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# Comparative Evaluation of Growth, Laying Performance, and Egg Quality in Six Korean Native Chicken Crossbred Strains

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***ABSTRACT*** Native poultry breeds are valuable genetic resources with considerable diversity, adaptability, and variation in productive traits. Despite their significance, many native strains have been underutilized in commercial breeding programs, highlighting the need for targeted characterization to support conservation and future genetic improvement. This study evaluated the growth performance, laying productivity, and egg quality traits of six Korean Native Chicken (KNC) crossbreds (RCYD, YCCF, YCCK, YDRC, YDCF, YDCK) from hatch to 32 weeks of age. A total of 480 birds were reared under standardized management during the growing (Day 1－Week 18) and laying (Week 18－32) phases. Productive parameters, including body weight, hen-day egg production (HDEP), egg mass, feed conversion ratio (FCR), and detailed external and internal egg quality traits, were recorded. Significant differences in body weight were observed among strains throughout the study ($P$<0.001), with YDRC showing the greatest final weight. In contrast, HDEP, egg mass, and FCR did not differ among strains ($P$>0.05), indicating comparable laying performance across the crossbreds. Strain-dependent variations in shell color, albumen height, and shell thickness were detected at week 24, while differences in shell color, albumen height, Haugh unit, and shell thickness were evident at week 32 ($P$<0.05). Notably, YDCK and YCCK produced darker shells, whereas YDRC and YDCF exhibited superior albumen height and Haugh unit values. Overall, these findings reveal meaningful phenotypic variation among KNC crossbreds and provide a valuable foundation for targeted breeding, conservation programs, and the continued development of slow-growing egg-producing lines.
(Key words: crossbreeds, egg quality, growth performance, Korean native chicken, hen-day egg production)

## INTRODUCTION

Native poultry breeds represent an important reservoir of genetic variation, characterized by broad phenotypic diversity, adaptability to local environments, and resilience under low-input systems. Despite their considerable genetic value, many native strains have historically been overlooked in commercial breeding programs, underscoring the need for targeted conservation and improvement efforts. Recent initiatives to characterize and utilize these genetic resources have provided a foundation for developing local slow-growing breeds (Jin et al., 2017). In Korea, native chicken breeds traditionally maintained by smallholder farmers continue to attract interest due to their robust adaptability and desirable meat quality traits (Choe et al., 2010). Although these birds generally exhibit lower growth and reproductive performance than commercial lines, their substantial phenotypic and genomic diversity make them a valuable national genetic asset (Ogola et al., 2021; Hong et al., 2022; Choi et al., 2024).

Eggs remain a nutritionally dense, affordable source of high-quality protein (Ahnen and Slavin, 2019; Réhault-Godbert et al., 2019). Domestic egg consumption and production have steadily increased alongside rising incomes and the expanded food service industry (Ministry of Agriculture, 2022). However, over 95% of local commercial egg-producing stocks originate from a small number of foreign breeding companies (Fuglie et al., 2011; Sohn et al., 2023). This heavy foreign reliance heightens vulnerability to international disruptions, raising concerns about the stability of local supply and market prices (Choi et al., 2024). Concurrently, despite premium market prices, consumer interest in native chicken products has increased owing to

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distinct nutritional and sensory attributes (Kim et al., 2021). However, Limited availability of native eggs and the absence of dedicated layer-type native strains have constrained market expansion, prompting national breeding programs to prioritize the improvement of productivity, egg quality, and economic viability in native poultry (Ogola et al., 2021; Hong et al., 2022). Crossbreeding has emerged as a practical approach to harness heterosis and accelerate genetic progress, with several studies reporting enhanced growth and laying performance in hybrid combinations derived from native foundation stocks (Kang et al., 2010; Kang et al., 2011; Soliman et al., 2020).

