Research Article

Effect of Hygiene on Hatching Performance of Duck Eggs (*Anas platyrhynchos domesticus*)

Hariadi Subagja[1]*, Zahrotul Aprilia Nadia[1], Siti Zubaidah[2]

[1]Poultry Business Management Study Program, Department of Animal Science, Politeknik Negeri Jember, East Java, Indonesia; [2]Department of Animal Nutrition and Feed Science, Faculty of Animal Science, Universitas Gadjah Mada, Jl. Fauna No. 3 Bulaksumur, Yogyakarta, Indonesia.

Abstract | The cleanliness of the eggshell is a factor that needs to be considered so that the outer part of the egg is clean from pathogenic bacteria that can interfere with embryo growth. Therefore, disinfectants are required to reduce bacterial contamination attached to the eggshell. This study aimed to determine the effect of salt solution and the turning process on the hatching performance of duck eggs. This study used four treatments with six replicates, involving 240 duck hatching eggs. The treatments were P1 (dirty eggs with simultaneous turning), P2 (dirty eggs with one-by-one turning), P3 (clean eggs with simultaneous turning), and P4 (clean eggs with one-by-one turning). In the P3 and P4 treatments, eggs were cleaned using a saline solution with a concentration of 30%. Parameters observed included percentage mortality, hatchability, and hatching weight of ducks. Data were analyzed using Analysis of Variance (ANOVA) followed by Duncan's multiple range test (DMRT). The results showed that neither the salt solution nor the turning process significantly affected the mortality percentage, hatchability, or hatching weight of ducks.

Keywords | Duck eggs, Hatchability, Hatching weight, Hygiene, Mortality, Saline solution

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***Correspondence** | Hariadi Subagja, Poultry Business Management Study Program, Department of Animal Science, Politeknik Negeri Jember, East Java, Indonesia; **Email:** hariadi_subagja@polije.ac.id
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INTRODUCTION

Duck farming is one of the businesses developed to meet protein needs, especially meat and eggs. Duck eggs and meat are highly nutritious, containing essential amino acids, vitamins and minerals. Both are significant sources of high-quality protein in Southeast Asia (Ismoyowati and Sumarmono, 2019). Global consumption of animal protein has increased at a rate of about 1% per year over the past 30 years, outpacing human population growth (Flock and Preisinger, 2007). Livestock and Animal Health Statistics, Indonesia (2022) reported that duck egg consumption in 2020 and 2021 remained constant at 0.032 eggs per unit). In Southeast Asia, including Indonesia, duck eggs account for a significant portion of total egg consumption, ranging from 10-30% (Ismoyowati and Sumarmono, 2019). This has increased the poultry farming business in Indonesia and is in demand by the community because the results of poultry farming can be promising (Has et al., 2022).

According to data from the Directorate General of Animal Husbandry and Animal Health (2022) stated that in

2022 there were 49,876,959 heads. From this figure, duck eggs contribute enough to animal protein needs, although not as much as animal protein from other types of poultry. One type of duck in Indonesia is the hybrid duck. Hybrid ducks are a cross between *Khaki Campbell* ducks and local ducks and have very fast growth and egg production can reach 200 - 250 eggs/head/year. In addition, the potential population of ducks in Indonesia has not been able to play a role as a mainstay food source because the productivity of existing ducks is relatively low, thus necessitating technological advancements in the development of duck farming, particularly for hybrid ducks (Hardjosworo, 2001).

