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Review article

Factors causing weight loss and death of broiler chickens during the transportation process

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Abstract

Transportation of broiler chickens is an important sector that should be put into consideration in the poultry production chain. The process consists of different stages, such as pre-loading, loading, transportation, unloading, and post-unloading stages. While each stage is crucial and necessary these processes often contribute to significant stress and result in weight loss and mortality. During transportation, the form of stress often experienced is heat stress, which is then exacerbated by the transport conditions. Temperature is a significant challenge for transportation, specifically in tropical climates such as Indonesia. Therefore, this research aims to review factors causing heat stress during terrestrial transportation of broilers from farm to the slaughterhouse. Primary factors that cause heat stress are ambient temperature, humidity (affected by season and time of transportation), and crating density. Other factors, such as handling, transportation distance, and duration, affect the intensity of heat stress experienced by broilers. Heat stress can be mitigated during transportation by transporting broilers under non-extreme temperatures, in low densities per crate, short transportation distances, and duration. Manipulating lairage time, water spraying before, and supplementing nutrients before transporting can also be carried out to reduce the effects of heat stress.

Keywords: Broiler, Heat stress, Mortality, Transportation, Weight loss.

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INTRODUCTION

Transportation of broiler chickens plays an important role in the poultry production chain, from the moving of chickens from farms to slaughterhouses. This process involves several stages, such as pre-loading, loading, transportation, unloading, and post-unloading. Since most farms are located separately from slaughterhouses, transportation is an essential step in the broiler production chain. Broilers experience a lot of stress when being transported, which can cause losses in weight (Arikan, 2017) or even death in some cases (Vieira et al., 2011). To reduce these issues and ensure better profits, it is important to look at the transportation process and figure out factors affecting broilers' well-being during transportation.

From the moment of being transported from the farm and arriving at the slaughterhouse, broilers experience different stressors. Several factors can lead to weight loss during transit, such as the handling method, loading and unloading (Minka and Ayo, 2010), the distance (Padalino et al., 2018), duration (Nielsen et al., 2011), time of day (Vieira et al., 2010), crate density (Hussnain et al., 2020), environmental conditions (Schwartzkopf-Genswein et al., 2012), vibrations, noise, vehicle speed, the type of transportation used, road conditions, and the skill of the handlers. Additionally, pre-transportation factors, including rearing methods (Chauvin et al., 2011), overall health status, and the duration of feed withdrawal prior to loading, play a critical role in determining broilers' survival during transportation. Kittelsen (2015) found that mortality on the farm, before transportation, was primarily caused by sudden death syndrome (36.38%), followed by endocarditis (28.03%), ascites (18.05%), osteomyelitis (9.7%), physical trauma (3.5%), and other causes (4.31%).

Among the various factors, climatic conditions (temperature and humidity) and crating density are the primary causes of broiler mortality (Qi et al., 2017). Temperature poses a significant challenge, especially in tropical climates such as Indonesia. Broilers are highly sensitive to heat, with the acceptable temperature range for transport being 26-27 °C (Frandson et al., 2009). In Indonesia, temperatures range from 22.8-25.9 °C at the lowest to 30-37.7 °C at the highest, with average humidity between 64-89%. In the afternoons, temperatures frequently exceed the optimal range, leading to heat stress in transported broilers. This stress is further compounded by their inability to sweat, dense feather coverage, and rapid growth due to genetic selection (Lu et al., 2007).

Microclimatic conditions inside crates play a significant role in the heat stress experienced by broilers. In addition to crating density, the way crates are stacked and their position in the truck also influences the temperature. Dos Santos et al. (2020) observed higher temperatures inside crates on the lower levels of the cargo bay, while crates at the front and upper levels displayed lower temperatures. An increase in temperature was observed diagonally, going from the front section of the cargo bay, passing through the center, and towards the rear. According to the investigation, inconsistent airflow, such as flow from the upper front part of the truck getting progressively weaker towards the back, creates a thermal gradient that may impact broilers' performance negatively (Knezacek, 2010). Therefore, a consistent airflow is necessary to ensure optimal dissipation of heat. Highway trailers in Northern America tend to be equipped with manually adjustable vents on the roof, headboard, and tailboard as well as curtains or screens attached to the open side of the trailers. This allows the facilitation or restriction of airflow depending on the environmental conditions to maintain thermal comfort (Schwartzkopf-Genswein et al., 2012). Trucks in Indonesia typically lacks these features, making the broilers susceptible to thermal stress.