Growth performance is key to productive performance at the end of rearing (Bahry et al., 2023). Linking growth performance to laying performance and egg quality could give important insights for optimized systems considering native slow-growing crossbreeds. Standard egg quality parameters are known to be affected by breed, diet, hen age, management, and environmental conditions (Wan et al., 2019). Recent comparisons among native strains have revealed substantial variation in both productive performance and egg quality traits (Kim et al., 2020; Park et al., 2024), suggesting significant genetic potential for improvement. However, it was the authors' observation that comprehensive evaluations of multiple native slow-growing egg-producing crossbreds remain limited. Given growing reliance on imported commercial layers, improving domestic egg-producing lines is vital for local food security. Therefore, the objective of the present study was to evaluate and compare the growth performance, productive performance, and egg quality characteristics of six slow-growing egg-producing crossbred strains from day 1 to 32 weeks of age.

## MATERIAL AND METHODS

The study was conducted at the Cheongyang Research Station of Chungnam National University, Republic of Korea. The experimental protocol and procedures were reviewed and approved by the Animal Ethics Committee (Protocol number: 202507A-CNU-162).

### 1. Birds, Diets, and Housing

A total of 480 slow-growing Korean native crossbreds were used in this study. Six crossbred strains that were denoted as RCYD, YCCF, YCCK, YDRC, YDCF, and YDCK were considered. Upon arrival, all chicks were individually weighed to record day-old body weight, then randomly assigned to 20 cages (20 replicates per strain), with four birds housed per cage. Subsequent body weights were recorded at 4-week intervals from hatch until 32 weeks of age. Birds were provided diets in two phases corresponding to the production stage: a growing phase (Day 1−Week 18) and laying phase (Week 18−32). Diets for each phase were formulated following local standards (National Institute of Animal Science, 2022), and the ingredient composition and calculated nutrient values are presented in Table 1. Feed consumption was restricted according to age and target body weight guidelines for egg-producing lines, whereas water was supplied *ad*

**Table 1.** Ingredients (% as-fed basis) and nutrient composition of experimental diets from hatch to 32 weeks of age

| Item | Diets | |
|---|---|---|
| | Growing phase (Day 1−Week 18) | Laying phase (Week 18−32) |
| Ingredient | | |
| Corn | 58.20 | 61.46 |
| Soybean meal | 22.78 | 20.42 |
| Corn gluten meal | 4.53 | 5.00 |
| Soybean oil | 2.50 | 1.26 |
| Monocalcium phosphate | 1.38 | 1.21 |
| Limestone | 9.65 | 10.00 |
| Salt | 0.25 | 0.25 |
| L-lysine | 0.20 | 0.03 |
| DL-methionine | 0.21 | 0.07 |
| Vitamin‐mineral premix[1] | 0.30 | 0.30 |
| Calculated composition | | |
| Metabolizable energy (kcal/kg) | 2,859 | 2,800 |
| Crude protein (%) | 18.20 | 17.50 |
| Calcium (%) | 4.10 | 4.20 |
| Available phosphorus (%) | 0.40 | 0.37 |

[1] Vitamin and mineral mixture provided the following nutrients per kg of diet: vitamin A, 24,000 IU; vitamin D3, 6,000 IU; vitamin E, 30 IU; vitamin K, 4 mg; thiamin, 4 mg; riboflavin, 12 mg; pyridoxine, 4 mg; folacin, 2 mg; biotin, 0.03 mg; vitamin B8 0.06 mg; niacin, 90 mg; pantothenic acid, 30 mg; Fe, 80 mg (as $FeSO_4 \cdot H_2O$); Zn, 80 mg (as $ZnSO_4 \cdot H_2O$); Mn, 80 mg (as $MnSO_4 \cdot H_2O$); Co, 0.5 mg (as $CoSO_4 \cdot H_2O$); Cu, 10 mg (as $CuSO_4 \cdot H_2O$); Se, 0.2 mg (as $Na_2SeO_3$); I, 0.9 mg (as $Ca(IOS) \cdot 2H_2O$).

*libitum* throughout the experiment. From 18 weeks of age, birds were subjected to a 16 h light and 8 h dark photoperiod (16L:8D) with a light intensity of 15 lux.

