Laying rate and egg quality of three hen genotypes in family farming of southwest Algeria

Tasa de puesta y calidad de los huevos de tres genotipos de gallinas en la agricultura familiar del suroeste de Argelia

Taxa de postura e qualidade dos ovos de três genótipos de galinhas na agricultura familiar do sudoeste da Argélia

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Abstract

The quality and number of eggs produced by laying hens introduced into family oasis farms in southwestern Algeria remain poorly studied. This study evaluated the effect of genotype (local hen, Fayoumi, and Plymouth Rock) on egg quality. A total of 180 eggs (60 per genotype) were collected over one year, and their external characteristics (egg weight, length, width, shape index and shell weight) and internal characteristics (yolk weight and albumen weight) were analyzed. A one-way analysis of variance (ANOVA) was used to assess the effect of genotype on the measured egg characteristics. Post hoc comparisons were conducted using Tukey's HSD test. The results showed that genotype had a significant effect on several traits. Egg weight ($p<0.05$), length ($p<0.05$), width ($p<0.001$), shell weight ($p<0.001$) and albumen weight ($p<0.05$) differed among genotypes. The shape index also varied ($p<0.001$), reflecting distinct egg morphology. The external measures were egg weight (Local hen: 44.42 g, Fayoumi: 40.07 g, Plymouth: 46.79 g), length (Local hen: 52.06 mm, Fayoumi: 46.58 mm, Plymouth: 48.80 mm), and width (Local hen: 36.93 mm, Fayoumi: 34.20 mm, Plymouth: 36.58 mm). The internal measures were yolk weight (Local hen: 15.00 g, Fayoumi: 14.37 g, Plymouth: 14.93 g) and albumen weight (Local hen: 24.72 g, Fayoumi: 23.40 g, Plymouth: 27.28 g). In conclusion, the study highlights the importance of considering genetic factors in poultry selection and improvement programs, particularly in family farming systems in southwest Algeria, where improving productivity and egg quality is essential for food security and improving farmers' livelihoods.

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Resumen

Este estudio evaluó por primera vez el efecto del genotipo (gallina local, Fayoumi y Plymouth Rock) sobre la calidad del huevo en granjas familiares del suroeste de Argelia, analizando 180 huevos. Los resultados, obtenidos mediante ANOVA y la prueba HSD de Tukey, mostraron diferencias significativas. En las características externas, el peso del huevo ($p<0.05$) fue mayor para Plymouth Rock (46.79 g), seguido de la local (44.42 g) y Fayoumi (40.07 g). La longitud ($p<0.05$) fue mayor en la gallina local (52.06 mm), comparada con Plymouth (48.80 mm) y Fayoumi (46.58 mm). La anchura ($p<0.001$) también varió, siendo mayor en la local (36.93 mm) frente a Fayoumi (34.20 mm) y Plymouth (36.58 mm). El peso de la cáscara ($p<0.001$) difirió significativamente entre genotipos. El índice de forma ($p<0.001$) confirmó una morfología distinta del huevo para cada genotipo. En las características internas, el peso de la albúmina ($p<0.05$) fue significativamente mayor en Plymouth Rock (27.28 g) que en la local (24.72 g) y la Fayoumi (23.40 g). Sin embargo, el peso de la yema no mostró diferencias estadísticas entre los tres grupos (local: 15.00 g, Fayoumi: 14.37 g, Plymouth: 14.93 g). En conclusión, los hallazgos demuestran que la genética de la gallina influye marcadamente en las propiedades morfométricas externas y en el componente de la albúmina del huevo, subrayando su importancia crítica para los programas de selección avícola en estos sistemas de agricultura familiar, donde mejorar estos atributos es esencial para la productividad, la seguridad alimentaria y los medios de vida locales.

Palabras clave: Fayoumi, Plymouth, gallina local, oasis, calidad del huevo.

