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A Comparative Study on Productive Performance, Egg Quality and Immunity of Different Strains of Laying Hens from Kurdistan Region-Iraq

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KEY WORDS:
layer strains, egg production, egg quality, immunity, Lohmann white and brown.

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ABSTRACT
This study was conducted to evaluate the productive performance, egg quality traits, and immune response of different strains during three months of laying hens reared in the Kurdistan Region of Iraq. A total of (720000) layers in three commercial strains- Lohmann White, Lohmann Brown, and Nick Chick- were compared with the correlations during their laying period. Productive performance was assessed through parameters such as egg production rate, hen day egg production, hen house egg production and feed conversion ratio. Results revealed significant differences among strains in Egg production and FCR, with Nick Chik and Lohmann white showing superior egg production compared to Lohmann brown, while the correlation between strain and month Lohmann white and Nick chick recorded higher significant ($p \leq 0.05$) in first and third months of HDEP, HHEP and FCR. Nick chick exhibited better egg weight, yolk diameter and shell thickness, however the correlation among the strains in the three months were significantly ($P \leq 0.02$) different. Immune response also varied, with strain-specific differences in antibody titers, Newcastle disease virus ND at 36 wks. recorded higher antibodies titers in Lohmann white and Nick chick, whereas Lohmann white had a higher ND titer in (44) wks. IBV titer recorded higher in Nick chick at (36) wks. While Lohman white and brown significantly ($P \leq 0.04$) recorded higher at (44) wks. These findings highlight the importance of strain selection in optimizing productivity, egg quality, and immunity of laying hens under the environmental and management conditions of the Kurdistan Region.

جودة البيض والمناعة لسلالات مختلفة من ,دراسة مقارنة للأداء الإنتاجي دجاج البياض من إقليم كردستان العراق

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الخلاصة

أُجريت هذه الدراسة لتقييم الأداء الإنتاجي، وصفات جودة البيض، والاستجابة المناعية لسلالات مختلفة خلال ثلاثة أشهر من دجاج البياض المُربى في إقليم كردستان العراق. وُقورنت نتائج الدراسة بمجموع (720,000) دجاجة بياضة من ثلاث سلالات تجارية - لوهمان الابيض، ولوهمان البني، ونيك تشيك - مع الارتباطات خلال فترة وضع البيض. وقُيّم الأداء الإنتاجي من خلال معايير مثل معدل إنتاج البيض، وإنتاج كما قيست صفات جودة البيض، بما .، ومعامل التحويل الغذائي(HHEP) ، وإنتاج بيض حظيرة الدجاج (HDEP) البيض في يوم الدجاجة في ذلك وزن البيضة، ومؤشر البيضة، وقطر الصفار، ووزنه ولون الصفار، وارتفاع البياض، ووحدة هو، وسمك القشرة، وقوة القشرة، ووزنها، وذلك لتحديد الاختلافات المرتبطة بالسلالة. بالإضافة إلى ذلك، قُيّمت الاستجابة المناعية الخلطية باستخدام المعايير الأجسام المضادة بين $p\leq0.05$) أظهرت النتائج اختلافات معنوية (.(IBV) وفيروس التهاب الشعب الهوائية المعدي (ND) ضد فيروس مرض نيوكاسل السلالات في إنتاج ومعدل تحويل العلف، حيث أظهر دجاج نيك تشيك ولوهمان الأبيض إنتاج بيض متفوق مقارنةً ب لوهمان البني، بينما سجل HHEPو HDEP في الشهرين الأول والثالث من ($p\leq0.05$) الارتباط بين السلالة والشهردجاجات لوهمان الأبيض و نيك أعلى معنوية ومعدل تحويل العلف. أظهر دجاج نيك وزن بيض أفضل وقطر صفار وسمك قشرة أفضل، ومع ذلك كان الارتباط بين السلالات في الأشهر ، مع وجود اختلافات خاصة بالسلالة في معايير الأجسام ($p\leq0.02$) . ايضا ازدادت استجابة المناعية معنويا ($p\leq0.05$)الثلاثة مختلفًا معنويا عند 36 أسبوعًا معايير أجسام مضادة أعلى في لوهمان الأبيض وأفراخ نيك، بينما كان لدى ND المضادة، سجل فيروس مرض نيوكاسل أعلى في دجاج نيك عند (36) أسبوعًا، بينما سجل لوهمان الأبيض IBV أعلى في (44) أسبوعًا. سجل عيار ND لوهمان الأبيض عيار في (44) أسبوعًا. تسلط هذه النتائج الضوء على أهمية اختيار السلالة في تحسين الإنتاجية وجودة البيض ومناعة ($P\leq0.04$) والبني أعلى دلالة الدجاج البياض في ظل الظروف البيئية والإدارية لإقليم كردستان.