### 2. Productive Performance

Egg production was recorded daily throughout the laying period and used to calculate hen-day egg production (HDEP), egg mass, and feed conversion ratio (FCR) from the onset of lay until 32 weeks of age (Oketch et al., 2025b). Average HDEP was determined based on the total number of eggs laid relative to the number of hens in each treatment group. Egg mass (g/hen/day) was calculated as the product of average egg weight and HDEP. The FCR was expressed as grams of feed intake per hen per day divided by grams of egg mass produced per hen per day.

### 3. Egg Quality Parameters

At 24 and 32 weeks of age, a total of 30 eggs per strain were randomly collected and evaluated for egg quality as previously conducted (Oketch et al., 2025b). Initially, Egg-shell breaking strength was evaluated using a texture analyzer (TA.XTplusC, Stable Micro Systems, Surrey, England). Shell color, albumen height, and Haugh units were measured using an egg multi-tester (QCM+ Range; TSS, Dunnington, York, UK). Yolk color intensity was assessed using the DSM yolk color fan (scale 1 = light yellow to 15 = orange). Eggshell thickness, measured without the inner membrane, was determined at three locations (upper, middle, and lower) using a shell thickness micrometer (Digimatic MDC-MX Series; Mitutoyo, Aurora, IL, USA). All internal quality and eggshell assessments were completed within 24 hours of egg collection.

### 4. Statistical Analysis

Collected data were analyzed using the general linear model (GLM) procedure for one-way analysis of variance (ANOVA) in the SPSS software package (Version 26; IBM Corp., Armonk, NY, USA). The cage served as the experimental unit for assessing productive performance and egg quality parameters. Statistical significance was declared at $P<0.05$, while trends were noted when $0.05<P<0.10$. When significant treatment effects were detected, means were separated using Tukey’s Multiple Range Test.

## RESULTS AND DISCUSSION

Given the heavy reliance on imported commercial layers, evaluating the performance of native slow-growing egg-producing crossbreeds is essential for strengthening domestic breeding programs. Therefore, this study compared the growth, laying performance (Table 2), and egg quality (Table 3) of six native crossbred strains from hatch to 32 weeks of age.

### 1. Body Weight

Body weight was affected by the strain throughout the study period from hatch to week 32 ($P<0.001$; Table 1). At day 1, the YCCF, YCCK, and YDCK strains show the heaviest chick weights (41.08−42.44 g), whereas RCYD and YDRC had lower initial weights (35.81−37.23 g; $P<0.001$). These differences show unique strain-specific variations during embryonic development for native breeds. However, by week 4, RCYD and YDCF strains exhibit the highest body weights (336.12−337.07 g; $P<0.001$), whereas YCCK had the lowest (309.51 g; $P<0.001$). By week 8, YDCK showed the slowest growth (750.13 g; $P<0.001$) while YDRC, YDCF, and RCYD maintained (782.32−788.12 g; $P<0.001$) the higher body weight. By week 12, YDRC gained the highest body weight (1,195.99 g; $P<0.001$). By week 16, RCYD shows the highest body weight (1,516.39 g; $P=0.002$), and it shows improvement, highlighting its superior mid-term growth potential. Beyond week 16, YDRC was the heaviest breed ($P<0.001$) as recorded at weeks 20, 24, 28, and 32.

Most native slow-growing crossbred populations are genetically diverse due to long-term regional isolation, selection for external traits (e.g., plumage color, comb type), and historical use as either meat or dual-purpose birds (Seo et al., 2023; Choi et al., 2024). This underlying genetic variability is reflected in the distinct growth trajectories observed among the six crossbred strains in the present study. Notably, the YDRC and RCYD strains demonstrated consistently superior growth potential, particularly after 12 weeks of age, suggesting that these crossbred combinations may carry traits associated with enhanced growth and long-term weight gain. In contrast, strains such as YCCF, YCCK, and YDCK, despite their relatively heavier chick weights at hatch, did not maintain this earlier advantage later in life. This supports findings that early