Resumo

Este estudo, realizado no sudoeste da Argélia, avaliou pela primeira vez a influência do genótipo (galinha local, Fayoumi e Plymouth Rock) na qualidade dos ovos em sistemas familiares de oásis. Foram analisadas características externas e internas de 180 ovos (60 por genótipo) ao longo de um ano, utilizando ANOVA unidirecional e o teste post hoc de Tukey. Os resultados revelaram diferenças significativas entre os genótipos. Para as características externas, o peso do ovo diferiu ($p<0,05$), sendo maior para Plymouth Rock (46,79 g), seguida pela galinha local (44,42 g) e Fayoumi (40,07 g). O comprimento ($p<0,05$) foi maior para a galinha local (52,06 mm), depois Plymouth Rock (48,80 mm) e Fayoumi (46,58 mm). A largura ($p<0,001$) também variou, com a galinha local (36,93 mm) e Plymouth Rock (36,58 mm) produzindo ovos mais largos que o Fayoumi (34,20 mm). O índice de forma ($p<0,001$) e o peso da casca ($p<0,001$) apresentaram variações significativas. Nas características internas, o peso do albúmen diferiu ($p<0,05$), sendo maior para Plymouth Rock (27,28 g), depois galinha local (24,72 g) e Fayoumi (23,40 g). O peso da gema não apresentou diferença estatisticamente significativa entre os genótipos. Em conclusão, o genótipo influencia marcadamente a morfologia e a composição dos ovos, destacando a importância de fatores genéticos em programas de seleção para melhorar a produtividade e a qualidade dos ovos, essenciais para a segurança alimentar e sustentabilidade dos agricultores familiares na região.

Palavras-chave: Fayoumi, Plymouth, galinha local, oásis, qualidade dos ovos.

Introduction

Because of their high nutritional value, eggs are among the most widely consumed foods worldwide. They provide high-quality protein containing all essential amino acids, along with vitamins, minerals, and key bioactive compounds such as antioxidants, choline, and essential fatty acids (Messerli *et al*., 2022; Puglisi & Fernández, 2022; Rafed *et al*., 2024).

Egg quality is influenced by both environmental and genetic factors, including hen genotype, diet, breeding system, age, and management practices (Zhang *et al*., 2023; Elnesr *et al*., 2024). Among these, genotype plays a major role in determining traits such as egg weight, yolk proportion, shell color and thickness, and internal composition (Škrbić *et al*., 2020; El-Komy *et al*., 2024). Local breeds, selected over generations, are particularly valued in alternative production systems such as free-range and family farming (Rakonjac *et al*., 2021; Krawczyk *et al*., 2023). Compared with commercial hybrids, they generally show lower productivity but greater variability in egg characteristics and better adaptation to harsh environments (Rizzi *et al*., 2022; Becker *et al*., 2023). Their eggs often display distinctive features such as thicker shells, richer yolks, and enhanced nutritional profiles that align with increasing consumer demand for natural, high-quality, and sustainable products (Ianni *et al*., 2021; Schreiter & Freick, 2023).

In Algeria, egg production represents a key component of livestock farming, with more than six billion eggs produced annually (MADR, 2021). Around 80 % are obtained from cage systems, while 20 % come from free-range and family farming (Alloui & Bennoune, 2013). Increasingly, consumers are purchasing eggs from local or purebred hens. Although these genotypes often produce fewer eggs and are associated with higher production costs, the quality of their eggs is comparable to that of commercial hybrids in terms of many physical and nutritional parameters, including protein composition, yolk color, shell structure, and fatty acid profile (Moula *et al*., 2013; Kara Ali *et al*., 2014). Eggs from local Algerian hens (like local breeds) often have superior nutritional profiles, including higher yolk percentages and richer mineral content (K, Ca, Mg) compared to industrial eggs (Kara Ali *et al*., 2014). As consumers increasingly value not only egg weight and shell quality but also sensory and nutritional attributes such as taste, freshness, yolk color, and lipid composition, it is important to evaluate the internal and external quality traits of eggs from different genotypes under family farming conditions. The aim of this study was therefore to assess the internal (albumen and yolk weight) and external (egg weight, length, width, shape index, and shell weight) characteristics of eggs produced by different laying hen genotypes on family farms in southwestern Algeria.

