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Comparing feed efficiency and egg production in Hy-Line W-80 and Iraqi indigenous chickens

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Abstract

The Iraqi indigenous chicken (IIC) is a native breed known for its remarkable ability to thrive in harsh environments. However, the primary challenge with this breed is its lower productivity levels especially when compared to commercial strains. This study evaluated the performance of 120 layers of IIC in comparison with an equal number of Hy-Line W-80 layers across multiple traits including feed efficiency (FE), feed conversion ratio (FCR), daily feed intake (DFI), egg mass (EM) and total egg number (EN) production. Over a period spanning four consecutive weeks intervals significant differences were observed between the two lines across all measured parameters. Hy-Line W-80 consistently exhibited superior FE, with values ranging from 0.49 to 0.54 compared to IIC values that ranged from 0.23 to 0.26. Similarly, Hy-Line W-80 demonstrated lower FCR values ranging from 1.85 to 2.03 contrasting with IIC (3.77 to 4.37). The DFI was notably higher in Hy-Line W-80 (ranging from 104.30 to 106.00 g *per* day) compared to IIC (73.75 to 90.20 g *per* day). Furthermore, Hy-Line W-80 consistently outperformed IIC in EM production with values ranging from 52.33 to 56.67 compared to IIC values (19.83 to 21.47). Another superiority of Hy-Line W-80 was observed by showing higher EN over IIC layers in all sixteen weeks of investigation. In conclusion, Hy-Line W-80 consistently outperformed IIC in various parameters such as FE, FCR, DFI, EM and EN production. Accordingly, these data could be exploited in selective breeding and genetic improvement strategies to enhance the productivity of IIC.

Introduction

Chickens play a crucial role in global nutrition and food security. The increasing global production and consumption of chicken eggs underscore their significance as a preferred protein source for humans. Eggs, valued for their nutritional benefits, simplicity in preparation and affordability find extensive use in breakfast meals and bakery products.[1] Commercial poultry production relies on various strains, predominantly hybrids selected for either egg or meat performance.[2] However, indigenous breeds like Iraqi indigenous chickens (IIC), originating from natural selection and hybridization over millennia, exhibit unique adaptability to diverse agro-ecological conditions making them increasingly favored by farmers.[3] Iraq comprises a wide biological diversity characterized by diverse climates ranging from desert and steppe to moderate and subtropical regions. Alongside these biological variations, differences in species composition are also observed such as livestock, birds and plants.[4-7]

These conditions have led to a wide range of flock and phenotypic diversity among IIC.[8-10] Indigenous chicken breeds particularly in Iraq and other developing countries are gaining prominence for their adaptability to local environments and economic viability in small-scale farming operations.[11] Among these indigenous breeds, IIC hold particular significance due to their resilience in harsh conditions, prompting dedicated efforts by the Iraqi Agricultural Research Center to develop and refine distinct genetic lines tailored to local environments.[12] The profitability of rearing native chickens such as IIC (Fig. 1) is due to their ability to produce eggs at a lower cost especially in backyard settings.[13] With a growing demand for natural food products, the popularity of indigenous poultry breeds is on the rise.[14] However, despite their potential, the egg production and hatching properties of IIC remain underexplored, necessitating comparative studies with commercial strains like Hy-Line W-80 to unlock their full productivity potential.[15] Studies have demonstrated promising outcomes in enhancing the performance of these

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genetic lines with improvements observed in body weight and egg production following advancements in environmental conditions and nutrition.[13] Notably, IIC exhibits robust immunity compared to other breeds in Iraq offering the potential for further enhance-ment of production capacity and performance.[16] Preservation of the genetic diversity of IIC remains imperative to ensure sustainable poultry farming practices, given their adaptation to Iraqi climates.[17] In contrast to indigenous breeds, exotic strains like the Hy-Line W-80 boast high productivity and superior performance metrics including feed efficiency (FE) and egg quality.[18] This line is a prime instance of a robust white egg layer that is well-known for its high egg production, strong eggshell, and ability to function well in a variety of settings and with low-density feed regimens. Alongside other Hy-Line W strains,[19] this line is renowned for its ability to adjust to various production systems, maintain composure for simple management and exhibit persistence during lengthy laying cycles which yields more eggs with less feed. The popularity that is gained by Hy-Line W-80 can be attributed to its superior performance in terms of longer production cycles,more hen-housed eggs, superior livability and better feed conversion compared to other breeds.