**Table 2.** Growth and productive performance of six crossbred Korean Native Chicken strains from hatch to 32 weeks of age

| Period | Strain | | | | | | SEM[1] | *P*-value |
|---|---|---|---|---|---|---|---|---|
| | RCYD | YCCF | YCCK | YDRC | YDCF | YDCK | | |
| Body weight (g) | | | | | | | | |
| Day 1 | 35.81[a] | 41.72[b] | 42.36[b] | 37.23[a] | 41.08[b] | 42.44[b] | 0.188 | <0.001 |
| Week 4 | 336.12[c] | 318.68[abc] | 309.51[a] | 329.17[bc] | 337.07[c] | 311.85[ab] | 2.012 | <0.001 |
| Week 8 | 788.12[b] | 755.92[ab] | 753.79[ab] | 782.32[ab] | 786.00[b] | 750.13[a] | 3.560 | <0.001 |
| Week 12 | 1,182.36[bc] | 1,146.96[abc] | 1,132.96[ab] | 1,195.99[c] | 1,186.51[c] | 1,127.65[a] | 5.184 | <0.001 |
| Week 16 | 1,516.39[b] | 1,450.61[a] | 1,447.59[a] | 1,498.59[ab] | 1,456.11[ab] | 1,445.04[a] | 6.483 | 0.002 |
| Week 20 | 1,876.39[bc] | 1,742.15[a] | 1,772.45[a] | 1,898.15[c] | 1,802.80[ab] | 1,794.13[ab] | 8.991 | <0.001 |
| Week 24 | 1,909.53[bc] | 1,798.33[a] | 1,801.55[a] | 1,937.51[c] | 1,805.52[a] | 1,815.56[ab] | 10.575 | <0.001 |
| Week 28 | 1,925.16[bc] | 1,834.84[ab] | 1,808.43[a] | 1,944.53[c] | 1,842.00[abc] | 1,834.92[ab] | 11.116 | <0.001 |
| Week 32 | 1,964.13[bc] | 1,842.68[a] | 1,862.49[ab] | 1,983.89[c] | 1,858.20[ab] | 1,852.29[ab] | 11.857 | <0.001 |
| Hen day egg production (%) | | | | | | | | |
| Week 18−20 | 18.33 | 21.98 | 17.38 | 11.90 | 20.80 | 15.95 | 1.092 | 0.101 |
| Week 21−22 | 46.19 | 46.31 | 46.55 | 39.88 | 45.89 | 46.43 | 1.243 | 0.604 |
| Week 23−24 | 68.57 | 71.07 | 66.31 | 68.81 | 69.11 | 67.62 | 0.908 | 0.779 |
| Week 25−26 | 71.19 | 74.17 | 68.33 | 71.43 | 69.88 | 70.00 | 1.091 | 0.752 |
| Week 27−28 | 60.95 | 58.09 | 55.24 | 56.31 | 55.95 | 50.24 | 1.378 | 0.362 |
| Week 29−30 | 65.24 | 62.74 | 71.43 | 66.43 | 67.92 | 60.12 | 2.501 | 0.845 |
| Week 31−32 | 62.26 | 61.31 | 64.88 | 62.02 | 63.15 | 64.64 | 1.007 | 0.890 |
| Egg mass (g/hen/day) | | | | | | | | |
| Week 18−20 | 9.12 | 10.95 | 8.94 | 5.97 | 10.23 | 7.93 | 0.547 | 0.118 |
| Week 21−22 | 22.97 | 23.06 | 23.95 | 19.99 | 22.59 | 23.07 | 0.623 | 0.564 |
| Week 23−24 | 34.10 | 35.39 | 34.12 | 34.49 | 34.01 | 33.59 | 0.452 | 0.915 |
| Week 25−26 | 35.40 | 36.93 | 35.16 | 35.80 | 34.39 | 34.78 | 0.546 | 0.827 |
| Week 27−28 | 30.31 | 28.93 | 28.42 | 28.22 | 27.54 | 24.96 | 0.689 | 0.355 |
| Week 29−30 | 32.44 | 31.24 | 36.75 | 33.29 | 33.43 | 29.87 | 1.277 | 0.742 |
| Week 31−32 | 30.96 | 30.53 | 33.38 | 31.08 | 31.08 | 32.12 | 0.509 | 0.628 |
| Feed conversion ratio (g/g) | | | | | | | | |
| Week 18−20 | 15.34 | 14.36 | 8.94 | 14.62 | 17.18 | 16.52 | 1.105 | 0.325 |
| Week 21−22 | 5.24 | 5.69 | 5.01 | 6.17 | 5.34 | 5.79 | 0.204 | 0.625 |
| Week 23−24 | 3.33 | 3.21 | 3.39 | 3.28 | 3.30 | 3.42 | 0.049 | 0.865 |
| Week 25−26 | 3.21 | 3.05 | 3.43 | 3.20 | 3.23 | 3.35 | 0.074 | 0.764 |
| Week 27−28 | 3.98 | 3.98 | 4.11 | 4.33 | 4.13 | 5.32 | 0.174 | 0.201 |
| Week 29−30 | 4.05 | 3.70 | 3.77 | 3.68 | 3.54 | 4.13 | 0.158 | 0.887 |
| Week 31−32 | 3.69 | 3.84 | 3.41 | 3.76 | 3.60 | 3.62 | 0.066 | 0.514 |