Materials and methods

This study was conducted in compliance with the statutes and regulations of the Algerian Ministry of Agriculture, which establishes general preventive measures in poultry husbandry (27 March 1995; number: 59). The study was conducted on a farm located in the Ain-Elfath agricultural development area of the wilaya of Adrar in southwestern Algeria, about 110 km south of Adrar city (27°03’00.0”N, 0°07’00.0”E). The climate of this region is typically hyper-arid, characterized by mild winters and hot, dry summers. January is the coldest month, with minimum temperatures reaching 0 °C, while July is the hottest, with maximum values exceeding 45 °C (Boubekeur *et al*., 2024).

Three laying hen genotypes were studied: Local, Fayoumi, and Plymouth Rock Barred. Initially, 36 chicks (12 per genotype) were purchased and reared together during the growing phase. After accounting for recorded mortalities (11.1 %) and eliminating roosters, five hens from each genotype were selected based on body weight, yielding a total of 15 hens at the onset of laying (15 weeks of age). At 20 weeks of age, each genotype group was housed separately on cemented floors in enclosures with an area of 9 m² (3.0 m length × 3.0 m width × 3.0 m height) under similar standard environmental conditions throughout the monitoring period. During the day, hens had free access to outdoor space surrounded by 180 cm high wire fencing and shaded by date palm trees. Wood shavings were used as litter, and each enclosure was equipped with a hardwood nest box (120 × 40 × 40 cm), a 10 L plastic drinker, and a circular PVC feeder (30 cm diameter). Feed and water were provided *ad libitum*. During the rearing phase, chicks were fed a commercial "starter" diet for 6 weeks, followed by a "grower" diet until 20 weeks of age (Table 1). After this period, hens received a commercial "layer" feed (100 $g.hen^{-1}.day^{-1}$), supplemented with household food waste, until the end of the experiment.

Table 1. Composition of feed and nutrients for the starter, grower and egg-layer rations distributed.

Compositions (%)	Start	Growth	Laying
Maize	25	33	50
Soybean meal	32	30	20
Made from cereals	37	31	15
Calcium carbonate	1.5	1.8	1
Sodium bicarbonate	0.17	0.17	0.15
Trace elements and vitamins	1.10	1	1
Vegetable oil	2.30	2	3
Metabolizable energy $Kcal.kg^{-1}$	2950	2850	2750
Crude Protein	20.5	20.0	17.0
Methionine	0.52	0.47	0.42
Lysine	1.16	1.03	0.84
Calcium	1.10	1.10	2.10
Phosphorus	0.48	0.44	0.44

In this study, data were collected over one year (September 2022-August 2023). Egg production of the three genotypes was recorded daily from the onset of laying. These records were used to calculate daily production and morphological parameters. Every two weeks, eggs from each pen were weighed for two days in a row to establish their weight.

A total of 180 eggs were collected and analyzed (60 per genotype). The eggs were stored in a refrigerator at 4 ± 2 °C for 28 days before analysis. Each egg was coded from the small end and evaluated individually. An electronic balance (±0.1 g) was used to measure the weight of the egg, and a digital caliper (±0.1 mm) was used to measure its length and width. The following formula was used to determine the shape index: (egg width/egg length) × 100 (Parmar *et al*., 2006). After recording external characteristics, eggs were broken onto a glass tray placed on a flat surface. The shell was rinsed with water, dried for 48 h at room temperature, and weighed. Yolk weight was determined after carefully separating the yolk from the albumen. Albumen weight was calculated as the difference between whole egg weight and the sum of yolk and shell weights. The yolk/albumen ratio was then calculated, and the relative proportions of shell, yolk, and albumen were expressed as percentages of the egg weight.

