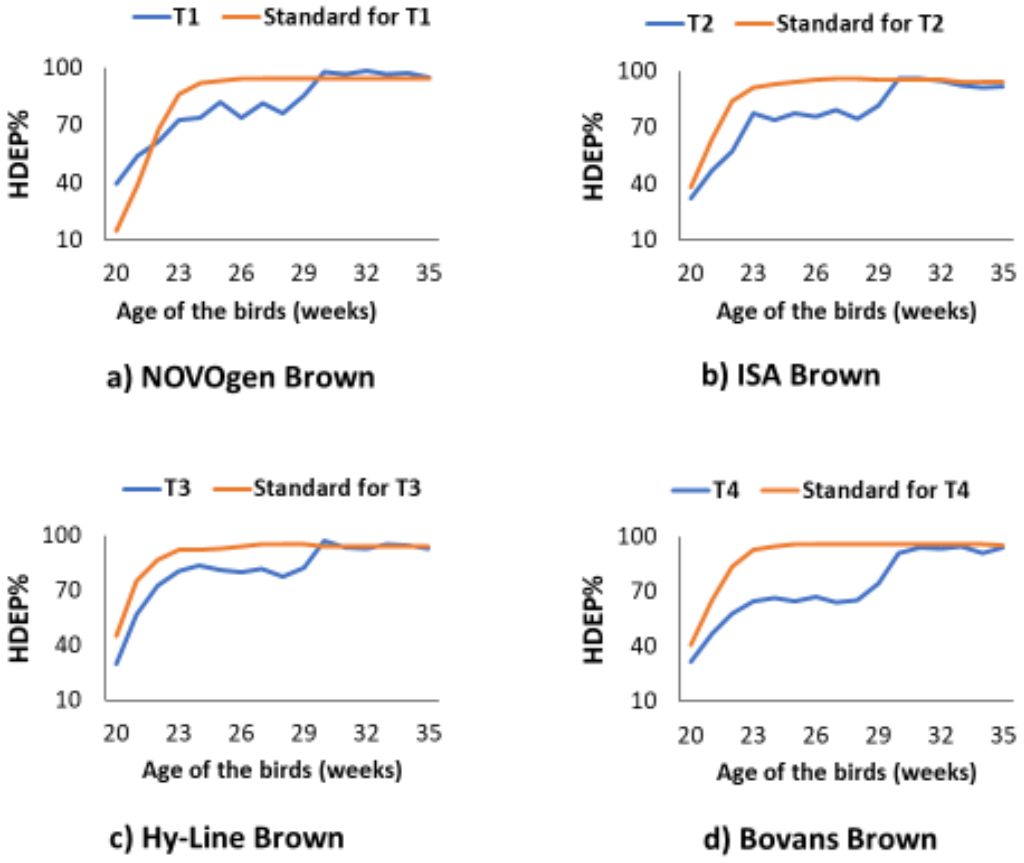


Fig. 1: Comparison of the weekly HDEP% data with each strain's management guide standard for various treatment groups and age ranges.

production of all treatment groups considered was longer than the standard. It would naturally take longer to reach 50% egg production because it reached sexual maturity 1 week later than usual, and that is exactly what occurred in this instance.

3) Age at peak production

No significant (p>0.05) difference in age of peak production among the strains compared in the study was observed (Table I). According to the management guidance, the age at peak production for NOVOgen Brown, ISA Brown, Hy-Line Brown, and Bovans Brown groups should be 182 days, 189 days, 189 days, and 196 days, respectively [12]. As a result, the age at peak production for Hy-Line Brown groups was lower than the standard and higher than the standard for the NOVOgen Brown, ISA Brown, and Bovans Brown groups. Since it took longer than normal to reach 50% egg production, naturally peak production would come late and that is what happened here.

4) Hen-day egg production (HDEP)

Results showed that there were no significant differences (p>0.05) observed during the entire period of study (Table I and Fig. 1). Egg production differed among strains of layers [13], [14]. In contrast, however, there was no significant effect of strain on egg production [15].

The findings of this research revealed that the egg production differed among strains of layers and showed no significant effect which supports the statements of earlier researchers [13]– [15].

The comparison of data between obtained and standard weekly HDEP% for each strain is presented in Fig. 1.