[a−c] Values in a row with different superscripts differ significantly ($P<0.05$).
[1] Pooled standard error of mean.

**Table 3.** Egg quality parameters of six crossbred Korean Native Chicken strains on week 24 and 32

| Item | Strain | | | | | | SEM[1] | *P*-value |
|---|---|---|---|---|---|---|---|---|
| | RCYD | YCCF | YCCK | YDRC | YDCF | YDCK | | |
| Week 24 | | | | | | | | |
| Egg weight (g) | 46.80 | 47.67 | 49.67 | 47.67 | 47.73 | 47.70 | 0.377 | 0.386 |
| Egg shell color (%) | 46.82$^{ab}$ | 53.59$^{c}$ | 56.01$^{c}$ | 45.97$^{a}$ | 51.76$^{bc}$ | 56.58$^{c}$ | 0.646 | <0.001 |
| Albumen height (mm) | 5.62$^{a}$ | 5.61$^{a}$ | 6.53$^{ab}$ | 6.47$^{ab}$ | 6.98$^{b}$ | 6.01$^{ab}$ | 0.147 | 0.037 |
| Haugh unit | 78.08 | 77.49 | 80.80 | 83.52 | 84.08 | 79.83 | 0.909 | 0.185 |
| Yolk color | 5.60 | 5.40 | 5.73 | 5.73 | 5.27 | 5.57 | 0.071 | 0.33 |
| Shell thickness (mm) | 0.27$^{a}$ | 0.30$^{b}$ | 0.28$^{ab}$ | 0.28$^{ab}$ | 0.29$^{b}$ | 0.30$^{ab}$ | 0.004 | 0.012 |
| Shell breaking strength (g) | 4,306.15 | 4,116.60 | 4,120.62 | 4,200.03 | 4,356.74 | 4,190.47 | 62.427 | 0.847 |
| Week 32 | | | | | | | | |
| Egg weight (g) | 52.50 | 51.93 | 53.23 | 52.57 | 50.70 | 51.67 | 0.350 | 0.391 |
| Egg shell color (%) | 45.13$^{a}$ | 53.20$^{b}$ | 52.47$^{b}$ | 48.03$^{ab}$ | 50.10$^{ab}$ | 54.20$^{b}$ | 0.706 | <0.001 |
| Albumen height (mm) | 7.11$^{a}$ | 7.24$^{ab}$ | 8.09$^{ab}$ | 8.54$^{ab}$ | 8.71$^{b}$ | 7.62$^{ab}$ | 0.155 | 0.007 |
| Haugh unit | 84.88$^{a}$ | 86.59$^{ab}$ | 90.76$^{ab}$ | 93.09$^{b}$ | 93.34$^{b}$ | 88.59$^{ab}$ | 0.835 | 0.012 |
| Yolk color | 6.83 | 6.43 | 6.73 | 6.70 | 6.53 | 6.70 | 0.083 | 0.773 |
| Shell thickness (mm) | 0.32$^{ab}$ | 0.33$^{ab}$ | 0.32$^{ab}$ | 0.31$^{a}$ | 0.32$^{ab}$ | 0.34$^{b}$ | 0.002 | 0.047 |
| Shell breaking strength (g) | 5,025.67 | 4,935.77 | 5,095.70 | 5,030.94 | 5,028.28 | 5,388.80 | 57.927 | 0.291 |