To combat heat stress, broilers rely on their thermoregulation system, which lowers body temperature by releasing heat through bodily water (Bruno, 2011), a process that demands considerable energy. However, due to feed withdrawal before transportation and the absence of feed intake, broilers rely on muscle glycogen stores for energy (Adamczuk et al., 2013). The stress of transportation triggers adrenaline secretion, which binds to α-adrenergic receptors, inhibiting insulin release and suppressing gluconeogenesis while stimulating glycogenolysis and glycolysis in muscles (Arnall et al., 1986; Raz et al., 1991). This response results in muscle mass reduction and elevated blood glucose levels. Additionally, the combination of high energy and water requirements, along with the inability to eat or drink during transport, contributes to significant weight loss. Exposure to high temperatures and humidity poses further risks, potentially leading to respiratory alkalosis due to excessive CO_2 loss, disrupting pH balance, and, in severe cases, causing death. To mitigate heat stress, broilers exhibit adaptive behaviors such as panting, wing-stretching, and lying down, actions that support their thermoregulation efforts.

Transportation stress also weakens the immune system, making broilers more vulnerable to diseases (Adenkola and Ayo, 2010). According to the results, common causes of death during transportation include lung obstruction, arterial and venous obstruction, and bleeding (Lund, 2013). However, research on factors contributing to weight loss and mortality during transportation in Indonesia and other tropical regions is limited. In Indonesia, the method of transportation often does not meet the same standards as in developed countries, mainly because there are no specific guidelines suited to local conditions. Most broilers are transported using unsuitable land transport modes, and the roads are not well-developed enough to support proper transport vehicles. Determining transport duration is particularly difficult, given the prevalence of narrow roads and frequent traffic jams. Presently, Indonesia still follows transportation standards from developed countries, even though the environment and logistics are quite different.

This literature review examines existing research on how transportation affects broiler chickens, stressors leading to losses, and ways to reduce the negative effects. By analyzing recent investigations and improvements in transport methods, this review aims to give a clear understanding of the challenges and possible solutions in broiler transportation.

Broilers' Handling

The transportation process starts with catching broilers on the farm and placing them into crates, a step called loading. The method applied by handlers is really important because their skill level can help prevent injuries and deaths. If broilers are handled roughly, such as being thrown, held the wrong way, or shoved into crates too quickly, these can lead to broilers getting hurt, bleeding, breaking bones, or even dying (Chikwa et al., 2019). Loading and unloading can be carried out by hand or with machines.

According to the National Chicken Council (2017), handlers should carry no more than five broilers at a time if the birds weigh up to 1.8 kg. Having experienced handlers is key to keeping the chickens safe. If someone struggles to lift five birds in one hand, they should carry fewer to lower the chances of injury or death.

Using machines for handling tends to cause more deaths compared to manual loading (Chauvin et al., 2011). In some countries, automated systems flip crates upside down, making the chickens slide down a funnel onto a conveyor belt. While this method is efficient for lighter broilers, it can cause fractures and fatalities in heavier broilers (Weeks, 2014). Stress and injuries sustained during loading negatively affect chickens' health and reduce their ability to endure transportation (Voslarova et al., 2016). Chickens that are injured or sick and not treated before transportation often die en route due to their weakened resilience (Adzitey, 2011). Both overly rapid and prolonged loading processes also increase stress levels. Lima (2019) found that chickens become more agitated and attempt to escape when loading takes too long. Excessive interactions with humans and other chickens during this time heighten their activity, increasing the risk of injury or death if handlers are not properly trained, and once loaded, broilers are ready for transportation.

Transportation Distance

Transportation distance significantly influences the level of stress experienced by broilers, as longer journeys expose them to more stressors, including fluctuations in temperature and humidity. Research consistently shows a correlation between longer transportation distances and higher mortality rates.