5) Egg weight (g)

Results showed that there were no significant differences ($p>0.05$) observed during the entire period of study (Table I and Fig. 2). Johnston and Gous [16] showed that the egg weight increased with the hens' age. Concerning the age effect, our results indicated that egg weight of different treatment groups increased numerically as age increased accepting the findings of Johnston and Gous [16]. Similar results have been reported by Suk and Park [4] in two commercial egg-type strains of chicken where egg weight increased with an increase in age.

The comparison of data between obtained and standard weekly egg weight for each strain is presented in Fig. 2.

6) Feed intake (g/b/d)

Results showed that there were mostly significant differences ($p<0.001$) observed during the entire period of study (Table I and Fig. 3). Significant differences in feed intake between strains were reported by Ragheb *et al*. [17]. In this experiment, feed consumption (g/bird/d) was affected by strains ($p<0.05$) which agrees with the findings of Ragheb *et al*. [17] and Petek [18].

7) Body weight (g)

Body weight gain of laying pullets did not increase significantly ($p>0.05$) (Table I). Ragheb *et al*. [17] reported that strain did not affect body weight change which supports the current study result. Regarding the age effect, our results of this experiment indicated that body weight increased as age increased. A similar trend was noticed by Mehta *et al*. [19] and Singh *et al*. [20] who reported that as the hens aged, feed intake increased with a corresponding increase in body weights.

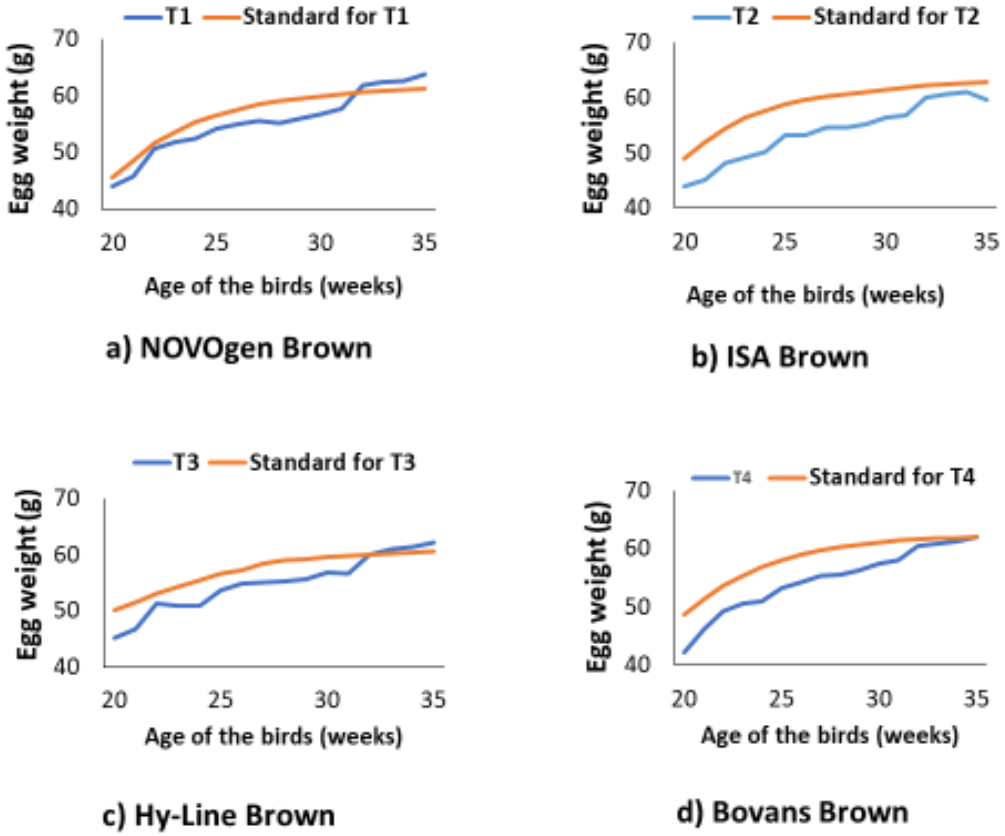
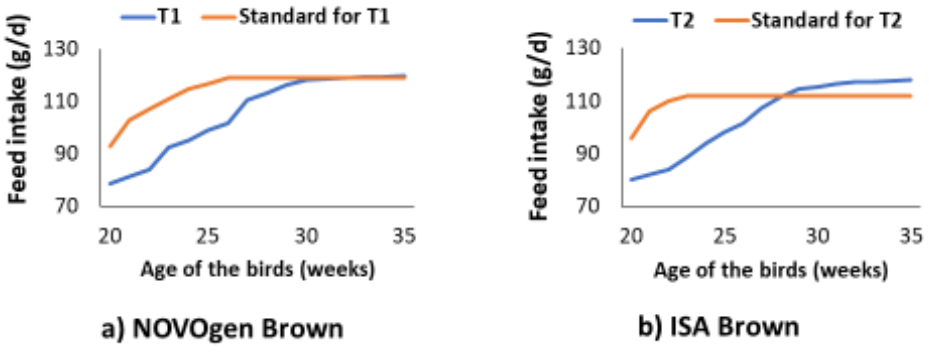


