RESEARCH ARTICLE Agricultural Science Digest, Volume 46 Issue 3: 534-538 (June 2026)

Impact of Floor-laid and Nest-laid Eggs on Hatchability and Chick Quality in Broiler Breeders

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10.18805/ag.DF-785

ABSTRACT

Background: The production of a high-quality chicken originates from a high-quality egg, characterized by its cleanliness, structural integrity and absence of fissures. Though, eggs laid on the floor often fail to meet these standards. This study aimed to compare hatchability and chick quality parameters between eggs laid in nests (NE) and those laid on the floor (FE) in broiler breeders.

Methods: The experiment was conducted in a commercial hatchery, following a completely randomized design with two treatments, each consisting of three replicates. Each replicate included 150 eggs, with a total of 900 eggs (450 nest eggs and 450 floor eggs) collected from a flock of 42-week-old Arbour Acres Plus breeds. The eggs were incubated in a Petersime commercial full-empty type incubator. After 504 hours of incubation, key production rates such as hatchability, unhatched eggs, embryonic mortality, pipping mortality and clear eggs were estimated. Chick quality was assessed through chick weight, chick yield and Pasgar score.

Result: The results revealed that FE eggs had significantly higher embryonic mortality (+4%; P=0.021) and lower hatchability (-9.6%; P=0.018) compared to NE eggs. However, there were no significant differences between the two egg types in terms of the pipping mortality and the number of infertile (clear) eggs (P>0.05). Furthermore, FE eggs resulted in a significant decrease in chick weight (-3.12%; P<0.001) and chick yield (-2.1%; P<0.001), whereas no significant impact was observed on the chick score.

Key words: Broiler, Chick quality, Floor eggs, Hatchability, Nest eggs.

INTRODUCTION

The poultry industry has always played a key role in the State's agricultural development strategies and initiatives (Ali *et al*., 2024; Boussaada *et al*., 2024). It also plays a crucial role in global food production, particularly in the broiler sector, where the demand for day-old chicks continues to rise (FAO, 2020). Commercial hatcheries are central to this industry, as they are responsible for producing high-quality chicks that meet market requirements. However, the incubation process presents several challenges, particularly regarding the types of eggs used, which can significantly affect hatchability and chick quality (Costa *et al*., 2022).

Due to the growing global demand for day-old chicks, the incubation of floor-laid eggs has recently gained attention (Costa *et al*., 2022; Perić *et al*., 2022; Franco *et al*., 2023). Commercial hatcheries typically use two types of eggs-floor-laid and nest-laid eggs-for incubation to meet market competition and demand. A flock produces various types of eggs, including nest eggs, floor eggs, double-yolk eggs, damaged eggs and small eggs. Among these, only nest-laid eggs are typically preferred for incubation. During peak production periods, as hatcheries receive a significant number of floor-laid eggs, their incubation becomes unavoidable. Therefore, understanding the incubation characteristics and chick quality parameters of both egg types is essential to produce high-quality day-old chicks (Singh *et al*., 2017).

Floor-laid eggs present specific challenges, collected manually are often dirty or damaged, leading to lower hatchability and saleability (Van den Brand *et al*., 2016). These eggs are more prone to contamination from dirt on the shell, which increases their susceptibility to microbial contamination (Van den Brand *et al*., 2016; Costa *et al*., 2022). Deeming *et al*. (2002) provided evidence that increased contamination in floor-laid eggs could negatively impact hatchability due to a higher incidence of infection in the yolk sacs of dead embryos during incubation.

Sheppard and Duncan (2011) reported that flocks of young breeders can produce up to 20% floor-laid eggs. However, they concluded that neglecting to incubate these eggs could result in significant production cost losses. While comparisons between nest- and floor-laid eggs have been reported in several regions, data from North Africa is

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How to cite this article: Benatallah, S.A., Boussaada, T., Aberkane, C., Djenane, A.A. and Lakhdari, K. (2026). Impact of Floor-laid and Nest-laid Eggs on Hatchability and Chick Quality in Broiler Breeders. *Agricultural Science Digest*. **46(3):** 534-538. doi: 10.18805/ag.DF-785.