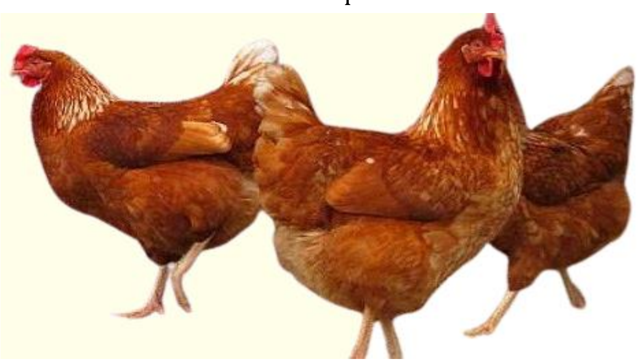

Fig. 1. The phenotypic characteristics of the Iraqi indigenous chickens used in the study.

Feed efficiency is a critical factor in determining the productivity and profitability of chicken production. It is generally defined as the relative ability of a chicken to convert feed into product such as meat or eggs. It represents a critical consideration for poultry breeders due to its substantial impact on production costs and profitability underscoring the importance of under-standing the comparative performance of indigenous and exotic breeds.[20] The novelty of this work is because of its comprehensive characteristics and potential of IIC, a breed that has not been extensively studied or documented in the context of modern poultry production. The aim of this study is to evaluate the performance of the IIC in comparison with the commercial Hy-Line W-80 layer breed across multiple production traits, including feed efficiency (FE), feed conversion ratio (FCR), daily feed intake (DFI), egg mass (EM), and total egg number (EN).

By assessing these parameters over a period of sixteen weeks, the study seeks to identify key productivity differences between the two breeds. Ultimately, the study aims to provide data that can inform selective breeding and genetic improvement strategies to enhance the productivity of IIC, making it more competitive with commercial strains while maintaining its adaptability to harsh environmental conditions.

Materials and Methods

Study location and experimental design. The study was conducted at the animal production farm of the College of Agriculture, University of Al-Qasim Green, to compare the production performance of IIC with the exotic Hy-Line W-80 strain over a 16-week period. A total number of 120 IIC and an equal number of Hy-Line W-80 layers were evenly distributed into three replicates with 40 layers *per* replicate. The birds were housed on the floor with deep litter bedding. It was ensured that the ages of both investigated breeds were approximately parallel. The experiments were started when layers of both breeds reached 44 weeks of age by the end of the peak production phase. Due to the tendency of hens to gradually decline in egg-laying performance and exhibit broodiness after approximately 44 weeks of age, both populations were analyzed between 44 and 59 weeks of age. The timing of this analysis was chosen to determine the extent to which this decline in egg-laying performance and increased broodiness were associated with the studied egg traits in IIC and Hy-Line W-80. Starting from the 44th week of age, continuous monitoring of the analyzed breeds was conducted until the end of the 59th week. Factors affecting egg production including housing, ventilation, lighting, vaccination, disease control and feeding management were kept constant throughout the study. The conducted experiments and housing conditions adhered to ethical standards for animal welfare throughout the study. This included providing adequate space, enrichment and care to ensure the well-being of the hens. The local animal welfare committee of Al-Qasim Green University College of Agriculture approved the animal-related procedures, granting approval No. 0014/2023. Two specialized veterinarians closely monitored the hen's health and behavior, and the housing conditions met ethical standards for animal welfare during the experiment.[21]

Feeding and management. All layers were provided with a standardized production ration consisting of a commercial feed mixture containing 17.13% crude protein and 2756.19 kcal kg^{-1} of feed metabolizable energy. Feed and clean water were provided *ad libitum*. The daily photoperiod consisted of 14 hr of light *per* day with an intensity of 3.00 - 4.00 watts *per* m^2 at the bird's head level. Temperature and humidity were maintained at 20.00 ˚C and 65.00 - 70.00%, respectively, during the breeding period. Each group of layers had free access to nest boxes at a ratio of one nest for every 5 - 6 layers.

Data collection. Growth performance data including daily feed intake (DFI) and feed conversion ratio (FCR) (grams of feed to grams of egg mass (EM)) were recorded throughout the 16-week trial. Egg weight and hen-day egg production were used to calculate EM multiplying the average egg weight by the hen-day egg production. All eggs were collected daily and weighed directly. Production data including the total egg numbers (EN), DFI, FCR and EM were recorded weekly. The total EN production of the two different groups was recorded on a weekly basis over 16 successive weeks. The data were then organized by week and averaged for each group to obtain a weekly total EN which was illustrated for both groups.