الكلمات المفتاحية: سلالات الدجاج البياض، إنتاج البيض، جودة البيض، المناعة، لوهمان الأبيض والبني

INTRODUCTION

As in other countries, egg production in the Kurdistan Region -Iraq is based on commercial hybrid laying chickens selected for excellent production performance. However, the continual adoption of commercial hybrids may lead to a gradual loss in genetic diversity (Lordelo *et al.,* 2020). The egg production system is likely one of the most significant difficulties facing the egg-producing sector in recent decades. Strains, different housing systems, genotype, age, and environmental conditions can all influence the performance and production metrics of laying hens, including first egg lay, egg weight, eggshell quality, feed efficiency, daily feed intake, and illness tolerance (Dikmen *et al.,* 2016).

As is well known, numerous businesses involved in poultry straining programs have benefited the poultry industry by maximizing broiler chicken production qualities and layer hen reproductive characteristics. Intensive directional genetic selection is the principal straining approach used to produce chicken strains with desired characteristics (Yang *et al.,* 2025). Crossbred chickens outperform other strains in terms of growth rate, feeding efficiency, age at first egg, and egg and meat production traits. Crossing hens with domesticated commercial names Lohmann-white and brown, Isa brown, Hy-line, Hisex, and Nick chick resulted in a significant improvement in productive qualities (Tawfeq *et al.,* 2023). Some of these commercial lines were imported into Iraq's Kurdistan region and adapted to the environment; similarly, white-feathered and brown-feathered were raised domestically with Lohmann –white. Several studies have demonstrated that there are significant modifications to egg production rate, egg quality, and immunity between strain

lines. White-feather strains have higher egg output than brown-feather strains (Abbas *et al.,* 2014).

According to the guidelines, Lohmann-white body weight is 1300 g during the first egg production phase and 1800 g in the final phase of egg production, with 96-97% of hen day egg production (HDEP%) and an average egg weight of 55 g during peak production (De Cloet *et al.,* 2023). However, Lohmann-brown is heavier than white, with 1500 g in the first day of egg production and 2000 g BW on the last day of egg production at 95 weeks of age, with 93-94 HDEP% and 65 g average egg weight during peak production (Maboneng, 2019). Likewise, Nick chicks are the new strain in the Kurdistan region; the background of this strain is a hybrid laying hen, and Cuxhaven has had a license straining program since 1959 in conjunction with Heisdorf and Nelson farms (H and N Nick- Chick), a white leghorn strain. They have white-feathered domestically with a body weight of 1380 g in the first egg production and 1750 g BW in the last egg production, with %95-96 %HDEP and (55g) average egg weight during peak production, respectively (H&N 2020). More research is needed to learn more about the differences in egg production and quality among these strains in Iraq's Kurdistan region, which are currently unknown. Therefore, the aim of this study is to investigate the productive performance, egg quality, and immunity of different strains of laying hens from the Kurdistan Region of Iraq.

MATERIALS AND METHODS

Experimental place

The study was conducted at the Mouhalbaidh Company for table egg production, located in Murtkay Gawra Qushtapa district, Erbil, Kurdistan Region of Iraq.

Experimental design

Seven hundred twenty thousand layers from three strains in Kurdistan region commercial strain layers were divided into three different houses production each strain has four-layer houses. Each house contains sixty thousand layers (240000/strain) with four lines of cage system. First house was Lohman- White, second house for Nick-chick and third house were for Lohmann- brown strain.

