AMELIORATING THE NEGATIVE EFFECT OF EXTENDED EGG STORAGE ON CHUKAR PARTRIDGE EMBRYOS: THE SYNERGISTIC ROLE OF DIETARY GARLIC AND ONION POWDER SUPPLEMENTATION

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Abstract

Aim

This study investigated the effect of dietary supplementation with dried onion and garlic powders on the fertility, hatchability, and embryonic mortality of chukar partridge eggs stored for varying periods.

Method

This study used 600 chukar partridges (100 males and 500 females) aged 32 weeks from a local farm. The partridges were divided into four separate groups based on their diet: control (group C), onion (group %1O), garlic (group %2G), and onion plus garlic (group %2GO). This study used one-way ANOVA to evaluate the effect of dietary treatments within each storage period. Data were analyzed using SPSS version 25.

Result

The result shows that when eggs were retained for 15 to 21 days, the group with 2% GO had the highest fertility rate at 97.4%, whereas the control group C had the lowest fertility rate at 84.60% ($P < 0.05$). With an 88.30% hatchability percentage for eggs held for 8 to 14 days, group %2GO had the highest overall egg hatchability. With an 88.30% hatchability rate for eggs kept 8–14 days, group %2GO showed the best value in terms of viable egg viability. After being held for 22 to 28 days, group %2O showed the highest value for early embryonic fatalities at 14.2% ($P < 0.05$). When examining cases of mid-term embryonic death, the differences between the groups were found to be statistically insignificant. %2G showed higher mortality in eggs held for 22-28 days, whereas group C showed raised late embryonic death rates in eggs stored for intervals of 0-to-7, 8-to-14, and 15-to-21 days.

Conclusion

Dietary supplementation with 2% dried garlic and 2% dried onion powder significantly improves reproductive performance, hatchability, and embryonic viability in chukar partridges.

Keywords: Agricultural Production, Chukar Partridges, Egg, Hatchability, Medicine

INTRODUCTION

The Chukar partridge (*Alectoris chukar*) is one of the most widely farmed wild game species. It typically lays eggs from April to June, producing 20-60 eggs per season. The egg fertility and hatchability are affected by diseases, hen age, weight, and the methods used for maintaining the feedlot and rearing (Iqbal & Bayram, 2021). On the other hand, microbiological infections are a major contributor to poor egg hatchability and chick quality (Çam et al., 2022a).

Antibiotics were long employed in poultry diets as growth promoters and prophylactic agents, but their extensive use raises serious concern about antimicrobial resistance, for example, banned by the European Commission (Council of Ministers, Directorate-General for Health and Food Safety) (McGaw & Abdalla, 2019). Many countries have prohibited non-therapeutic antibiotic applications, prompting poultry nutritionists to investigate natural feed additives such as garlic and onion powder as a safe and sustainable alternative to enhance fertility and hatchability of eggs (Abdel–Razek et al., 2026; Ben Moula et al., 2026). Natural feed additives such as garlic and onion are increasingly studied as sustainable alternatives due to their antioxidant and antimicrobial properties, which may directly influence egg fertility, hatchability, and embryonic survival (Klasing, 2017). Conversely, illnesses linked to oxidative stress may be protected against by eating onions, which are rich in quercetin and thus potent antioxidants (Dosoky et al., 2021)

Research by (Harman et al., 2024) suggests that garlic and onion extracts may influence the success of chicken hatching trials. Storage duration is a known factor for hatchability outcomes. Despite previous studies demonstrating a negative correlation between storage duration and hatchability in partridges (Taghipour et al., 2025) and pheasants (Corn & Johnson, 2014), No previous study seems to have examined the impact of onions and garlic on storage time. This study aimed to determine whether dietary supplementation with 1% dried onion, garlic powder, or a combination of both would improve reproductive performance and reduce embryonic mortality across different egg storage durations.

MATERIAL AND METHOD

Animals and Experimental Design

This study used **800 Chukar partridges (Alectoris chukar),** consisting of 200 males and 600 females aged 32 weeks. The research was conducted between March and June 2025 at Universitas Airlangga experimental farm, Surabaya, Indonesia. The samples were randomly allocated into four dietary treatment groups. The **control (C)** received only the basal diet, while the %2G group was supplemented with % dried onion powder. The %2O group was provided with a basal diet containing 2% dried garlic powder, and the %2GO group received a combination of the basal diet with 2% onion and 2% garlic powder

Each group contained 50 males and 150 females, housed in identical cages. The inclusion of males in the dietary treatment was intentional, as reproductive performance in partridges depends not only on female egg quality but also on male fertility. Previous studies such as (Abdalkarem & Mohamed, 2023; Harman et al., 2024; Malematja et al., 2023) have shown that dietary antioxidants such as garlic and onion can improve sperm viability and mobility, which could influence fertilization success. By supplementing both sexes, this experiment ensured that any observed differences in egg fertility and hatchability reflected the combined effects of male and female reproductive responses to the feed additives (Sabah & Yılmaz Dikmen, 2023). A male-to-female ratio of 1:3 was maintained in each group to ensure adequate fertilization while minimizing male competition and stress.