Statistical analysis

R statistical software (version 4.2.2) was used to analyze the collected data (R Core Team, 2022). For every quantitative variable, descriptive statistics were calculated, and the results were presented as means ± standard deviation (SD). To ensure compliance with ANOVA assumptions, the normality and homogeneity of variance of the data were examined before analysis. The homogeneity of variances was assessed using Bartlett's test, and the normality was confirmed using the Shapiro-Wilk test. Each analysis was preceded by both tests. The impact of genotype on the morphological and qualitative characteristics of eggs was then assessed using a one-way ANOVA. Following a significant ANOVA result, pairwise comparisons were performed using Tukey's HSD test.

Results and discussion

Egg-laying rate

Significant differences ($p<0.05$) in laying rate were observed among the genotypes (Table 1). Fayoumi chickens exhibited the highest productivity (56.24 %), followed by Plymouth Rock hens (48.87 %), while the local population showed the lowest rate (37.06 %) (Figure 1). Egg production in local hens was significantly lower than the 47.5 % reported for northern Algeria by Moula *et al*. (2013). These differences may be attributed to climatic variations, as the harsher conditions of southwest Algeria appear less favorable to egg production. By contrast, the laying rate of Fayoumi hens in this study exceeded the 36 % reported by Khawaja *et al*. (2013). Ferreira *et al*. (2017) reported an average laying rate of 62.5 % for the Plymouth Rock Barred breed during the 21-52 week laying phase, which is higher than the rate observed in the present study. These results suggest that the Fayoumi breed is better adapted to the climatic conditions of southwest Algeria than the Plymouth Rock Barred. Peak egg production occurred in March (the 6th month of laying) for Fayoumi and Plymouth Rock hens, but one month later (April) for the local breed. For Fayoumi hens, maximum production was reached in the third month, in agreement with the findings of Emam (2021). Breed-specific variation in peak laying may be linked to regional climatic patterns as the 3rd to 5th months of production coincided with winter (December-February), when temperatures can drop to 0 °C. After the peak, all three breeds showed a marked decline in egg production (Figure 1), which corresponded with rising summer temperatures (May-August), often exceeding 30 °C. Heat stress is known to reduce egg output in laying hens by up to 30 % (Gençoğlan, 2023). Similarly, Bordas *et al*. (1994) reported that increasing ambient temperature from 21 to 31 °C reduced average egg weight by 6-8 % and egg number by 18 %.

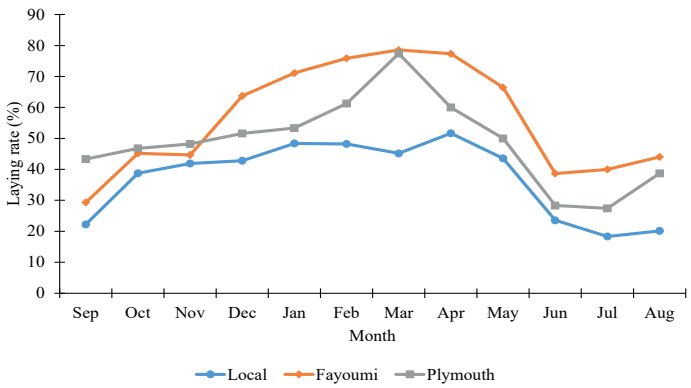

Figure 1. Evolution of laying rate of the three genotypes (local hen, Fayoumi and barred Plymouth Rock).

External egg characteristics

The results of external egg quality traits for the three genotypes are presented in Table 2.

Table 2. Laying rates and morphological characteristics of eggs from the different laying hen genotypes studied (mean ± SD).