Study traits

-Productive performance: egg production number, hen house egg production (HHEP%), hen day egg production (HDEP%), feed intake (FI), feed conversion ratio (FCR) (g feed/1 egg).

HDEP%= (Total number of eggs produced on that day/total number of hens present on that day)* 100

-Egg quality characteristics: Egg weight (g), egg index, yolk diameter (mm), albumin height (mm), haugh unit, shell strength (kg/cm2), shell thickness (mm), shell weight (g). All these parameters were recorded weekly. A representative sample of eggs from each house was collected 15 eggs per replicate per week (n = 60 per replicate/ month).

$$HU=100 \log (H+7.57-1.7\times W0.37)$$

where: HU= Haugh Unit
H= Albumin height (mm)
W= egg weight (g)

-Immunity test: Blood samples were taken in the birds for Newcastle disease (NDV) and infectious bronchitis virus (IBV) tests during two periods. The first test was at age 36 weeks, the second test was 44 weeks, and the results were recorded.

Ethics approval

The Animal Care and Use Committee of Salahadin University, and the Animal Care and Use Committee of the College of Agricultural Engineering Sciences approved the experimental design of the current study involving animals. This study followed all institutional guidelines for the care and use of animals.

Table 1. The chemical composition of the experimental layer diet for Lohmann White, Lohmann Brown and Nick Chick

Ingredients	Amount/1000kg Lohmann White	Amount/1000kg Lohmann Brown	Amount/1000kg Nick Chick
Yellow corn	510	517	510
Soybean meal 46%	200	245	200
Dufamix*	25	25	25
Wheat	70	60	70
Wheat bran	50	20	50
Vegetable oil	28	25	28
Limestone	110	100	110
MonoCalsium	5	6	5
Choline chloride	0.5	0.5	0.5
Enzyme	0.5	0.5	0.5
Antitoxin	1	1	1
Calculated composition			
Crude protein	15.52	17	15.52
ME (kcal/kg)	2729	2749	2729
Lysine	0.74	0.85	0.74
Methionine	0.40	0.43	0.40
Ca	3.92	3.85	3.92

*Dufamix: vit. A=4,500,000 IU, vit. D=1,660,000 IU, vit. E=20,000 mg.kg-1, K3=1, mg.kg-1, vit. B1=1,800 mg.kg-1, vit. B2=2,500 mg. vit. B6=1,600 mg.kg-1, vit. B12=8.75 mg.kg-1, folic acid=600 mg.kg-calcium pentonite=5,500 mg.kg-1, niacinamid=18,000 mg.kg-1, biotin=60 mg cholin clorid=30,000 mg.kg-1, betain=65,000 mg.kg-1, cobalt=150 mg.kg- 1, Iodine=380 mg.kg-1, Mn=45,800 mg.kg-1, cupper=6,500 mg.kg-1, Si=110 mg.kg-1, Zn=28,300 mg.kg-1, Fe=27,200mg.kg-1, Mo=350 mg.kg-1.

Statistical analysis

Data were analyzed by using the general linear model's procedure (PROC GLM) statistical analysis system (SAS, 2014). Nested design to show the effects of strains. the interaction between Strain* Month to show the effect between them. Duncan (1955) was used to test the significant differences between the meanings of the levels of each factor.

$$Yijk = \mu + Ai + Bj(i) + ek(ij)$$

Where: Yijk = observation k in level j of factor month nested within level i of factor strain

μ = overall mean

Ai = effect of strain

Bj(i) = effect of factor month nested within factor strain

ek(ij) = random error term

RESULT AND DISCUSSION

Results of comparative three strains (Lohmann-White, Nick Chick, and Lohmann-brown) in egg production and other productive performance are given in Table 2. As shown, total number of eggs produced during three months of the experiment: Nick-chick layers (2136480) eggs and Lohmann-white layers (2136300) eggs were significantly ($p<0.0001$) recorded higher number of egg production compared to Lohmann-brown layers (1714400) eggs, which recorded the lowest number of egg production. The same result was noticed for the hen house egg production (HHEP%) and hen-day egg production (HDEP%), which significantly ($p\leq0.05$) produced a higher percentage of egg production (95% and 93.5%), compared to Lohmann-brown layers (89%), which showed the lower percentage. In addition, Lohmann-white and Nick-Chick showed a better feed efficiency (FCR) in converting food into eggs (128.20 and 126.25) than FCR in Lohmann-brown layers (135.16). Concerning the interaction between strains and months, the mentioned two strains for three months were significantly ($p\leq0.02$) superior in total number of egg production, HHEP%, HDEP%, and FCR than Lohmann-brown layers in the first and second months.