$^{a-c}$ Values in a row with different superscripts differ significantly (*P*<0.05).
[1] Pooled standard error of mean.

chick weight is not a reliable predictor of long-term performance, especially in crossbreds developed for preserving traditional phenotypes rather than being selected for growth efficiency (Jayasena et al., 2013; Ogola et al., 2021; Yu et al., 2021). The week-32 body weight range observed (1,842–1,984 g) aligns well with previously reported values for native populations at similar ages, further confirming that these crossbred strains exhibit consistent growth patterns over the years (Kim et al., 2021a; Park et al., 2024).

## 2. Hen Day Egg Production (HDEP)

HDEP did not differ among strains across all observed periods until week 32 (*P*>0.05). All six strains started laying at relatively the same time; thus, the onset of lay was not considered in this study. However, YCCF (21.98%) and YDCF (20.80%) showed numerically higher early laying percentages (*P*>0.05), whereas YDRC recorded the lowest early production (11.90%; *P*>0.05). Hen day egg production gradually increased up to week 23, and at week 23–26, all crossbreeds achieved the highest levels, ranging from 68–74%, with YCCF showing numerically higher HDEP at peak production, although the differences among strains were not statistically significant (*P*>0.05). After week 27–32, HDEP gradually decreased in every strain, following a typical post-peak decline, aligning with the natural production curve of native chickens. All crossbreeds started laying at 18 weeks of age and achieved peak egg production between weeks 23 and 26, showing comparable performance among strains, as previously corroborated (Choi et al., 2024; Park et al., 2024). These results reflect the assertion that egg production is a genetically dependent and thus, a highly heritable trait (Oketch et al., 2024). Maintenance of production around 60–65% during the post-peak period between weeks 27–32 is consistent with earlier reports that native slow-growing lines exhibit lower, and earlier-declining production compared to commercial layers like Hy-Line Brown hens (Park et al., 2024).

## 3. Egg Mass

There was no strain effect on egg mass (*P*>0.05; Table 1) across all observed periods until week 32. By week 18-20, egg mass ranged from 5.97−10.95 g/day, reflecting lower values in the early laying period. However, all six crossbreeds reached peak egg mass between 34−37 g/hen/day during weeks 23−26. YCCF tended to exhibit higher egg mass during peak laying, although no significant differences were detected among strains (*P*>0.05). Beyond week 27−32, egg mass slightly decreased in line with the noticed decline in egg production. Previous research indicates that the average egg weight of native egg-producing lines typically ranges from 47 to 56 g and is likely to remain relatively stable with marginal strain-dependent variations (Choi et al., 2024; Park et al., 2024). Consequently, during early laying (18−20 weeks), egg mass was lower due to the smaller size of initial eggs and low HDEP, a common feature observed in native slow-growing breeds (Jin, 2023; Choi et al., 2024). Accordingly, as the hens approached 32 weeks, average egg mass stabilized around 34−35g/hen/day, aligning with a previous study (Park et al., 2024).