Fig. 2: Comparison of weekly egg weight data with each strain's management guide standard for various treatment groups and age ranges.



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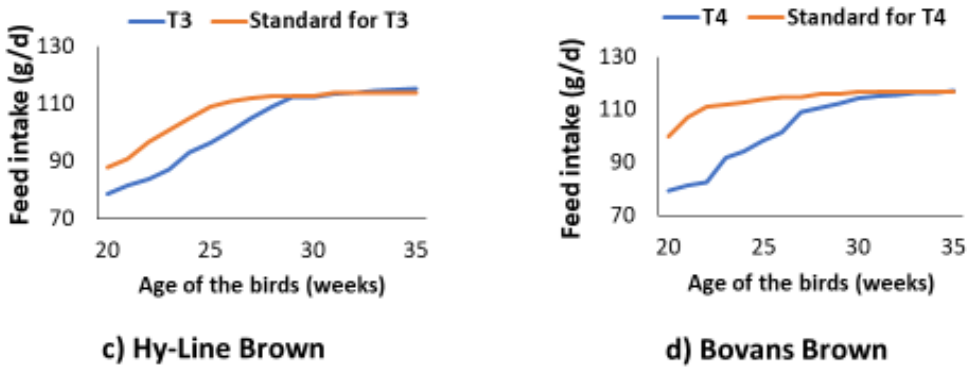

Fig. 3: Comparison of the weekly feed intake data with each strain's management guide standard for various treatment groups and age ranges.

B. External Egg Quality

External egg quality is mostly refers to the eggshell quality and eggshell quality plays a key role in the economics of egg production because egg breakage accounts from 8 to 10% of total egg production causing economic losses. A considerable effect on eggshell quality is associated with housing system, season of rearing, age of the laying hens, nutrition of the hens, etc. Shape index and eggshell thickness are the two most important parameters to assess eggshell quality in laying hens. In this research, we measured the eggshell quality in three different ages of laying pullets say, 24, 29 and 34 weeks. The data of eggshell quality has presented in the Table II.

TABLE II: DIFFERENT BROWN TYPE COMMERCIAL LAYER STRAIN ON EGGSHELL QUALITY (20-35WKS)

Age (Wks)	Parameter	T_1	T_2	T_3	T_4	p-value
24	Shape Index	79.08	78.19	78.81	78.66	0.677
	Shell (%)	10.47	9.85	10.36	10.86	0.631
	Shell Thickness (mm)	0.39^{a}	0.37^{ab}	0.35^{c}	0.36^{bc}	0.011
29	Shape Index	78.76	77.53	77.84	78.39	0.735
	Shell (%)	10.16	9.55	10.25	10.24	0.093
	Shell Thickness (mm)	0.38^{a}	0.36^{ab}	0.34^{c}	0.35^{ab}	0.035
34	Shape Index	78.62	77.38	77.57	78.17	0.631
	Shell (%)	9.81	9.80	9.84	10.14	0.609
	Shell Thickness (mm)	0.37^{a}	0.36^{ab}	0.33^{c}	0.34^{bc}	0.008

T_1=NOVOgen Brown, T_2=ISA Brown, T_3=Hy-Line Brown and T_4=Bovans Brown. ^{a,b,c} means with different superscripts within the same row differ significantly; ** =Significant (P<0.05).

1) Shape index

In this experiment, the egg shape index was influenced and showed a decline with the advancing age (Table II). The result of this experiment supports the findings of Van Den Brand *et al*. [6] and Suk *et al*. [4]. The decrease in egg shape index with age indicates that eggs become elongated in shape as the hen ages.