The current findings agree with those of Sharma *et al.,* (2022), who revealed significant disparities in egg production and FCR between poultry strains. Moreover, this finding consistent with Kareem, (2026) who described that white Lohmann chickens improved egg production due to significantly higher large quantity of LAB group in cecal contents. However, the findings contrast those of Gangnat *et al.,* (2020), who found that egg production did not differ significantly between strains. It was noticed that layer with white and black neck had a higher ratio of egg production than white (Omer *et al.,* 2016). Furthermore, Okoro *et al.,* (2017) reported that brown strains produced fewer eggs and had a better FCR. According to the findings, Nick-Chick layers have a higher HDEP%, HHEP%, and FCR than Lohmann—White and Brown, indicating that they have better background genetics than others, and that Lohmann-strains can apply modern techniques during gene selection. Furthermore, Nick-Chick has a healthy appearance, ovary, and hormones, which could aid in egg production and FCR. Furthermore, the results showed that egg production of Lohmann-white and Nick-Chick chickens is near together, which is presumably due to their similar genetic backgrounds (Rahaman, *et al.,* 2022).

The results of this study show that, under the environmental and management conditions of the Kurdistan Region, genetic strain plays an important part in determining productive performance, egg quality traits, and immune response in commercial laying hens. In comparison to Lohmann-Brown, Nick Chick and Lohmann-White presented significantly higher egg production, HHEP%, HDEP%, and improved FCR. These findings are consistent with recent research showing that white-feathered commercial strains have superior metabolic efficiency and reproductive persistency. The superior performance recorded by Nick Chick and Lohmann-White in the current study is supported by Mekky *et al.,* (2016), who reported that white-egg layers consistently outperform brown strains in egg number and laying persistency due to lower maintenance energy requirements and enhanced ovarian efficiency. According to (Sabo *et al.,* 2022; Rahman *et al.,* 2022), brown strains are typically heavier and require more feed to maintain production, which results in lower HDEP% and higher FCR. These findings are consistent with Lohmann-Brown's poor performance in egg number and feed efficiency. The performance of Lohmann-White and

Nick Chick is so similar that it may indicate a similar selection history in breeding programs.

Table 2. Effect of three strains and their interaction with three months on productive performance traits.

Traits / Treatments		Egg Production No.	HHEP %	HDEP %	FCR/1egg
Strain					
Lohmann-white		2136300^{a}	93.54^{a}	93.60^{a}	128.20^{b}
Nick Chick		2136480^{a}	95.00^{a}	95.05^{a}	126.25^{b}
Lohmann-brown		1714400^{b}	88.97^{b}	89.06^{b}	135.16^{a}
MSE		9.32	11.53	11.50	29.70
P-value		0.004	0.02	0.02	0.03
Strain*Month					
Lohmann-white	m1	2169360^{a}	94.40^{ab}	94.46^{ab}	127.03^{ab}
Nick Chick	m1	2139660^{a}	94.60^{ab}	94.66^{ab}	126.76^{ab}
Lohmann-brown	m1	1609320^{c}	88.65^{d}	88.75^{d}	135.83^{a}
Lohmann-white	m2	2130300^{ab}	93.25^{bc}	93.32^{bc}	128.58^{ab}
Nick Chick	m2	2116080^{ab}	94.09^{b}	94.14^{b}	127.46^{ab}
Lohmann-brown	m2	1581840^{c}	87.85^{d}	87.90^{d}	137.05^{a}
Lohmann-white	m3	2109240^{ab}	92.96^{c}	93.03^{c}	128.99^{ab}
Nick Chick	m3	2153700^{a}	96.30^{a}	96.35^{a}	124.53^{b}
Lohmann-brown	m3	1952040^{b}	90.408^{cd}	90.54^{cd}	132.60^{ab}
P-value		<.0001	0.05	0.05	0.02

HDEP%= Hen-day egg production, HHEP%= Hen-house egg production. m1, m2, m3= months. $^{a-d}$ for each means of same traits in each column with different letters differ significantly, ($p \leq 0.05$). MSE= Pooled standard error mean.