Submitted: 10-08-2025 **Accepted:** 08-10-2025 **Online:** 28-10-2025

notably scarce. In Algeria, broiler breeder management is influenced by regional housing systems, manual egg collection practices and hatchery biosecurity constraints, which may affect egg quality and incubation outcomes. This study provides novel data from Algerian commercial flocks, offering region-specific insights to guide practical hatchery management under local conditions. In response to these challenges, the present study aims to compare the hatchability and chick quality of floor-laid and nest-laid eggs evaluating their impact on broiler breeder production.

MATERIALS AND METHODS

All procedures used in the experiments of this study adhered to the European Union Directive on Legislation concerning the welfare of animals used for scientific research, 2010-63-EU.

Eggs collection and experimental treatment

The study was conducted in 2023 at the Boulhilet poultry complex (ORAVIE: Eastern Poultry Group), located in the commune of Chemora, 54 km northeast of Batna, Algeria. Eggs were collected from-Arbor Acres Plus broiler breeder stock (42 weeks). The experimental design was completely randomized, with two egg types: clean nest and floor. A total of 900 eggs were collected, with 450 eggs from each group. The experiment included three replicates per egg type, each consisting of 150 eggs. Only intact, medium-sized eggs without cracks, deformities, or heavy contamination were included in the experiment. Floor eggs were considered “clean” if they showed no adhering feces, litter, or stains. Eggs were not chemically sanitized but were dry-cleaned with a soft cloth to remove surface particles, reflecting standard local hatchery practice. The eggs were subsequently stored for 3 days in the hatchery, maintained under stable environmental conditions with temperatures maintained between 17 and 18°C and a relative humidity at approximately 70%.

The eggs from each group were incubated in a full-empty type incubator (Petersime Vision), placed on separate trays, alternately positioned inside the incubator. During the first 5 days of incubation, the temperature was maintained at 37.8°C, with humidity ranging from 60% to 50% and CO_2 levels between 0.1% and 0.2%. From day 5 to day 18, the temperature gradually decreased from 37.2°C to 36.7°C, while humidity levels ranged from 50% to 45%. Data loggers were used to monitor air temperature and relative humidity in the incubator throughout the process. The eggs were rotated 90° every hour until day 18.

On day 18 of incubation, eggs were candled and those from a single setter tray were moved to hatcher baskets. Eggs from each replicate (setter tray) were divided between two hatcher baskets and placed together in the same hatcher. The temperature in the hatcher was maintained at 36.7°C, with relative humidity fluctuating between 50% and 55%. The hatcher’s inlet and outlet valves were adjusted to ensure CO_2 levels remained below 0.35%.

Hatchability

After 504 hours of incubation, the number of hatched chicks in each basket was recorded and hatchability, expressed as a percentage of the total eggs set, was calculated. Each egg type was replicated three times (150 eggs per replicate tray).

Embryonic mortality

Once the chicks were removed from the hatcher at 504 hours of incubation, an experienced individual, unaware of the treatments, examined the remaining unhatched eggs to assess the stage of embryonic mortality. The evaluation differentiated between embryonic mortality and pipping mortality. All unhatched and pipped eggs were opened for further inspection. Mortality rates were determined based on the total number of fertile eggs.

Chick quality

Chick quality was evaluated using several criteria, including Pasgar score, hatching weight and chick yield. After the chicks were fully dried, 100 chicks from each treatment group were randomly selected for Pasgar scoring, where they were assigned scores out of 10 based on factors such as activity level, navel condition, leg and beak confirmation and yolk membrane status (Boerjan, 2002). These chicks were then measured for weight, yield (calculated for each group using the below formula and length (measured from the tip of the beak to the implantation point of the nail on the middle toe) (Hill, 2001; Willemsen *et al*., 2008).

$$\text{Chick yield} = \frac{\text{Average chick weight}}{\text{Average hatching egg weight before incubation}} \times 100$$

Data analysis

All data were initially tested for normality using the Shapiro-Wilk test at a significance level of 5%. The data were then analyzed using SPSS statistical software (SPSS, Version 22.0, IBM Corporation, NY). Since the experiment included only two treatments (nest-laid vs. floor-laid eggs), comparisons were performed using an independent samples t-test. When multiple replicates were considered simultaneously, a one-way ANOVA was applied. A significance level of $P<0.05$ was adopted and results are reported as significant only when applicable.