Statistical analysis. Experimental data were analyzed using two-way analysis of variance with the GLM procedure of SAS Software (version 9.4; SAS Institute, Cary, USA). The model included the effects of genotype (IIC vs. Hy-Line W-80) and housing system. A significance level of $p \leq 0.05$ was considered for all measurements ensuring statistical rigor in evaluating differences between the two lines.

Results

Feed efficiency and FCR comparison. Both FE and FCR traits for Hy-Line W-80 and IIC are presented in Table 1. The comparison between FE traits for Hy-Line W-80 and IIC revealed highly significant differences ($p \leq 0.001$) across all experimental periods (Weeks 44 - 59). Hy-Line W-80 consistently exhibited higher FE compared to IIC as indicated by their respective FE values that were ranged between 0.49 to 0.54 for Hy-Line W-80 and 0.23 to 0.26 for IIC. Hy-line W-80 exhibited a high FE cohort due to its ability to consume more amount of feed during the four periods, respectively. In contrast, the IIC showed a low FE cohort due to its consumption of significantly lower amounts of feed during the experiment periods. This difference was further emphasized by the significant disparity in FCR values where Hy-Line W-80 consistently showed lower FCR values compared to IIC.

Table 1. Comparison between feed efficiency (FE) and feed conversion ratio (FCR) traits for Iraqi indigenous chicken (IIC) and Hy-Line W-80. The values are expressed as mean ± SD.

Parameters	Weeks	Hy-Line W-80	IIC
FE	W44-W47	0.49 ± 0.00 [a]	0.26 ± 0.00 [b]
	W48-W51	0.50 ± 0.00 [a]	0.23 ± 0.00 [b]
	W52-W55	0.50 ± 0.00 [a]	0.25 ±0.00 [b]
	W56-W59	0.54 ± 0.00 [a]	0.26 ± 0.00 [b]
FCR	W44-W47	2.03 ± 0.02 [b]	3.72 ± 0.04 [a]
	W48-W51	1.99 ± 0.04 [b]	4.37 ± 0.05 [a]
	W52-W55	1.99 ± 0.05 [b]	3.99 ± 0.04 [a]
	W56-W59	1.85 ± 0.04 [b]	3.77 ± 0.01 [a]

[ab] Different letters in each row indicate significant difference at $p < 0.0001$.

During Weeks 44-59, Hy-Line W-80 maintained an average FCR ranging from 1.85 to 2.03, and IIC exhibited considerably higher FCR values ranging from 3.72 to 4.37. The significant influence of FCR on the variation in voluntary DFI was evident in the comparison between IIC and Hy-Line W-80. The low FE cohort of IIC exhibited markedly higher FCR values ($p \leq 0.01$) compared to Hy-Line W-80. Specifically, IIC displayed FCR values of 3.72, 4.37, 3.99 and 3.77 across the measured 4-week intervals, whereas, Hy-Line W-80 consistently demonstrated lower and more typical FCR values of 2.03, 1.99, 1.99, and 1.85, respectively. These findings underscored the superior FE of Hy-Line W-80 compared to IIC across all studied periods.

Daily feed intake and EM comparison. Both indices of DFI and EM are shown in Table 2. Analysis of DFI values indicated that Hy-Line W-80 consumed significantly more feed compared to IIC throughout the experimental duration. In particular, Hy-Line W-80 consistently consumed an average of 105.00 to 106.00 g of feed *per* day and IIC consumed significantly less with daily averages ranging from 73.75 to 90.20 g. This discrepancy in DFI contributed to the observed differences in FCR between the two chicken types. Furthermore, the comparison of EM values revealed significant differences between Hy-Line W-80 and IIC. Hy-Line W-80 consistently exhibited higher EM production compared to IIC across all experimental weeks. Starting from the first-week interval (W44th - W47th), Hy-Line W-80 produced an average EM of 52.33 g, whereas, IIC produced only 19.84 g on average. This trend persisted throughout the experimental period indicating the superior egg production performance of Hy-Line W-80.

Table 2. Comparison between daily feed intake (DFI) and egg mass (EM) values for Iraqi indigenous chicken (IIC) and Hy-Line W-80. The values are expressed as mean ± SD.