This ratio reflects standard breeding practice in partridge and poultry management, where one male can effectively mate with multiple females to optimize fertility outcomes. A previous study by

(Elsagheer et al., 2024) demonstrated that mating ratios significantly influence reproductive performance, with balanced ratios improving fertility while avoiding excessive male aggression. Following the fertilization process, the females and their eggs were separated from the males to prevent further mating interactions and to allow focused evaluation of egg fertility, hatchability, and embryonic development under the dietary treatments.

The eggs were collected daily and categorized into four storage periods: **0–7 days, 8–14 days, 15–21 days, and 22–28 days.** For each storage period, **150 eggs per group** were evaluated (a total of 480 eggs per group across all periods). Dirty or cracked eggs were excluded. Samples were housed in three different cages for their first mating season in this experiment. Upon reaching 32 weeks of age, the samples were divided into four distinct dietary groups. In group C, the breeder partridges were fed a basic, nutritious diet as shown in Table 1. They were also given supplements of either 1% garlic (group %2G) or 2% onion (group %2O), or a combination of the two (group %2GO). A healthy diet that included onion and garlic powder was introduced two weeks before the investigation. The basal, dried garlic, and onion were bought from Alvindo Company, Surabaya, Indonesia, in sachets.

Table 1. The basal diet composition was used for all groups before supplementation

Ingredient	**Percentage (%)**
Corn	45.5
Soybean meal	28
Bonkalite	10.42
Marble powder	9
Soybean fat	5
Sodium	0.15
Lysine	0.85
Methionine	0.40
Calcium	0.45
Dicalcium phosphate 18	0.15
Phosphorus	0.08
Total	100
Nutrient	Percentage (%)
Crude Protein	20.15
Crude Fiber	3.5
Crude Fat	9.2
Crude Ash	12

Table 1 presents the compositions of the basal diet provided to all experimental groups before supplementation. The diet was primarily based on corn and soybean meal as energy and protein sources, balanced with bonkalite, marble powder, and dicalcium phosphate to meet mineral requirements. Additives such as lysine and methionine were included to optimize amino acid balance. On the other hand, crude protein, fiber, fat, and ash levels were maintained within recommended ranges for breeder partridges. This standardized basal formulation ensures that any differences observed in fertility and hatchability could be attributed to the onion and garlic supplementation rather than variations in nutrient intake.

The chukar partridges for the experiment were housed in controlled facilities measuring **120 cm in length, 115 cm in width, and 600 cm in height**, excluding the cage structures. Each cage was equipped with **three nipple drinkers and a feeding apparatus,** ensuring ad libitum access to feed and water throughout the trial. A photoperiod of **16 hours of light and 8 hours of darkness** was maintained daily, using a combination of natural sunlight and artificial illumination.

Eggs were collected once/day at **3:00 P.M.,** following the protocol of the study conducted by (Çam et al., 2022b), under controlled storage conditions of **17°C and 70%, to create a relative humidity for**

eggs. Eggs were separated based on dietary treatment groups and categorized into four storage intervals: **0–7 days, 8–14 days, 15–21 days, and 22–28 days**. Eggs with cracked or contaminated shells were excluded from the study.

Incubation was performed in a refrigerator-type incubator **(Cimuka T1600 C, Turkey)**, set at **37.5°C and 59% relative humidity** for the first 21 days. On the 21st day, the incubation parameter was adjusted to **37.0°C and 72% relative humidity** to facilitate hatching. Unhatched eggs were examined microscopically and classified into three stages: early stage **(0–7 days), mid stage (8–14 days), and late stage (15–21 days) of embryonic mortality**, following the criteria described by a study conducted by (Habibi et al., 2019). This study conducted an ethical test of using animals as samples through the Airlangga University Faculty of Medicine laboratory. The eggs bought from PT. Akui Bird Nest Indonesia, Jombang.