Technology in the development of duck-hatching businesses is needed to meet duck production, so the use of duck egg-hatching machines is used as support. Hatching using machines is more effective than natural broodstock. The application of egg-hatching technology in hybrid duck farming is expected to increase the hybrid duck population relatively fast time and ensure continuity of availability (Azis *et al*., 2024). The use of hatching machines as a medium for hatching duck eggs has been widely practised, but the hatchability of duck eggs is often low due to the low hygiene of duck hatching eggs. One of the factors that must be considered in the hatching process is the cleanliness of the eggshell, which is the outermost part of the egg that still contains bacteria, especially excreta, which can potentially be a source of pathogenic bacteria that can interfere with embryo growth. De Reu *et al*. (2006) stated that *Salmonella* sp. bacteria are found in many hatching eggs. *Salmonella* contamination not only affects embryo survival but also reduces the overall hatchability rate. With a significant reduction in hatchability due to bacterial contamination, the hatchery must maintain strict biosecurity measures (Saidane *et al*., 2024). Several factors cause embryo mortality: lack of egg turning, pH (potential hydrogen), temperature and humidity (Bruggeman *et al*., 2009).

Duck eggshells have a harder texture than chicken eggshells. Duck eggshells contain the most dominant $CaCO_3^-$ (calcium carbonate), which is around 95%, and other organic materials such as 3% magnesium (Mg), 3% phosphorus (P), Na, Zn, Mn, Fe and Cu (Ajayan *et al*., 2020). Seeing the hard shell of this duck egg, the mother usually helps to break it during hatching. Therefore, the machine's hatching process needs to use materials to help break the eggshell. One alternative to help break the eggshell is salt (Persson, 2009).

Salt or sodium chloride (NaCl) consists of Na^+ and Cl^- ions. Natrium (Na) is an ion that can protect cell activity and maintain pH balance (Fu *et al*., 2021), while chloride (Cl) is an acid that is corrosive or causes other objects to be destroyed (Glass and Buenfeld, 1997). Changing the rotation angle from 75° to 60° during incubation can reduce embryonic mortality from 3.88% and increase egg hatchability to 96.5%, while hatched ducklings have the best growth during rearing. This technique can provide very large results of very large economic efficiency for duck breeding and is expected to have excellent application potential (Chen *et al*., 2024). Based on the description above, it is necessary to research the effect of salt solution and the turning process on the hatching performance of hybrid duck eggs (*Anas platyrhynchos domesticus*).

MATERIALS AND METHODS

This study used hatching eggs from intensively reared farms in Puger village, Jember, East Java, Indonesia. The hybrid ducklings were 8 months old, and egg selection was done first. Eggs that met the selection criteria weighed between 60 and 70 g. This study used 240 hybrid duck-hatching eggs stored for 5 days with four treatments and six replicates. Treatments P1 = dirty eggs with simultaneous turning, P2 = dirty eggs with one-by-one turning, P3 = clean eggs with simultaneous turning, and P4 = clean eggs with one-by-one turning. In treatments P3 and P4, eggs were cleaned with a 30% saline solution, applying 10 drops using a pipette, and the solution was spread evenly using a cotton swab to remove dirt from the eggshell.

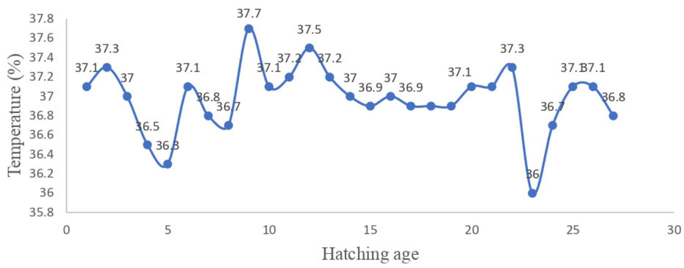

Figure 1: Temperature (°C) recording during incubation.

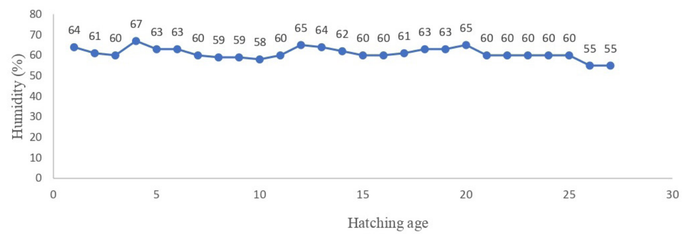

Figure 2: Humidity (%) recording during incubation.