Egg quality characteristics: The effect of three strains on egg quality is shown in Table 3. The results indicated that there are significant differences in egg quality between strains. Eggs were laid by Nick chick layers have a heavier egg (63.60 g) than Lohmann-white eggs (62.18 g) and Lohmann-brown eggs (61.44 g). Egg index in Lohmann-brown eggs recorded a high value of 77.98. Concerning yolk diameter (mm) and albumin, high in Nick-chick eggs (43.17 and 4.27) showed a highest significantly ($p \leq 0.005$) compared to other strains. However, Lohmann-white egg albumin recorded a high value of 3.88 mm, significantly different with other strains. As for the haugh unit (HU), there was a significant superiority of Lohmann-white and Nick-chick eggs (88.98 and 88.99%) compared to Lohmann-brown eggs (88.39%). Egg shell thickness, Nick-chick eggs have a thicker shell of 0.588 and significantly ($p \leq 0.0002$) differ to other strains. However, there was no significant effect on eggshell strength (kg/cm^2) among treatments. The two strains of Lohmann-white and Nick-chick eggs (6.433 and 6.534 g) have documented a heavier shell weight than Lohmann-brown eggs (6.24 g). Regarding the interactions between strains and months, there were also significant differences between treatments in egg weight (g). The results showed that Lohmann-brown layers in the second month lay heavier eggs (78.48 g) than other strains and months. Concerning, Nick-chicks in the second month significantly ($p \leq 0.01$) had a higher egg index of (67.21) than other strains and months. This higher egg index in Nick-Chick strains during the second month might be related to the genetic background of the strain and its physiological capacity to maintain egg shape quality during

the early peak of the laying cycle. Lohmann-white and Nick chick layers have laid eggs with yolk diameters of 43.58 and 43.71 mm, as well as albumin high mm, which were significantly ($p \leq 0.04$) superior in eggs from Lohmann-brown and Nick chick in the first month (4.61 and 4.73 mm) compared to other strains and months. While the haugh unit was a significant ($p \leq 0.01$) higher in eggs from Lohmann-white and Nick-chick layers in the third month (89.15 and 89.07%). Shell strength kg/cm^2 eggs from Nick Chick and Lohmann-brown in the second month recorded a strong eggshell of 0.759 kg/cm2. Likewise, eggs laid from Nick-chick layers in the second month have a thicker eggshell (0.759 mm) than other strains and months. The same strain layers in the first month eggshell weight (g) were heavier (6.94 g), significantly ($p \leq 0.02$) different from other strains and months.

The current findings are consistent with those of AL-Obaidi1*et al.,* (2020), who found that some varieties lay heavier eggs than others. The study agrees with Abbas *et al.,* (2014), who found a correlation ($p \leq 0.01$) between egg quality features and egg production until peak, after which they begin to drop. It can be seen that egg weight (g), egg index, and haugh unit in the three strains Lohmann-white, Nick-Chick, and Lohmann-Brown eggs were taken in the same three periods 36-39, 40-43, and 44-47 weeks of age, therefore tiny discrepancies between them may be due to genotypes. Genotypes have a direct impact on egg weight and eggshell features. Egg weight is genetically related to all three of the primary components are shell, albumen, and yolk. It was discovered that genotypes had a significant effect on egg weight. Some studies have also shown a correlation between egg weight and egg quality indicators such as yolk %, yolk weight, and albumin weight (Abdulla *et al.,* 2016).