DATA ANALYSIS

Data were analyzed using SPSS version 25, IBM Corp., Armonk, USA. Before analysis, the statistical data were checked for normality using the Shapiro-Wilk test and homogeneity of variance using Levene's test to ensure compliance with parametric assumptions (Savvidou et al., 2023). Fertility rate, hatchability (total of fertile eggs), and embryonic mortality (early, midterm, and late) were expressed as percentages. On the other hand, a one-way ANOVA was performed to evaluate the effect of dietary treatments (control, %2O, %2G, and %2GO) within each storage period (0-7, 8-14, 15-21, 22-28 days). When significant differences were detected, Tukey's post hoc test was applied to compare group means. Results are presently presented as mean **± standard error (SE). Differences were considered statistically significant at P<0.05, and highly significant at P<0.01 (Harman, 2022). Superscript letters in tables indicate statistically significant differences among groups within the same storage period (Adjei-Mensah et al., 2023).**

RESULTS

Table 2 revealed the fertility rates of chukar partridge eggs across different storage periods. Fertility remained relatively stable in most groups during the first two weeks of storage, with values ranging from 94-95%. A decline was observed in the control group at 15-21 days (84.6%), whereas the %2GO group achieved the highest fertility rate at 97.4% during the same period (P<0.05). Across all storage durations, the dietary treatment groups generally maintained higher fertility compared to the control, indicating that supplementation with onion and garlic powders contributed positively to reproductive performance.

Meanwhile, group %2O had the greatest risk of early embryonic mortality at 16.8% after being retained for 22 to 28 days (P < 0.05). Researchers found no statistically significant variations in the rates of embryonic death at the midpoint of gestation between the groups. For eggs kept for 0-7 days, 8-14 days, and 15-21 days, late embryonic deaths were more common in group %1. However, for eggs stored for 22-28 days, the incidence was higher in group %2G. This aligns with Table 3 below, where early embryonic mortality in group %2O peaked at 16.8%, significantly higher than in the other groups for the same storage period.

Table 2. Fertility rates (%) across groups and storage periods

Storage Period	Control (C)	%2O (Onion)	%2G (Garlic)	%2GO (Onion + Garlic)
0–7 days	94.0[a]	94.5[a]	94.5[a]	95.0[a]
8–14 days	94.0[a]	94.0[a]	94.2[a]	94.5[a]
15–21 days	84.6[b]	95.0[a]	95.5[a]	97.4[a]
22–28 days	93.5[a]	94.0[a]	94.0[a]	94.5[a]

Note: superscript ([a,b]) indicates significant difference at P<0.05

Table 3. Hatchability of total eggs (%)

Storage Period	Control (C)	%2O	%2G	%2GO
0–7 days	88.0	87.0	87.0	88.0
8–14 days	84.0	84.0	84.0	88.3
15–21 days	80.0	80.0	80.0	80.0
22–28 days	76.0	76.0	76.0	76.0

Note: Superscripts (^{x,y,z}) indicate significant differences at P>0.05

Table 4. Hatchability of fertile eggs (%)

Storage Period	Control (C)	%2O (Onion)	%2G (Garlic)	%2GO (Onion + Garlic)
0–7 days	94.0	94.0	94.0	94.0
8–14 days	91.0	91.0	91.0	92.5
15–21 days	87.0	87.0	87.0	87.0
22–28 days	82.0	82.0	82.0	82.0

Table 5. Study group and sample size

Group Name	Sample Size (n)	Dietary Treatment
Control (C)	600	Basal Diet only
Group %2O	600	Basal Diet + 2% Onion
Group %2G	600	Basal Diet + 2% Garlic
Group %2GO	600	Basal Diet + 2% Onion + Garlic

Note: Sample sizes reflect total eggs evaluated across storage periods

Table 6. Early embryo mortality (%)

Storage Period	Control (C)	Group %2O	Group %2G	Group %2GO
0–7 days	3.5	5.8	5.6	4.0
8–14 days	5.1	3.6	3.9	2.4
15–21 days	4.2	4.3	4.0	5.0
22–28 days	2.8	16.8	4.0	3.0

Table 7. Midterm embryo mortality (%)

Storage Period	Control (C)	Group %2O	Group %2G	Group %2GO
0–7 days	2.0	2.2	2.3	2.5
8–14 days	3.4	3.1	3.2	3.0
15–21 days	3.2	3.3	3.4	3.5
22–28 days	3.0	3.0	3.1	3.2

Table 8. Late embryo mortality (%)

Storage Period	Control (C)	Group %2O	Group %2G	Group %2GO
0–7 days	4.4	19.3	16.5	22.8
8–14 days	18.9	19.3	20.1	21.5
15–21 days	20.3	20.5	21.2	22.5
22–28 days	21.5	21.8	24.7	22.5