2) Percent of eggshell

The age of hens influenced the eggshell quality [21], [22] which deteriorated with the advancing age of hens. In this experiment, the shell percentages deteriorated (Table II) which influenced the eggshell quality that supports the statements of Silversides *et al*. [21] and [22].

3) Eggshell thickness

Many researchers have reported that eggshell thickness decreased with increasing hen age [23]–[25]. In this experiment, the eggshell thickness decreased with the age of birds **(**Table II and Fig. 4) which supports the statements of Lee *et al*. [23], Molnár *et al*. [24] and Rodríguez-Navarro *et al*. [25].

The eggshell thickness of various brown layer strains at different ages is presented in Fig. 4.

C. Internal Egg Quality

Albumen quality

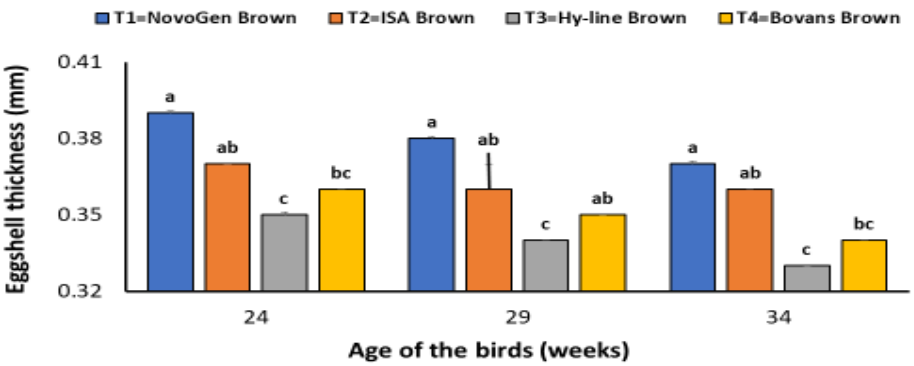

Fig. 4: The eggshell thickness of brown layer strains at different ages.

TABLE III: DIFFERENT BROWN TYPE COMMERCIAL LAYER STRAIN ON ALBUMEN QUALITY (20–35WKS)

Age (Wks)	Parameter	T_1	T_2	T_3	T_4	p-value
24	Albumen Index	11.63	9.00	10.41	9.30	0.098
	Haugh Unit (HU)	95.94	88.84	92.68	90.50	0.093
	Albumen (%)	68.30	69.61	68.72	68.00	0.428
29	Albumen Index	9.73	8.33	9.29	8.38	0.528
	Haugh Unit (HU)	89.14	84.01	87.84	83.07	0.352
	Albumen (%)	66.95	68.45	67.73	66.94	0.356
34	Albumen Index	8.74	7.33	8.75	8.33	0.262
	Haugh Unit (HU)	85.58	80.59	82.39	82.43	0.436
	Albumen (%)	66.59	65.64	66.91	66.46	0.734

1) Albumen index and Haugh Unit

Albumen height and Haugh units (HU) are traits used to evaluate albumen quality, which deteriorates with age [26]. Kraus *et al*. [27] found that when the albumen index increased, the Haugh unit also showed an increment. Wall *et al*. [28] and Ragheb *et al*. [17] found that the difference between the two strains on the Haugh unit was not significant and the current study found the same results. HU will decrease with increasing bird age value, with HU decreasing by around 1.5 to 2 units [29] for each month of lay. In this experiment, the Haugh Unit decreased with the age of birds (Table III) which supports the statements of Liljedahl *et al*. [26] and Coutts and Wilson [29].

2) Percent of albumen

The albumen as a percentage of total egg weight decreased with the advancing age of the hens [6], [5]. In this experiment, the percentage of albumen decreased (Table III) with the age of birds which supports the statements of Van den Brand *et al*. [6] and Rizzi and Chiericato [5].

3) Albumen weight

Rossi and Pompei [33] and Suk and Park [4] observed that the albumen weight increased with the advancing age of layers. In this experiment, the weight of albumen increased with the age of birds (Table III) which supports the statements of Rossi and Pompei [33] and Suk and Park [4].

Yolk quality

1) Yolk index

Ledvinka *et al*. [30] and Kraus and Zita [27] indicated that the yolk index decreased with hen age. In this experiment, the yolk index decreased with the age of birds (Table IV) which accepts the statements of Ledvinka *et al*. [30] and Kraus and Zita [27].