The results in this study showed that under optimal environmental conditions, Nick-Chick have a little better egg quality traits and higher egg quality characteristics, particularly egg weight (g), yolk diameter (mm), and shell thickness (mm), than Lohmann-White and Brown eggs. The reason is unclear, whereas it might be due to the fact that Nick-Chick has genetically higher levels of some traits of eggs than the Lohmann strains. On the other hand, the Nick-chick compared to other commercial strain layers, has more potential improvements about calm behavior and superior egg quality (Aygün & Dogan, 2017). Genetic influence was also noticeable in egg quality traits. When compared to both Lohmann strains, Nick Chick's eggs were noticeably heavier, had a larger yolk diameter, and had a thicker shell. These results are consistent with those of Roberts (2004), who showed that improved oviduct protein secretion and calcium metabolism give modern white-egg strains better albumen and shell characteristics. Yang *et al.,* (2025), further highlighted that the observed superiority of Nick Chick in yolk and shell characteristics is confirmed by differences in egg structural traits that result from molecular and genomic differences among layer lines. Significant strain × month interactions were also confirmed by the current study, where Nick Chick and Lohmann-White performed more effectively during the production cycle, especially in the first and second months. Rahaman *et al.,* 2022), Poudel *et al.,* (2026), reported similar temporal interactions, demonstrating out that strains' adaptive metabolic responses and nutrient utilization efficiency vary over time, supporting white-egg lines.

Table 3. The effect of three strains and their interaction with three months on egg quality

Characteristic / Treatments		Egg weight (g)	Egg index	Yolk diameter (mm)	Albumen height (mm)	Haugh unit	Shell strength (kg / cm^2)	Shell thickness (mm)	Shell weight (g)
Strain									
Lohmann-white		62.18^{b}	75.79^{b}	42.15^{b}	3.88^{b}	88.98^{a}	448.06	0.446^{b}	6.433^{a}
Nick Chick		63.60^{a}	75.80^{b}	43.17^{a}	4.27^{a}	88.99^{a}	450.64	0.588^{a}	6.534^{a}
Lohmann-brown		61.44^{b}	77.98^{a}	40.11^{c}	3.42^{b}	88.39^{b}	457.35	0.430^{b}	6.243^{b}
MSE		1.12	0.98	0.89	0.23	4.24	150.8	0.003	0.036
P-value		<.0001	0.19	0.005	0.01	0.05	0.32	0.0002	0.0009
Strain*month									
Lohmann-white	m1	61.64^{bc}	77.02^{b}	42.55^{ab}	4.61^{a}	88.65^{b}	441.73^{bc}	0.443^{c}	6.60^{b}
Nick Chick	m1	61.43^{bc}	75.63^{cd}	42.90^{ab}	4.73^{a}	89.06^{a}	443.86^{bc}	0.438^{c}	6.94^{a}
Lohmann-brown	m1	60.55^{c}	77.98^{ab}	40.11^{cd}	4.22^{ab}	88.32^{c}	457.33^{b}	0.472^{bc}	6.20^{d}
Lohmann-white	m2	63.29^{b}	75.07^{d}	40.32^{cd}	3.53^{bc}	89.14^{a}	462.00^{b}	0.466^{bc}	6.53^{bc}
Nick Chick	m2	67.21^{a}	76.33^{c}	42.90^{ab}	4.44^{ab}	88.83^{ab}	480.80^{a}	0.579^{a}	6.31^{bcd}
Lohmann-brown	m2	62.38^{bc}	78.48^{a}	41.15^{c}	3.08^{c}	88.44^{bc}	488.86^{a}	0.419^{c}	6.48^{c}
Lohmann-white	m3	61.62^{bc}	75.29^{cd}	43.58^{a}	3.38^{bc}	89.15^{a}	440.46^{bc}	0.428^{c}	6.16^{de}
Nick Chick	m3	62.16^{bc}	75.43^{cd}	43.71^{a}	3.64^{b}	89.07^{a}	427.26^{c}	0.568^{b}	6.34^{cd}
Lohmann-brown	m3	61.38^{bc}	77.48^{ab}	39.08^{d}	2.97^{c}	88.41^{bc}	425.86^{c}	0.400^{c}	6.04^{e}
P-value		0.0003	<.0001	<.0001	0.04	0.0007	0.02	<.0001	0.02

HDEP%= Hen-day egg production, HHEP%= Hen-house egg production. m1, m2, m3= months. $^{a-e}$ For each means of same traits in each column with different letters differ significantly, (P≤0.05). MSE= Pooled standard error mean.