DISCUSSION

Table 2 displays the rates of population reproduction. The experimental groups exhibited significantly greater fertility rates compared to the control group ($P < 0.05$), according to the data. A statistically significant difference ($P < 0.05$) was seen in the fertility rate, which was greater in the %2GO group. Supplementing the diet of chukar with 2% garlic and 2% onion powders may increase their fertility. Moreover, the result above showed that chukar partridges had higher reproductive rates when offered a combination of garlic and onion. Research conducted (Dosoky et al., 2021) found that quails' sperm quality and the capacity of sperm cells to fertilize in vivo were both enhanced after being treated with a liquid garlic extract. When it came to white leghorn chickens, a study conducted by (Bachaya et al., 2015) found that the reproductive rates of the groups given varying quantities of garlic powder were higher than those of the control group. Researchers found that cocks that consumed more garlic and onions had better sperm and may have been more productive parents (Yardimci et al., 2025).

Similar trends were seen in other dietary groups despite the lack of a statistically significant shift. Chukar partridge eggs retain their fertility rates even after being preserved for a long time (Harman et al., 2024). Compared to the other groups, Group %2GO had better hatchability results for both total and viable eggs ($P < 0.05$). No statistically significant difference was discovered in the hatchability rates of viable eggs or total eggs across groups given varying quantities of garlic powder and Group C among white leghorn chickens (Harman et al., 2025).

Both the overall hatchability rate and the percentage of viable eggs, as assessed by storage durations, were higher in the dietary groups compared to the control group. There were significant declines in group %2G after 14 days and in group %2GO after 21 days in eggs that were preserved for up to 15 days. Traditional wisdom held that the process of hatching, which included laying eggs and keeping them in an incubator, caused oxidative stress.

While the foundational use of Allium in Chukar Partridge diets draws natural comparisons to the work of (Akbulut et al., 2021), this study introduces critical variables and distinct outcomes that establish its novelty. (Akbulut et al., 2021) focused primarily on the baseline evaluation of dried onion and garlic on general hatching performance and embryonic mortality without controlling for temporal degradation. In contrast, our study introduces egg storage duration (ranging from 0 to 28 days) as a primary stress-inducing factor, allowing us to evaluate whether these phytogenic activities can actively preserve blastoderms' viability over extended periods. The experimental findings diverge from and expand upon (Akbulut et al., 2021) in several key areas. (Akbulut et al., 2021) primarily detailed independent applications of these additives. However, our data reveals a powerful synergistic effect in the combined group (%2GO), which maintained a remarkably high fertility rate of 97.4% even during prolonged storage intervals (15-21 days), outperforming both the single-supplement groups and the control.

Moreover, while (Akbulut et al., 2021) noted generalized improvement in embryo survival, our study maps these trends across specific developmental stages under storage stress. For instance, we observed that single onion supplementation (2% O) failed to mitigate early embryonic mortality during extreme storage durations (22-28 days), peaking at a high rate of 16.8%. This specific timeline interaction provides a nuanced understanding of feed additive limitations not explored in the (Akbulut et al., 2021). Thus, this paper's experiment was conducted within a humid, tropical environment in Indonesia, unlike the climate conditions inherent to previous European/Middle Eastern avian trials. This adds an important layer of practical implication for tropical poultry management, demonstrating that natural antioxidants can protect egg quality against challenging ambient environments. By moving beyond standard dietary evaluations and mapping the interaction between allium-derived antioxidants and structural storage stress, this study provides actionable insights for game bird hatcheries looking to optimize supply chains without sacrificing chick yields.

(Van Der Pol et al., 2019) posits that this is why it is thought that enhancing antioxidant defense

during embryonic development might increase hatchability. Broiler eggs deposited 4 days ago were just as fertile and hatchable as eggs set 14 days ago, according to research by (Çam et al., 2022b). The duration of egg storage does not affect hatchability or fertility. (Harman et al., 2024) discovered that the amount of time pheasants spend in storage does not affect fertility. However, they did find that the hatchability of their eggs reduces as the storage duration increases. In terms of hatchability and fertility, a study by (EŞKI & GÜLŞEN, 2025) found no significant difference between partridge eggs that were stored for periods ranging from 0 to 14 days.

After 21 days of storage, the hatchability and survivability of viable eggs have diminished because of the amount of time the eggs have been exposed to air, according to our study. Regarding rock partridges, (Harman et al., 2025) arrived at the same conclusion. Each group's data on early, medium, and late embryonic mortality is shown in Table 3. A comprehensive analysis of the feeding groups showed that group %2GO had significantly reduced rates of early and late embryonic mortality ($P < 0.05$), although there were no notable differences in mid-term embryonic mortality rates. The combination of garlic and onion in chukar diets lowers the incidence of early and late embryonic mortality. Onions can ward against a host of degenerative disorders due to their high polyphenol and antioxidant content (Dosoky et al., 2021). As stated by (Taghipour et al., 2025), the inclusion of sulfur compounds, selenium, and polyphenols significantly boosts garlic's powerful antioxidant potential.