RESULTS AND DISCUSSION

Hatchability parameters and embryonic mortality

The production rates for each egg category are presented in Table 1. Hatchability was significantly higher in nest-laid eggs compared to floor-laid eggs (90.0 vs. 80.4; $P = 0.018$), representing a 9.6% reduction in FE. Embryonic mortality was also significantly affected by egg type ($P = 0.021$). In contrast, no significant differences were found between the two categories for peeping mortality or clear egg rates ($P>0.05$), with clear egg values of 4.9 (NE) and 9.1 (FE).

In this study, eggs laid on the floor exhibited a significantly lower hatchability rate (80.4%) compared to eggs laid in nests (90%) (P = 0.018). These findings align with those of Ahamed *et al.* (2019), who reported that eggs laid in nests had a significantly higher hatchability rate than those laid on the floor (90% vs. 83.16%, respectively). Similarly, Van den Brand *et al.* (2016) found that eggs laid on the floor had a lower hatchability rate than washed eggs and eggs laid in nests (74.4% 70.6% and 92.6%, respectively).

Our results are also consistent with those of Heire and Jarp (2001), who concluded in an epidemiological study that incubating eggs laid on the floor led to a 1.07% decrease in overall flock hatchability. This reduction can likely be attributed to the increased embryonic mortality rate in floor-laid eggs, which, in turn, negatively impacted hatchability.

The type of egg significantly influenced (P = 0.021) embryonic mortality in this study. However, no significant differences (P>0.05) were observed between the two egg types regarding culling mortality. Embryonic mortality refers to eggs containing dead embryos that show no signs of culling. The embryonic mortality rate was notably higher in floor-laid eggs (+4%; P = 0.021), which is consistent with the findings of Van den Brand *et al.* (2016), who observed significant differences in embryonic mortality between eggs laid on the floor and those laid in nests during various stages of incubation.

The higher embryonic mortality in floor-laid eggs may be partially explained by increased bacterial penetration, which leads to higher mortality during incubation (Van den Brand *et al.*, 2016). However, floor-laid eggs, which often have more cracks and higher bacterial contamination, are more susceptible to bacterial penetration (Smeltzer *et al.*, 1979) before and during incubation, potentially leading to lower hatchability (Heier and Jarp, 2001) compared to clean nest eggs. Furthermore, Deeming *et al.* (2002) demonstrated that eggs laid on the floor were more prone to bacterial contamination of the yolk sac (43% versus 11% in clean nest eggs), which resulted in embryonic death around 18 days of incubation, even when the eggshell remained intact. This suggests that bacteria can penetrate the eggshell and negatively impact embryo development by infecting the yolk sac.

Floor-laid eggs are more likely to be dirty (Berrang *et al.*, 1997), harbor higher levels of bacteria on the eggshell and have a greater incidence of breakage or cracks compared to clean nest eggs (De Reu, 2006). Additionally, the increased proportion of dirty eggs laid on the floor may elevate the risk of contamination of other eggs if they rupture during incubation, further exacerbating the negative impact of bacterial contamination of eggs on overall hatchability and chick quality. Studies have demonstrated that cracked eggs are associated with lower hatchability, poorer chick quality at hatching and/or higher mortality rates later in life (Barnett *et al.*, 2004; Khabisi *et al.*, 2012) when compared to intact eggs.

In this study, pipping mortalities were similar between FE and NE eggs (P>0.05). Peeping mortality is primarily related to the mechanical action of peeping, which requires significant effort and energy from the chick, as well as the conditions of gas exchange (CO_2 and O_2) and possibly the shell's rigidity (Sauveur, 1988). Peeping mortality may also be attributed to overheating during hatching caused by poor humidity and ventilation conditions, leading to suffocation and embryonic death (Azeroul, 2011).

Chick quality

The day-old chick quality results for each egg category are shown in Table 2. Day-old chick quality results are shown in Table 2. While average egg weights did not differ significantly between groups (P>0.05), chicks from NE were heavier at hatch (+3.12%; P<0.001), representing 68.4% of egg weight compared to 66.3% for FE. Chick yield was also significantly higher in NE (+2.1%; P<0.001). No significant differences were observed in the Pasgar score between groups (P>0.05).

In contrast to the positive effects observed for NE eggs on chick quality at hatch in this study, Ahamed *et al.* (2019) found no significant impact of floor-laid eggs on live weight, yield, or Pasgar score of day-old chicks.