Before the hatching eggs enter the hatching machine, the hatching machine is fumigated using a formalin solution to prevent the growth of microorganisms. The hatching machine was turned on for 3 hours (Wijianti and Setiawan, 2015). The incubator uses six lamps with a voltage of 40 watts and a temperature between 37.2°C and 37.8°C (Figure 1). Meanwhile, see Figure 2, for the following weeks, humidity was set about 60 to 55 and the following weeks, it was set at around 60% - 70% (Meghan, 2023). The duck egg incubation samples were then placed into an incubator equipped with water trays, and the eggs were positioned horizontally.

After 28 days, calculate the mortality rate, hatchability, and hatch weight of Day-Old Duck (DOD) Hybrid Ducks. Mortality was calculated by dividing the number of dead embryos by the number of live eggs and multiplying by 100%; hatchability was calculated by dividing the number of eggs hatched by the number of fertile eggs and multiplying by 100%.

Research data were analyzed using analysis of variance (ANOVA), and if there were differences between treatments, it was followed by Duncan's multiple range test (DMRT) (Steel and Torrie, 1989).

RESULTS AND DISCUSSION

Mortality

The results of the hatchability test of duck eggs disinfected using a salt solution with different concentrations could be seen in Table 1. The study was resulted indicate that the cleanliness of the eggs during the turning process, whether done individually or collectively using a 30% salt solution, did not affect the mortality rate (P>0.05).

Table 1: Mortality, hatchability and egg weight of hybrid duck eggs disinfected with a saline solution under various treatments.

Parameter	P1	P2	P3	P4	P-Value
Mortality (%)	10.00 ±10.95	23.33 ± 16.33	8.33 ± 4.08	10.00 ± 12.65	0.135
Hatchability (%)	90.00 ± 10.95	76.67 ± 16.33	88.33 ± 7.53	85.00 ± 13.78	0.292
Hatch weight (g)	50.40 ± 10.95	49.09 ± 3.81	45.39 ± 4.80	49.41 ± 4.70	0.275

Note: P1: dirty eggs with simultaneous turning; **P2:** dirty eggs with one-by-one turning; **P3:** clean eggs with simultaneous turning; **P4:** clean eggs with one-by-one turning.

Differences in mortality rates occurred in each treatment, including the simultaneous dirty turning treatment (without NaCl) with a mortality rate of 10%, the one-by-one turning treatment without NaCl with a mortality rate of 23%, the simultaneous turning treatment using NaCl with a mortality rate of 22%, and the one-by-one turning treatment using NaCl with a mortality rate of 15%. It is hypothesized that improper cleaning of the eggs may cause dirt to block the pores of the eggshell, thereby closing the air cavity, which is a source of oxygen for the embryo. Although the P1 treatment had lower mortality than the other treatments, the difference showed no significant difference between treatments. The inconsistent procedure of rotating eggs might cause heat to be applied unevenly to the eggs, causing the embryo to stick to the shell and die. The embryo will adhere to the sell and finally perish (Subagja *et al*., 2024).

The dose of salt per litre of water automatically increases the salt content, both sodium and chloride, progressively. Sodium, which is the cation Na^+, mostly binds with chloride in the regulation of acid-base balance, osmotic pressure balance, or fluid within cells, thereby preventing excessive fluid loss (Schaafsma *et al*., 2000), while chloride ions (Cl^-) were the main anions in extracellular fluid, constituting 85% of the total chloride in cells (Catterall, 2000). Azis (2018) stated that salt water spraying had a significant effect on fertility and hatching time, but had no effect on mortality and hatchability. Thus, salt water spraying could only be used to increase fertility and shorten hatching age.