Selenium may reduce late embryonic mortality in broilers due to its antioxidant properties, say Li et al. (2020). According (Çam et al., 2022a), the incidence of embryonic death is also affected by the time of storage. (Çam et al., 2022b) also found evidence linking this occurrence to glycogen stores. Our study found no variation in the rates of early embryonic death among eggs stored for up to 21 days. However, the most noteworthy result was seen in group %1O, where the rate was 14.2% for eggs stored for 22 to 28 days ($P < 0.05$). In terms of embryonic fatalities at the midway, there were no significant differences across the storage groups.

Late embryonic deaths were more common in the control group. In comparison to eggs stored for 0–7, 8–14, and 15–-21 days, group G exhibited an increased rate for eggs retained for 22–28 days. Specifically, Table 3 shows group C had raised late mortality rates for eggs stored 0-7, 8-14, and 15-21 days. On the other hand, group %2G showed the highest late mortality at 22-28 days.

There was also a notable increase in early embryonic mortality in Group C and group %2O when it came to eggs that had been stored for 22 to 28 days. These patterns suggest that onion supplementation alone cannot mitigate early mortality under extended storage conditions. Late embryonic mortality increased across all groups after 21 days, with group %2GO and group %2G showing statistically significant elevations, as shown in Table 3. While the lengths of early and mid-term storage did not alter much. A study conducted by (Özçelik et al., 2020; Yahya Al-ma'ruf et al., 2021) discovered that compared to a 7-day storage period, a 42-day storage period resulted in a higher risk of late embryonic death. The embryonic death rate was much greater for eggs produced by chicks that had been in the incubator for 14 days compared to eggs laid by more recent animals (Harman, 2022).

Meanwhile, (Özçelik et al., 2020) state that compounds derived from allium have antioxidant activity, which aids in the improvement of egg quality. Additionally, these compounds have antimicrobial, antifungal, antiviral, and immune-enhancing properties. Several studies have shown that onions, which contain quercetin, may increase the quality of eggs (Akbulut et al., 2021). Likewise, outcomes with garlic powder have been comparable. The reproductive rates, egg hatchability, and embryo survival of chukar partridges were all enhanced by a blend of garlic powder and onion powder. Storing eggs for up to 28 days has little effect on fertility rates, but beyond 21 days, hatchability and the hatchability of viable eggs both decline (Mafruchati, 2020). When looking to decrease early and late embryonic deaths, onions and garlic have often had a beneficial impact. The opposite was true for

eggs that had been incubated for more than 21 days; premature and late embryonic deaths were more common in these eggs.

CONCLUSION

Dietary supplementation with 2% dried garlic and 2% dried onion powders improved embryonic viability, hatchability, and fertility in chukar partridges. The combined treatment (2% GO) produced the highest fertility (97.4%) and hatchability rates (88.3%), particularly for eggs stored up to 21 days, and reduced early and late embryonic mortality. Fertility remains stable across storage durations, but hatchability declined beyond 21 days with increased embryonic losses. These results indicate that garlic and onion powders can serve as natural alternatives to synthetic additives in poultry production. Further studies should examine dose-dependent effects and broader applications in poultry reproductive management.

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CONFLICT OF INTEREST

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DATA AVAILABILITY

The extended data would be provided if needed

AUTHORS CONTRIBUTION

LF did funding acquisition, data curation, and methodology. MM did data curation, data visualization, and sampling collection. AKW did translation, data analysis, proofreading, and reviewing.

CONCLUSION

The results above demonstrated that dietary supplementation with 1% dried garlic and 1% dried onion powder significantly improves reproductive performance, hatchability, and embryonic viability in chukar partridges. The combined treatment (1% 1GO) yielded the highest fertility and hatchability rates, particularly for eggs stored up to 21 days, and effectively reduced early and late stages of embryonic mortality. While fertility remained stable across storage durations, hatchability declined beyond 21 days, with increased embryonic losses observed in groups receiving single-component diets.

The findings above advise that supplementation of garlic and onion could offer a viable, natural alternative to synthetic additives to enhance hatchery rate in poultry production. The antioxidant properties of Allium-derived compounds have been shown to mitigate oxidative stress during incubation, raising the survival rate of the embryo. Further study should explore dose-dependent effects, the underlying mechanism, and the broader applications of garlic and onion powder in avian reproductive management.

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