Parameters	Weeks	Hy-Line W-80	IIC
DFI	W44-W47	106.00 ± 0.58 [a]	73.75 ± 0.58 [b]
	W48-W51	105.00 ± 0.58 [a]	90.20 ± 0.41 [b]
	W52-W55	105.00 ± 0.58 [a]	83.83 ± 0.31 [b]
	W56-W59	104.30 ± 0.58 [a]	81.00 ± 0.58 [b]
EM	W44-W47	52.33 ± 0.10 [a]	19.84 ± 0.10 [b]
	W48-W51	52.70 ± 0.12 [a]	20.69 ± 0.13 [b]
	W52-W55	52.68 ± 0.08 [a]	20.96 ± 0.14 [b]
	W56-W59	56.68 ± 0.12 [a]	21.48 ± 0.09 [b]

[ab] Different letters in each row indicate significant difference at $p < 0.0001$).

Total EN productivity comparison. To analyze the performance of the two different groups of the investigated populations over time, a direct comparison of the total EN values between two different groups IIC and Hy-line W-80 was continuously monitored over consecutive successive weeks (week 44th to week 59th). The total EN productivity for both IIC and Hy-Line is shown in Figure 2.

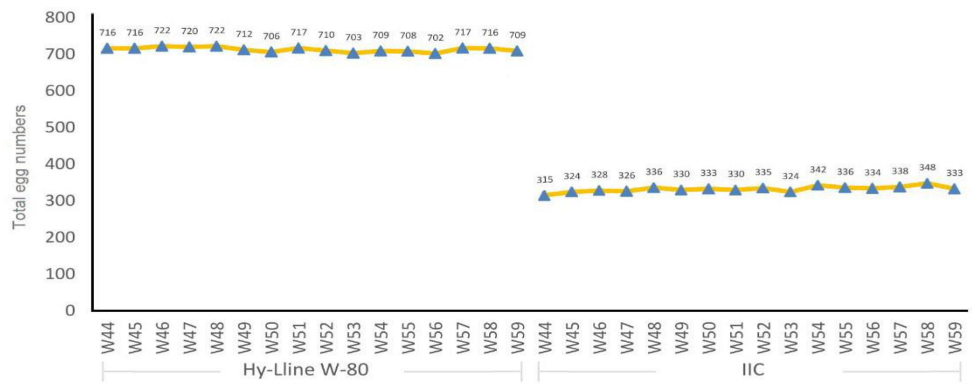

Fig. 2. Total egg numbers for all 16 weeks (week 44 to week 59) for both Hy-Line W-80 and Iraqi indigenous chicken (IIC) breeds.

The Hy-Line W-80 group showed a relatively stable trend with slight fluctuations, maintaining values between approximately 702 and 722 total eggs throughout the period. On the other hand, the IIC group started at a lower value than that found in Hy-Line W-80, however, slightly increased over time, reaching a plateau around the 315-348 total EN range from 44th week to 59th week. The IIC group values were consistently below those of the Hy-Line W-80 group throughout the observed period. The slightly increasing trend in the IIC group suggested improvement or adaptation over time, however, this increase did not ever match or surpass the Line W-80 group performance.

Discussion

As shown in Table 1, the comparison of FE and FCR between Hy-Line W-80 and IIC yielded substantial insights into the inherent differences in their physiological and genetic traits governing nutrient utilization and productivity. Across all experimental periods (Weeks 44 - 59), highly significant differences were detected in FE between the two breeds. Hy-Line W-80 consistently exhibited superior FE values and IIC displayed comparatively lower FE values. This disparity in FE underscored the breed-specific variations in nutrient assimilation efficiency and metabolic processes influencing feed utilization. The underlying factors contributing to the higher FE observed in Hy-Line W-80 are multifaceted. One contributing factor could be the breed genetic predisposition towards efficient nutrient metabolism and utilization, potentially resulting in higher growth rates and reproductive performance.[17,22,23] As shown in Table 2, the observed higher DFI by Hy-Line W-80 compared to IIC lower consumption likely contributed to the breed superior FE. This suggested that Hy-Line W-80 ability to consume and efficiently convert larger quantities of feed into productive outputs played a crucial role in its overall higher FE. Our study was in agreement with various studies that reported the superiority of Hy-Line W-80 over other breeds in terms of FE and other related traits.[24-26]

It is commonly recognized that a bird is deemed to be an efficient producer if it can use a comparatively greater portion of its feed intake to create eggs.[27] The observed significant differences in FCR between IIC and Hy-Line W-80 highlighted important aspects of feed utilization efficiency in poultry production. The higher FCR values exhibited by IIC low FE cohort compared to the consistently lower values seen in Hy-Line W-80 underscored the varying degrees of FE between these two breeds. This finding suggested that genetic and physiological factors might play significant roles in determining how efficiently chickens converted feed into productive outputs such as growth and egg production.[28] The elevated FCR values observed in IIC low FE cohort indicated that these chickens consumed less feed relative to their output resulting in a less efficient utilization of dietary resources.