Genotype	Laying rate (%)	Length (mm)	Width (mm)	Egg weight (g)	Shape index
Local	37.06 ± 3.56^{b}	52.06 ± 0.39^{b}	36.93 ± 0.51^{a}	44.42 ± 1.58^{ab}	70.93 ± 0.66^{a}
Fayoumi	56.24 ± 5.08^{a}	46.58 ± 0.93^{a}	34.20 ± 0.44^{b}	40.07 ± 1.60^{b}	73.55 ± 0.65^{b}
Plymouth	48.87 ± 4.03^{ab}	48.80 ± 0.68^{a}	36.58 ± 0,38^{a}	46.79 ± 1.46^{a}	75.03 ± 0.58^{b}
p-value	<0.05	<0.05	<0.001	<0.05	<0.001

$^{a, b}$Means with different letters between lines are significantly different (Tukey, p<0.05).

Egg width and shape index differed among the three hen genotypes (p<0.001). Local hens produced the widest eggs (36.93 mm), followed by Plymouth Rock (36.58 mm) and Fayoumi (34.20 mm). Dahloum *et al*. (2015) reported slightly higher values for local hens, with average widths ranging from 38.2 to 39.5 mm. Variations in egg width among genotypes may be influenced by the rearing system. The cage system, in particular, has been associated with higher egg shape indices (Pormento *et al*., 2025). However, this effect is dependent on both genotype and specific management conditions. These findings align with studies by Uçar (2024), which reported significant genotype-based differences in egg width and shape, and Pormento *et al*. (2025), which observed a significant interaction between housing system and diet on egg shape index.

In terms of shape index, local breed eggs showed the lowest value (70.93), followed by Fayoumi (73.55) and Plymouth Rock (75.03). These results are lower than those reported by Moula (2018), who found values of 75.10 for local hens and 77.91 for industrial strains. The variation observed among genotypes indicates that egg shape is influenced by hen-specific factors such as age, size, and health status (King'ori, 2012).

Significant differences (p<0.05) were also observed in egg length and weight among the studied genotypes (Table 2). Local hens laid produced the longest eggs (52.06 mm), compared to Plymouth Rock (48.80 mm) and Fayoumi (46.60 mm). These values are lower than those reported by Moula (2018), who recorded 55.80 mm for local hens and 59.22 mm for industrial strains in eastern Algeria. Overall, variation in egg length and weight can be attributed to genotype (Tůmová *et al*., 2007; Tyasi *et al*., 2022).

Regarding egg weight, Plymouth Rock hens produced the heaviest eggs (46.79 g), followed by local hens (44.42 g) and Fayoumi hens (40.07 g). Despite producing smaller eggs, Fayoumi hens compensate with higher annual productivity (Bordas *et al*., 1994). Moula *et al*. (2018) reported an average egg weight of 54.15 g for local hens in eastern Algeria, while studies in West and Central Africa recorded lower values ranging from 37.95 to 44.9 g (Mohammed *et al*., 2005; Keambou *et al*., 2009). Egg weight is highly dependent on genetic factors. According to Merat *et al*. (1991), certain genes such as the Naked Neck (Na) gene in hens increase egg weight by an average of 2 g, regardless of rearing conditions.

Internal characteristics of the egg

Table 3 presents the mean values (± SD) of egg quality traits for the different genotypes studied, including yolk weight, albumen weight, shell weight, yolk rate, albumen rate and shell rate.

Table 3. Internal egg quality characteristics of laying hens from the different genotypes (mean ± SD).

Parameters	Genotype			p-value
	Local	Fayoumi	Plymouth	
Shell weight (g)	4.87 ± 0.10^{b}	3.38 ± 0.11^{a}	4.58 ± 0.22^{b}	p<0.001
Albumen weight (g)	24.72 ± 1.37^{ab}	23.40 ± 0.84^{b}	27.28 ± 0.80^{a}	p<0.05
Yolk weight (g)	15.00 ± 0.26^{a}	14.37 ± 0.75^{a}	14.93 ± 0.48^{a}	0.65 (ns)
Yolk/Albumen ratio (%)	0.63 ± 0.03^{a}	0.61 ± 0.02^{ab}	0.55 ± 0.01^{b}	p<0.05
Shell rate (%)	11.04 ± 0.25^{a}	8.50 ± 0.26^{b}	9.76 ± 0.20^{c}	p<0.001
Albumen rate (%)	55.28 ± 1.23^{a}	58.61 ± 1.23^{a}	58.35 ± 0.37^{a}	p<0.05
Yolk rate (%)	34.15 ± 1.07^{a}	35.71 ± 0.45^{b}	31.92 ± 0.27^{b}	p<0.001

$^{a, b}$Means with different letters between lines are significantly different (Tukey, p<0.05).