## 4. Feed Conversion Ratio

FCR did not affect across strains (*P*>0.05), suggesting that the efficiency of converting feed to egg remained constant among the evaluated native egg-producing lines. Early laying period FCR at week 18−20 exhibited the highest values (8.94−17.18 g/g), reflecting low egg weights relative to growing feed intake. At the birds reached peak production, FCR improved to 3.05−3.43 g/g, indicating better feed conversion into egg mass. YCCF showed numerically lower FCR values during peak production, indicating a trend toward improved feed efficiency, although differences were not statistically significant (*P*>0.05). Higher FCR values that were recorded early in the laying cycle between 18−20 weeks are attributed to higher feed intake combined with low initial HDEP, as previously corroborated (Seo et al., 2023; Park et al., 2024). As hens reached peak production between 21−26 weeks, FCR improved significantly, stabilizing around 3.0−3.4 g/g, in line with previous studies (Hong et al., 2019; Park et al., 2024) whose FCR values ranged from 3.0 to 4.5, reflecting the moderate productive efficiency characteristic of these birds.

## 5. Egg Weight

Egg weight did not differ among strains at either week (*P*>0.05). The slight increase in egg weight from week 24 (46.80−49.67 g) to week 32 (50.70−53.23 g) is consistent with the expected progression toward peak lay as hens mature (Seo et al., 2023). It is known that hen weight affects productive parameters (Bahry et al., 2023). Thus, YCCK tended to produce heavier eggs, although egg weight did not differ significantly among strains at either time point (*P*>0.05), in line with previous reports on its enhanced body size and production metrics (Shin et al., 2023). This may indicate its intrinsic genetic potential for egg size-related traits among specific native slow-growing lines.

## 6. Eggshell Color

Eggshell color varied significantly among strains at both time points (*P*<0.001), with pigmentation values highest in YCCK and YDCK, and lowest in RCYD. This pattern remained stable across the two time points, reflecting the strong genetic determination of protoporphyrin IX deposition in brown-shelled eggs (Yang et al., 2022). The consistent superiority of YDCK and YCCK in shell pigmentation could indicate that these strains have elevated pigment synthesis pathways (Zhu et al., 2021). Given consumer preference for darker shells in many Asian markets, these strains may hold a commercial advantage. The stability of eggshell color across age further reinforces that pigment biosynthesis is strain-dependent (Oketch et al., 2024) and minimally influenced by hen maturity (Wang et al., 2023).

## 7. Albumen Height

Albumen height differed among strains (*P*<0.05), with YDCF and YDRC exhibiting higher values at both weeks. The marked increase from week 24 (5.6−7.0 mm) to week 32 (7.1−8.7 mm) across all strains indicates improved albumen protein deposition as hens approach peak production. This trend is well-documented, wherein albumen quality improves as hens develop full reproductive maturity (Chang et al., 2024). The improved albumen height of YDCF and YDRC may be indicated by strain-specific differences in oviductal protein synthesis, a factor associated with genotype- linked expression patterns in native chickens (Kruenti et al., 2022).

## 8. Haugh Unit (HU)

Haugh unit is an important measure of internal egg freshness and corrects for variations in albumen height due to egg weight (Oketch et al., 2025a). The current study reported significantly varied HU values at week 32 ($P<0.05$), with YDRC and YDCF recording higher levels. The highest HU values were recorded at week 32 at 93.34. These results align with a previous study showing that the HU was dependent on albumen height (Jang, 2022). In agreement with (Park et al., 2024), the enhanced HU performance of YDRC and YDCF suggests that these strains could be prioritized for breeding programs targeting egg freshness, storage quality, and albumen integrity.

## 9. Yolk Color

Yolk color did not differ across strains at any time point ($P>0.05$). Dietary consumption of carotenoid-rich foods, like yellow maize and corn gluten meal, is the main factor influencing yolk color, a crucial sensory characteristic that affects consumer preference (Moreno et al., 2020; Asare et al., 2024). This finding noted the minimal genetic contribution to yolk color variability in local native chickens under standardized feeding conditions. Thus, yolk color appears unsuitable as a discriminating trait among native strains raised under similar nutritional regimens.

## 10. Eggshell Thickness and Breaking Strength

Eggshell quality is a critical trait in the poultry industry with definitive impacts on both egg yield and hatchability (Cheng and Ning, 2023). Major factors influencing shell quality include oviposition timing, age, housing system, and, most importantly, genetic background (Ketta and Tůmová, 2016). It was observed that eggshell thickness exhibited strain-specific differences at week 24 ($P = 0.012$) and at week 32 ($P = 0.047$). Thicker shells in YCCF and YDCK at week 24 may reflect genetic advantages in calcium deposition efficiency, a trait associated with both improved mineral metabolism and shell gland function (Li et al., 2021). Although differences narrowed in week 32, YDCK maintained higher values, suggesting potential for enhanced shell quality beyond the current experimental period.