Arikan (2017) examined the effects of transportation in Turkey across four seasons, such as spring, summer, autumn, and winter, and two age groups, including 31–39 days and 40–46 days. The results showed average body weight losses of 259.40 g per broiler for short-distance transportation (≤50 km), 307.35 g for medium-distance transportation (51–150 km), and 350.14 g for long-distance transportation (≥151 km). In the same age group and season, longer distances consistently resulted in greater weight loss compared to shorter trips. Additionally, broilers at 40–46 days old experienced more significant weight loss than broilers at 31–39 days old, suggesting that age also plays a role in stress tolerance during transportation. Del Vesco et al. (2017) in their research found that broilers at 42-day-old under heat stress produce higher reactive oxygen species (ROS) and, thereby, were more susceptible to oxidative stress caused by heat stress compared to 21-day-old broilers. This shows that older broilers are more susceptible to heat stress, thereby experiencing more weight loss and possibly death during transport.

A study conducted in Pakistan showed that broilers experienced a body weight decrease of 3.76% (74.26 g), 5.69% (112.37 g), and 6.80% (134.3 g), with corresponding mortality rates of 2.00±0.70%, 6.277±1.79%, and 10.22±2.12% for transportation distances of 80, 160, and 240 km, respectively (Hussnain et al., 2020). Transportation took place in August, with temperatures ranging from 27.2 to 33.6 °C and relative humidity between 52.7% and 62.9%. This research confirmed that longer transportation distances led to greater weight loss and higher mortality rates in broilers.

Dos Santos et al. (2020) conducted a study in Brazil involving transportation of 48-day-old broilers, which had an average weight of 2.895 ± 0.20 kg, over two distances: an average of 15 km (dist15) and 90 km (dist90). The transport took place during both the rainy and dry seasons in a tropical wet and dry climate, characterized by dry winters and hot, humid summers. The average annual temperature in the region is 22°C, with relative humidity levels ranging from 20% to 75%. The results indicated a body weight loss of 1.36±0.57% (39.37 g per bird) for the 15 km transport distance and 2.39±0.63% (69.19 g per bird) for the 90 km distance. When comparing transportation distances within the same season, longer distances consistently resulted in higher mortality rates.

Vecerek et al. (2016) monitored transportation of broilers in the Czech Republic from 2009 to 2014, categorizing transportation distances into several ranges: up to 50 km, 51-100 km, 101-200 km, 201-300 km, and over 300 km. The results showed mortality rates of 0.33% for distances below 50 km, 0.31% for 51-100 km, 0.45% for 101-200 km, 0.6% for 201-300 km, and 0.72% for distances exceeding 300 km. With the exception of the shortest distance (below 50 km), the data indicated a trend of increasing mortality as transportation distance increased.

The results show a clear trend of increased weight loss and mortality with longer transport distances. Extended transportation leads to prolonged feed and water withdrawal, along with greater exposure to stress-inducing factors. Villarroel et al. (2018) found that mortality increases by 0.036% for every additional 50 km travelled in a range of 8-119 km. Transportation distance is directly correlated with travel duration; longer distances require more time, while shorter distances can be covered more quickly under typical infrastructure and road conditions.

In a study conducted in Turkey by Aral et al. (2014), six transportation durations were evaluated, including Group I (0-120 minutes), Group II (121-240 minutes), Group III (241-360 minutes), Group IV (361-480 minutes), Group V (481-600 minutes), and Group VI (over 600 minutes). The average weight loss observed for each group was 4.33%, 4.95%, 5.55%, 5.73%, 6.02%, and 6.63%, respectively, while the corresponding mortality rates were 0.29%, 0.38%, 0.40%, 0.43%, 0.42%, and 0.46%. These results show that both weight loss and mortality increase with longer transportation durations, which correlates with increased transport distance.

The National Chicken Council (2017) recommends that transportation duration from loading to slaughtering should be less than 12 hours. Subsequently, exceeding this time can significantly increase stress levels in broilers. In Indonesia, estimating transportation duration based on distance is challenging due to suboptimal infrastructure and varying road conditions. The traffic conditions are often unpredictable, with frequent congestion that prolongs travel times. Ideally, the distance from the farm to the processing facility should be minimized in order to reduce weight loss and the risk of broilers' mortality.