According to Glass and Buenfeld (1997), when saltwater comes into contact with other objects, such objects may break or become damaged. Na+ and Cl- ions interact with water molecules to diminish water activity, causing microbial cells to lose water due to osmotic shock and promoting cell death or reducing cell development (Treesuwan *et al*., 2023). Temperature, light regulation, and humidity all play a role in the hatching process. Lighting management was significant in hatching and embryo growth, reducing stress, reducing post-hatching environmental responses, and eventually altering ducks' performance, behavior, and welfare (Yalcin *et al*., 2022).

Changing the rotation angle from 75° to 60° during incubation could reduce embryo mortality by 3.88% and increase egg hatchability to 96.5% (Chen *et al*., 2024). Bird eggshells contain microbes shortly after laying, and under the right environmental conditions, these microbes can multiply rapidly, penetrate the shell's pores, infect the egg's contents, and cause embryo death (Cook *et al*., 2005).

Hatchability Percentage

The results of the hatchability test for duck eggs disinfected with a salt solution at different concentrations are presented in Table 1. The study was resulted indicate that the disinfection of hybrid duck eggs using a NaCl solution with a concentration of 30ml did not affect the hatchability rate (P>0.05).

Kim *et al*. (2023) stated that eggs cleaned with a 1.6% hydrogen peroxide disinfectant had a 3.1% higher hatchability, 4% fewer dead embryos than the control, and improved chick quality. They were increased the safety of 1-day-old ducklings compared to eggs cleaned with water. In this study, the higher the concentration of NaCl in the hybrid duck-hatching eggs, the higher the hatching rate achieved.

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The hatchability of the eggs is inversely proportional to the egg mortality rate; when the mortality rate is low, the hatchability is automatically high. The average hatchability of hybrid duck eggs in this study is generally high (>70%). The supporting factors in the hatching process are functioning as they should. Zakaria *et al*. (2023) state that the factors for success in the egg-hatching process include the incubator (temperature and humidity) meeting the eggs' requirements, the hatching process's management, and other occasional occurrences such as power outages. The level of cleanliness of hybrid duck-hatching eggs was suspected to be the cause of the decrease in hatchability. Active compounds derived from NaCl with the treatment of NaCl bleaching are capable of minimizing/killing microorganisms on the eggshells of hybrid duck eggs, possessing several active compounds that function as antibacterial agents and can accelerate the hatching time (Catterall, 2000).

Based on the research results that have been conducted, it could be seen that the lowest hatchability rate was in the treatment without cleaning with individual turning, resulting in a hatchability rate of 77%. The treatment cleaned with NaCl and individual turning resulted in a hatchability rate of 85%. The treatment cleaned with NaCl and simultaneous turning resulted in a hatchability rate of 88%. The treatment without cleaning and simultaneous turning resulted in a hatchability rate of 90%. The dirty treatment with simultaneous turning yielded higher results due to the absence of salt solution rinsing during the cleaning process (Septiani et al., 2016). Regarding the above explanation, it can be concluded that simultaneous turning could increase the hatchability of hybrid duck eggs and optimize the time during the incubation process in a manual incubator.

The cleanliness of the eggshell was also a factor that must be considered in the hatching process because a dirty eggshell is a breeding ground for microorganisms that could damage the egg's quality and disrupt the embryo's development during incubation. However, using NaCl could improve hatchability because the reaction in the NaCl solution applied to the eggshell effectively breaks down the eggshell (Catterall, 2000). The cleanliness of hatching eggs before incubation was used to minimize/kill microorganisms on the eggshell. Verma *et al*. (2023) that the eggshell was the outermost part of the hatching egg, which contains dirt, especially excreta, and thus had the potential to be a source of pathogenic bacteria such as *E. coli* (84% on the outer shell and 21% on the inner shell) and *Staphylococcus* spp (77% on the outer shell and 15% on the inner shell). Both of these bacteria could disrupt embryo development, leading to hatch failure due to embryo death, which affects the hatchability percentage produced (He *et al*., 2024).