The three laying hen lines' antibody titers against Newcastle Disease Virus (NDV) and Infectious Bronchitis Virus (IBV) altered significantly at 36 and 44 weeks of age, as presented in Table 4, indicating the strong influence of age and genetic background on humoral immune responses. In contrast to the more stable IBV responses noticed in Lohman White and Lohman Brown, Nick Chick showed significantly higher IBV titers at 36 weeks but a significant decline by 44 weeks. Lohman White hens also showed the highest NDV antibody titers at both ages, indicating greater and more constant immune competence. These results indicate a line age interaction, meaning that immune durability varies across genetic strains as well as between viral antigens. Previous study has demonstrated that genetic variation, such as immune gene polymorphisms and major histocompatibility complex (MHC) haplotypes, has a significant effect on chickens' antibody production and vaccine responsiveness. Additionally, it has been demonstrated that there are breed-specific immune responses to IBV, with some lines displaying stronger early antibody responses but not sustaining long-term protection (Chhabra *et al.,* 2015).

Heritability estimates for antibody response to NDV vaccination are additionally significant, according to data from field populations, highlighting the possibility of genetic selection for enhanced immune competence (Hako *et al.,* 2021). The observed age-related differences also align with research demonstrating that more effective vaccination strategies, like recombinant vector vaccines, may extend antibody persistence against NDV (Shirvani *et al.,* 2018; Shi *et al.,* 2024). Data on immune responses additionally emphasize how important genetic background plays. At both ages, Lohmann-White had the highest NDV antibody titers, demonstrating greater and longer-lasting immune competence. These variations were attributed by Arango *et al.,* (2024), to MHC haplotypes among commercial strains, which control the production of antibodies after vaccination. Nick Chick, on the other hand, showed a strong early IBV response at 36 weeks but a noticeable decline by 44 weeks. This pattern is consistent with the findings Chuwatthanakhajorn *et al.,* (2023), who reported that some genetically improved strains mount rapid early antibody responses, but exhibit reduced long-term persistence. Shi *et al.,* (2024), noticed that in order to maintain long-term immunity in high-producing commercial layers, conventional NDV and IBV vaccines may require strategic boosters or recombinant vector vaccines. These findings are consistent with age-related reductions in antibody titers observed in all strains (Shi, *et al.,* 2024).

Table 4. Effect of three chicken strains in two age periods on Immunity for NDV and IBV.

Lines	**NDV**		**IBV**	
	Age 36 weeks	**Age 44 weeks**	**Age 36 weeks**	**Age 44 weeks**
Lohman White	18754 [a]	22558 [a]	41920 [b]	40551 [a]
Nick Chick	17360 [a]	18329 [b]	68019 [a]	33317 [b]
Lohman Brown	16367 [b]	18411 [b]	41503 [b]	40139 [a]
MSE	425.9	340.8	1001.3	2126.9
P-value	0.0024	0.0001	0.0001	0.0413

NDV = Newcastle disease virus, IBV= Infectious bronchitis virus. [a–b] For each means of same traits in each column with different letters differ significantly ($P<0.0001$), ($P\leq0.05$). MSE= Pooled standard error mean

CONCLUSION

The comparison of Lohmann White, Lohmann Brown, and Nick Chick hens determined that age and strain have a significant impact on immune competence, productivity, and egg quality. Both Nick Chick and Lohmann White demonstrated superior egg production quality and efficiency; Nick Chick showed a strong but less persistent IBV response, while Lohmann White showed the most consistent NDV immunity. These findings demonstrate how strain selection and vaccination strategies must consider both immune and performance traits to ensure increased productivity, resistance to viral diseases, and the sustainability of egg production systems. Lohman white is ideal if the focus is mainly on egg production and immune stability, especially in later laying stages.

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