As to eggshell breaking strength, no differences among strains were noticed at week 24 and 32 ($P = 0.847$; $P = 0.291$, respectively). Numerically higher values were observed for YDCF at week 24 and YDCK at week 32, alluding to relatively higher resistance to external pressure, which could be advantageous for storage and transportation due to reduced breakage risk. The consistent numerical increment in eggshell breaking strength between 24 and 32 weeks indicates an overall improvement in shell mechanical integrity with age during the early to mid-laying period (Anene, 2022). Despite small numerical differences, the lack of statistical significance suggests that within this set of native slow-growing egg-producing strains, genetic background had only a minor effect on shell breaking strength when birds were reared under uniform management and nutrition. The current observations reinforce the observation that thicker eggshells do not necessarily translate to higher eggshell-breaking strength (Oketch et al., 2025a).

## 11. Breeding Interpretation of the Relationship among Traits

The present results indicate that variation in body weight among native slow-growing crossbred strains was not accompanied by corresponding differences in laying performance, suggesting that growth traits and egg production efficiency are not strongly coupled in these populations. In contrast, variation in internal egg quality traits appears to be more closely associated with physiological maturity than with laying intensity. This pattern implies that heavier genotypes may allocate relatively more resources toward internal egg quality rather than egg number particularly during early to mid-laying phases. From a breeding standpoint, these findings emphasize the importance of multi-trait selection in native chicken improvement programs, as selection based solely on growth traits is unlikely to enhance laying performance, whereas targeted selection for egg quality traits may improve product value without compromising production efficiency. Therefore, breeding strategies for slow-growing native laying lines should be guided by clearly defined production objectives aligned with practical industry needs.

## SUMMARY

The evaluation of six native slow-growing egg-producing crossbred strains revealed strain-dependent differences in growth performance and egg quality traits, while laying performance parameters did not differ significantly among strains. YDRC and RCYD consistently exhibited higher body weight across growth stages, indicating their suitability for meat-oriented or dual-purpose production systems. In contrast, hen-day egg production, egg mass, and feed conversion ratio were comparable among all strains, suggesting that increased body weight alone does not guarantee improved laying performance under standardized management conditions.

Strain-specific variation was evident in egg quality characteristics. YDRC and YDCF demonstrated superior internal egg quality, as reflected by higher albumen height and Haugh unit values, whereas YCCK and YDCK showed darker eggshell pigmentation, and YCCF and YDCK exhibited relatively greater eggshell thickness. From a commercial breeding perspective, these results provide practical criteria for classifying native crossbred strains according to production objectives, facilitating targeted selection for meat yield, egg quality, or dual-purpose use. Collectively, this study offers foundational phenotypic data to support strategic crossbreeding, genetic improvement, and the commercial utilization of Korean native slow-growing laying lines.

## STUDY LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

Although the present study provides a comprehensive comparative evaluation of growth performance, laying performance, and egg quality traits of six native slow-growing egg-producing crossbred strains under standardized management conditions, several limitations should be acknowledged. First, the experimental period was limited to 32 weeks of age, and thus the long-term laying persistence, egg quality stability, and productive lifespan of the evaluated strains could not be fully assessed. Second, the study focused primarily on phenotypic performance, without estimating genetic parameters or correlations among growth, laying performance, and egg quality traits. In addition, economic efficiency and adaptability under alternative rearing systems were not evaluated. Future research should therefore extend the evaluation period to later stages of lay, incorporate genetic and genomic analyses to support selection decisions, and assess economic performance and environmental adaptability under commercial production conditions. Such integrated approaches will strengthen breeding strategies aimed at the sustainable development and industrial utilization of Korean native slow-growing laying lines.

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