In this study, chick weight at hatch was significantly higher in the NE group (+3.12%; P<0.001). However, some studies have indicated that live weight is the most commonly used parameter for assessing day-old chick quality. The differences observed in hatch weight may be primarily due to the initial egg weight and moisture loss during incubation (Petek *et al.*, 2010).

It is widely accepted that chick weight is correlated with broiler chicken slaughter performance (Tona *et al.*, 2004; Van Den Brand *et al.*, 2016; Boussaada and Ouachem, 2018; Jabbar, 2017). Some researchers have found a positive relationship between chick length and live weight at 42 days of age. Additionally, chick length is an important indicator of chick quality and can be measured

Table 1: Production rates for each egg category.

Parametrs	Floor eggs	Nest eggs	P-value
Hatchability (%)	80.4±3.8	90.0±2.0	P=0.018
Unhatched (%)	19.6±3.8	10.0±2.0	P=0.018
Embryonic mortality (%)	8.0±1.8	4.0±0.7	P=0.021
Pipping mortality (%)	2.4±2.1	1.1±1.4	P>0.05
Clear eggs (%)	9.1±2.8	4.9±2.7	P>0.05

Table 2: Egg weight at the incubation and chick quality for each egg category.

Parameters	Floor eggs	Nest eggs	P-value
Egg weight (g)	66.15±0.64	66.18±0.65	P>0.05
Chick weight (g)	43.97±2.66	45.34±2.32	P<0.001
Chick yield (%)	66.30±3.28	68.40±1.97	P<0.001
Pasgar score	9.46±1.02	9.61±0.75	P>0.05

quickly (Decuypere *et al*., 2001; Tona *et al*., 2004; Ípek and Sözcü, 2013). Ípek and Sözcü, (2013) reported that an increase in chick length in male broilers, derived from the same egg size on the day of hatching, resulted in increased live weight. Chick length is also vital for ensuring greater uniformity and predicting growth performance (Ould-Ali and Schulte, 2015).

Regarding chick yield, the results of this study show that NE eggs significantly improved chick yield compared to FE eggs (+2.1%; P<0.001). Water loss is crucial for optimal chick yield. The recommended chick yield for high-quality chicks is 69%. Water loss and chick yield are closely linked; if chick yield exceeds 69%, it can lead to dehydration, making it difficult for chicks to hatch and resulting in higher mortality during rearing. On the other hand, when chick yield is below 67%, excess water retention in chicks can occur, leading to lethargy and refusal to feed. Eggs with contaminated shells are unable to retain sufficient water for proper hatching (Tona *et al*., 2004; Jabbar, 2017).

In this study, no significant difference in Pasgar scores was observed between the two egg categories (P>0.05). The Pasgar score is a visual scoring system used to assess chick quality based on five morphological criteria: reflexes, navel condition, legs, beak and yolk sac condition. Some studies have reported that high-quality chicks receive a Pasgar score of 10 (Tona *et al*., 2004; Ould-Ali and Schulte, 2015).

Several morphological criteria are used to evaluate day-old chicks. The chick should appear clean, dry and free from dirt or contamination, with bright and clear eyes. It should be active and responsive to sound. Chicks with deep, clear yellow coloring are considered superior to those with pale or light yellow. The navel should be fully healed and the body and legs should have a normal conformation, with no swelling or lesions on the hock. The skin and toes should be well-formed and the beak should be properly shaped, closed and straight. The abdomen area should be checked for thickness, which is influenced by temperature and humidity (Tona *et al*., 2004; Ípek and Sözcü, 2013).

CONCLUSION

This study demonstrated the impact of egg type on both hatchability and chick quality. The results showed that floor-laid eggs (FE) negatively affected hatchability and embryonic mortality, while nest-laid eggs (NE) yielded the best outcomes. Egg type not only influenced hatching success but also significantly impacted chick quality. Specifically, chick weight and yield at hatching were notably higher in the NE group.

The techno-economic implications of egg type go beyond just the number of chicks hatched; they play a crucial role in the overall efficiency and quality of production. Additional research will be necessary to investigate other factors that affect hatchability and day-old chick quality.

Conflict of interest

The authors declare that there is no conflict of interest.

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