2) Yolk color

Ledvinka *et al*. [30] indicated that yolk color was significantly affected by hen age. Variation in yolk color at different ages was reported by Niranjan *et al*. [31] and Rajkumar *et al*. [32]. In this experiment, the yolk color score varied with the age of the birds (Table IV) which accepts the statements by Niranjan *et al*. [31] and Rajkumar *et al*. [32].

3) Percent of yolk

Rossi and Pompei [33] and Rizzi and Chiericato [5] observed that the yolk percentage increased with the hens' age. In this experiment, the percentage of yolk increased with the age of birds (Table IV) which accepts the statements of Rossi and Pompei [33] and Rizzi and Chiericato [5].

4) Fresh yolk weight

Yasmeen *et al*. [34] and Singh *et al*. [20] found that the yolk weight increases with the advancing of layers ages. In this experiment, the weight of yolk increased with the age of birds (Table V) which supports the statements of Yasmeen *et al*. [34] and Singh *et al*. [20]. However, the increase in yolk weight could be based on that yolk weight is equally dependent upon increasing flock age or increasing egg weight [35].

TABLE IV. DIFFERENT BROWN TYPE COMMERCIAL LAYER STRAIN ON YOLK QUALITY (20–35WKS)

Age (Wks)	Parameter	T_1	T_2	T_3	T_4	p-value
24	Yolk Index	45.19	43.92	45.55	43.19	0.508
	Yolk Color Score	7.25	6.00	7.25	7.00	0.133
	Yolk (%)	21.24	20.55	20.93	21.14	0.494
29	Yolk Index	43.39	43.08	44.29	42.99	0.756
	Yolk Color Score	6.50	5.75	6.50	7.00	0.094
	Yolk (%)	22.89	22.00	22.02	22.83	0.616
34	Yolk Index	43.07	42.74	42.93	42.91	0.989
	Yolk Color Score	6.25	5.75	6.00	6.50	0.794
	Yolk (%)	23.60	24.56	23.25	23.40	0.638

Where, T_1=NOVOgen Brown, T_2=ISA Brown, T_3=Hy-Line Brown and T_4=Bovans Brown. ^{a,b,c} means with different superscripts within the same row differ significantly; ** =Significant (P<0.05).

TABLE V: DIFFERENT BROWN TYPE COMMERCIAL LAYER STRAIN ON EGGSHELL WT., ALBUMEN WT., AND YOLK WT. (20-35WKS)

Age (Wks)	Parameter	T1	T2	T3	T4	p-value
24	Test Egg Weight (g)	53.87	51.47	53.80	52.85	0.713
	Fresh Yolk Weight (g)	11.45	10.58	11.26	11.16	0.384
	Fresh Albumen Weight (g)	36.76	35.82	36.97	35.97	0.863
	Shell Weight (g)	5.67	5.08	5.58	5.72	0.602
29	Test Egg Weight (g)	57.92	55.50	54.65	56.17	0.459
	Fresh Yolk Weight (g)	13.25	12.20	12.05	12.83	0.294
	Fresh Albumen Weight (g)	38.80	38.00	37.00	37.60	0.702
	Shell Weight (g)	5.88	5.30	5.60	5.75	0.101
34	Test Egg Weight (g)	65.72^a	61.27^b	61.50^b	60.65^b	0.037
	Fresh Yolk Weight (g)	15.53	15.03	14.30	14.20	0.313
	Fresh Albumen Weight (g)	43.75	40.25	41.15	40.30	0.074
	Shell Weight (g)	6.45	6.00	6.05	6.15	0.250

Where, T1= NovoGen Brown, T2= ISA Brown, T3= Hy-Line Brown and T4= Bovans Brown. a,b,c means with different superscripts within the same row differ significantly; ** =Significant (P<0.05).

5) Shell weight

Several studies have shown that eggshell weight increased as the hen's age increased [36], [37] and Singh *et al*. [20]. In this experiment, the weight of eggshells increased with the age of birds (Table V) which verifies the statements of Nys *et al*. [36], Roberts *et al*. [37] and Singh *et al*. [20].

IV. Conclusion

Based on the results obtained from this study, it may be concluded that the commercial layer strains compared in this study were mostly similar in terms of laying performance and egg quality parameters. Therefore, a details study using a similar research protocol may be needed to draw a meaningful conclusion on the comparative performance of layer strains in Bangladesh.

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Conflict of Interest

The authors declare that there is no conflict of interest in the publication of this paper.

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