Several factors influence failure in the hatching process, including handling during hatching, such as careless egg turning (Gonzalez *et al*., 1999). The distance of the rotation performed too closely does not show any difference in the hatching rate of the eggs. This is likely due to the rotation range of four to eight times per day not affecting the condition of the embryo inside the incubated egg. Egg turning can improve hatchability compared to no turning (Melo *et al*., 2021). Eggs rotated 90° every 12 hours during storage positively affect embryo development, shorten incubation time, and improve chick quality (Damaziak *et al*., 2018).

Temperature and humidity were important factors for embryo development; temperatures too low or too high would cause embryo death or abnormalities. Higher levels of humidity reduce egg weight loss and improve shell quality, which was crucial for successful hatching (Romao *et al*., 2009). Higher humidity levels help maintain the highest quality of the sink, reducing the water loss rate through the eggshell. This was important as excessive water loss could weaken the sink and affect embryo development (Veldsman *et al*., 2020). The temperature and humidity in the incubator must be stable to maintain the eggs in good condition during the incubation process. El-Hack *et al*. (2019) state that eggs that were not turned will affect the embryo's position, resulting in the embryo not being able to grow normally or experiencing defects and eventually dying. Temperature and the turning were processed during egg incubation.

Hatch Weight

The results of the hatch weight test for duck eggs disinfected with a salt solution at different concentrations were shown in Table 1. The study was resulted indicate that the different salt solution concentration treatments did not affect ducks' hatch weight ($P>0.05$).

The larger the weight of the egg, the larger the hatch weight; the smaller the weight of the egg, the lower the hatch weight produced. This was supported by the opinion of Iqbal *et al*. (2016) that small hatch weight comes from small eggs, while large hatch weight comes from large eggs. Heavier eggs have more egg components compared to smaller eggs. The egg's internal contents, such as the yolk and egg white, could determine the egg's weight, resulting in a larger hatch weight due to abundant food reserves during embryo development. Internal and external factors influence the development of the embryo in the egg. The internal factor was the food reserves available within the egg, while the external factors include the incubation environment, humidity, turning, and light (Yalcin *et al*., 2022).

The rotation of eggs that were too close together is suspected to disrupt the stability of temperature and humidity in the incubator. Excessively high temperatures and excessively low humidity can cause a decrease in hatch weight. Tribudi *et al*. (2023) state a very significant relationship between egg weight and hatch weight; the higher the weight of the incubated egg, the greater the hatch weight produced.

The results of this study were supported by Iqbal *et al*. (2017) that larger egg sizes contain more nutrients than smaller eggs, so more nutrients were used for embryo growth, and the hatch weight produced was in line with the amount of nutrients available in the incubated eggs. Based on the research results, it could be concluded that the hybrid duck egg weight did not affect the hatch weight produced. Duck eggs sprayed with 10 g per litre and 20 g per litre salt solution with 38°C warm water can reduce mortality, increase hatchability but did not affect the hatching weight of duck eggs. Factors that affect egg weight were the environment, laying period (early or towards the end), and feeding management (Sutiyo et al., 2020).

CONCLUSIONS AND RECOMMENDATIONS

The results of this study indicate that neither cleaning with a salt solution nor the turning process significantly affected the hatching performance of duck eggs.

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NOVELTY STATEMENTS

Egg hygiene using saline solution and hatching duck egg turning process on mortality, hatchability percentage, hatch weight

AUTHOR'S CONTRIBUTIONS

Hariadi Subagja: Designed and supervised the experiment and revised the manuscript.
Zahrotul Aprilia Nadia: Experimented, conducted the laboratory analysis, and analyzed the data.
Siti Zubaidah: Wrote and revised the manuscript.
All authors were responsible for the reading and approval of the final manuscript.

Conflict of Interest

All authors declare that they have no competing interests.

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