In contrast, the consistently lower and more typical FCR values demonstrated by Hy-Line W-80 reflected a more efficient conversion of feed into productive outputs. This difference in feed utilization efficiency might be attributed to inherent genetic differences between the two breeds influencing factors such as metabolism, nutrient absorption and growth rate. Furthermore, the lower feed consumption observed in IIC suggested a reduced appetite compared to Hy-Line W-80 which might contribute to the observed differences in FE. It has been proposed that lines with low FE might also exhibit low metabolizability of dietary energy.[29] They put forth the notion that selecting for FE could potentially enhance feed digestibility as well. It has been identified that the genetic disparities among breeds and lines concerning FE may also manifest variances in the rate of feed passage through the gastrointestinal tract.[30] Variations in body composition may also have an impact on FE because research has shown that birds with poorer reproductive success typically exhibit higher levels of fat deposition.[31-33]

The comparison of EM production between Hy-Line W-80 and IIC further elucidates the breed-specific variations in egg production performance. Hy-Line W-80 consistently outperformed IIC in EM production across all experimental weeks, underscoring its superior egg production capacity. This superior egg production performance of Hy-Line W-80 was aligned with its higher FE and lower FCR values, reinforcing the strain overall efficiency in converting feed into EM. Furthermore, the total EN productivity comparison that is shown in Figure 2 over successive weeks revealed a consistent performance advantage of Hy-Line W-80 over IIC. This trend underscored the breed-specific differences in egg production potential and overall productivity that could be observed in the average weekly egg production values from the age of 44 weeks to 59 weeks. The movements of the two different values were parallel to each other. We observed no decreases or sudden sharp falls in the indices of egg production indicating that both lines of chickens were continuously producing eggs. It could be inferred from these data that the gap in egg production was attributed to genetic variation between them.[34]

Based on the above data, it has been shown that the possible differences between hen's breeds might be attributed to various genetic and consequent physiological factors.[35] The differences in these genetic and non-genetic aspects have possibly been reflected in their ability to digest feed. Notably, the possible manifestation of these differences might be reflected in broodiness behavior, which was one of the major factors that exerted a negative impact on egg production in this age of production.[36,37] In addition to body care and egg production, a variety of other factors could have contributed to the variations in FE including the housing environment temperature, humidity, ventilation, illumination and stocking density all of which can have an impact on the chickens energy needs and usage.[38] Accordingly, the comprehensive analysis of FE, FCR, DFI, EM production and total EN productivity provided valuable insights into the breed-specific variations in nutrient utilization efficiency and productivity between the indigenous and the exotic commercial lines. These findings had important implications for poultry breeding programs and management practices aimed at optimizing FE, enhancing productivity and ensuring sustainability in poultry production systems.

By bringing attention to IIC, the study addressed a gap in the literature regarding their adaptability, productivity and economic viability in local environments. Furthermore, this study provided a novel evaluation of the egg production, hatching properties and overall performance of IIC against a well-established commercial strain Hy-Line W-80, providing insights into the potential benefits and limitations of using indigenous breeds in commercial settings. By conducting this sort of comparison, this study could provide various informative data for targeted breeding and management strategies to maximize the productivity potential of indigenous chicken breeds, thereby, contributing to the sustainability and resilience of poultry production systems. However, further research into the underlying genetic and physiological mechanisms governing nutrient utilization efficiency in different chicken breeds is warranted to facilitate the development of targeted breeding strategies and management practices aimed at improving overall poultry performance and sustainability.

In conclusion, significant differences in FE, FCR, DFI and egg production performance indices were found between Hy-Line W-80 and IIC. Hy-Line W-80 consistently exhibited superior FE demonstrated by higher FE values, lower FCR values and higher EM production compared to IIC. It could be inferred that this superiority in feed utilization efficiency and egg production capacity suggested genetic and physiological advantages inherent to Hy-Line W-80. The observed differences in FE and productivity between the two breeds underscored the importance of genetic selection and management practices in poultry breeding programs that are crucial for optimizing and improving the overall efficiency and sustainability of the IIC hens.

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Conflict of interest

The authors declare no conflict of interest.

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