Shell weight and proportion

Shell weight is a key quality trait for eggs intended for consumption. Significant differences in shell weight were observed among the three hen genotypes (p<0.001), with local hens producing the heaviest shells (average 4.87 g). This contrasts with other studies where local breeds produced lighter shells than commercial strains (Moula, 2018). This variation can be attributed mainly to genotype, hen age, nutrition (particularly calcium intake) and laying period (Ketta & Tůmová, 2016; Negoiță *et al*., 2017; Islam *et al*., 2025). Regarding shell proportion, values ranged between 8.54 % and 11.04 %, with significant differences among genotypes (p<0.001). These proportions were higher than those reported by Moula (2018), who recorded 6.68 % and 7.54 % in local and commercial hens, respectively.

Albumen weight and proportion

Significant differences (p<0.05) in albumen weight were observed among the genotypes.

Plymouth Rock eggs had the highest albumen weight, followed by those from local and Fayoumi hens. Furthermore, albumen weight was positively correlated with total egg weight, a well-established relationship indicating that breeds laying larger eggs, such as the Plymouth Rock, generally produce more albumen (Willems *et al*., 2014; Vlčková *et al*., 2019).

Significant differences in albumen percentage were observed among genotypes (p<0.05). The highest value was recorded for Plymouth Rock eggs (58.66 %), followed by Fayoumi (58.38 %) and local hens (55.24 %) (Table 2). These values are consistent with the typical composition of hen eggs reported in France, where albumen represents around 60 % and yolk about 30 % of egg weight (Nys & Sauveur, 2004). In Algeria, Dahloum *et al*. (2015) observed proportions ranging from 54.8-62 % for albumen and 25.14-31.72 % for yolk in table eggs. Genetic factors can also contribute: the presence or absence of the Na gene, for instance, has been linked to differences in albumen fluidity and proportion (Dahloum *et al*., 2015).

Yolk weight and proportion

Genotype had no significant effect on yolk weight (p>0.05). However, significant differences were observed in yolk proportion (p<0.001). Fayoumi eggs had the highest proportion (35.65 %), followed by local hens (34.19 %) and Plymouth Rock. A higher yolk proportion is considered advantageous in terms of egg nutritional quality (Samandoulougou *et al*., 2016). Yolk content is one of the most critical parameters in commercial breeding, as it directly influences both the nutritional and economic value of eggs. The proportions observed in this study are higher than those reported by

Dahloum *et al*. (2015), who found values ranging between 6.68 % and 7.54 % in both local and industrial hens. Variability in this trait can be explained by multiple factors, including genetic differences among hen (Hartmann *et al*., 2003; Milisits *et al*., 2013; Icken *et al*., 2014). According to Schneider (2015), several genes (VTG1, VTG2, APOB…) influence the size of the yolk, its lipid composition and its nutritional density.

Conclusion

This study confirms that genotype has a major influence on laying rate and egg quality. Several genes strongly influence the productivity and quality of eggs in laying hens. The significant differences observed among local hens, Fayoumi, and Plymouth Rock barred demonstrate the role of genetics in determining egg weight, shell characteristics, and the proportions of albumen and yolk. Fayoumi hens showed good adaptation to the harsh climatic conditions of Adrar, though they produced lighter eggs, whereas Plymouth Rock hens laid heavier eggs but performed below their genetic potential in these conditions.

Future research should further investigate the adaptive and productive potential of different strains under the ecological conditions of southwestern Algeria to promote sustainable and profitable poultry production.

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