Climate Condition

Weight loss and mortality during transportation is also influenced by seasonal variations and the timing of transportation, which are directly related to the ambient temperature and humidity, significantly affecting broilers' ability to thermoregulate. Increased ambient temperatures can lead to heat stress, increasing the energy expenditure required for thermoregulation. This increased energy consumption contributes to weight loss, and in extreme cases, severe heat stress due to excessively high ambient temperatures can result in increased mortality.

Research by Arikan (2017) also evaluated the effects of seasons on weight loss in transported broilers weighing on average, 2556 ± 0.002 g. For short-distance transport (≤ 50 km), broilers aged 31-39 days experienced the greatest weight loss in summer (299.08 ± 5.25 g or 11.72%) compared to those transported in spring (164.29 ± 3.89 g or 6.42%) and autumn (289.17 ± 4.80 g or 11.31%), and winter (211.43 ± 5.28 g or 8.27%). In medium-distance transport, the weight losses were 303.20 ± 4.69 g (11.86%) in summer, 229.76 ± 4.94 g (8.98%) in spring, 302.83 ± 5.49 g (11.84%) in autumn, and 229.81 ± 5.05 g (8.99%) in winter. Longer distances exhibited a similar trend, with summer showing the highest loss (336.55 ± 12.12 g or 13.16%), followed by spring (230.95 ± 14.92 g or 9.03%), autumn (304.92 ± 13.38 g or 11.92%), and winter (326.05 ± 12.72 g or 12.75%). These results consistently indicate that the highest weight loss occurs during summer when temperatures peak. Interestingly, during autumn, despite the lower temperatures (14.5°C) compared to spring (17.4°C) and summer (24.3°C), weight loss was still significant, particularly in older broilers (40-46 days old) transported over distances of less than 50 km and between 51-150 km, where autumn losses even surpassed those of summer.

Research by Vieira (2011) in São Paulo, Brazil, found that the highest mortality rate during transport occurred in summer (0.42%) compared to autumn (0.23%), winter (0.28%), and spring (0.39%). Broilers were transported over an average distance of 120 km, with a travel duration of approximately 90 minutes. The average temperatures recorded were 21.7°C in spring, 22.9°C in summer, 19.8°C in autumn, and 18.8°C in winter, with corresponding humidity levels of 83%, 80%, 68%, and 82% respectively. Although the temperature differences across seasons were not substantial, the mortality rate followed a pattern of higher mortality with increasing environmental temperatures. Humidity likely played a crucial role in these outcomes. The combination of lower humidity and cooler temperatures during autumn may have facilitated thermoregulation, reducing the impact of heat stress.

Elsayed (2014) conducted research in Egypt to investigate the effects of transportation distance and season on mortality rates and the physiological status of 42-day-old broilers. Although specific temperatures were not provided, the study found that mortality was highest in winter (0.31%) compared to summer (0.28%), autumn (0.19%), and spring (0.19%). These findings suggest that extreme temperatures (both cold in winter and heat in summer) induced stress in broilers, leading to higher mortality rates than during the milder conditions of autumn and spring.

Grilli et al. (2018) conducted a survey on broiler transportation in Italy, covering the period from January 2 to December 31, 2012, using data from the Official Veterinary Activity. A total of 22.3 million broilers were monitored, categorized by size: large (3.5 kg), medium (2.7 kg), and small (1.67 kg). Across all sizes and within the same transport distances, the highest mortality rate was observed during winter (0.52%), followed by spring (0.48%), summer (0.31%), and autumn (0.22%). The average seasonal temperatures recorded were 4.8 °C in winter, 13.1 °C in spring, 24.9 °C in summer, and 15.3 °C in autumn.

The results indicate that the highest mortality rates occur during summer and winter, driven by extreme ambient temperatures in both seasons. Temperatures exceeding 26°C (Frandson et al., 2009) can induce heat stress, potentially resulting in hyperthermia and death. Conversely, transportation under extremely cold conditions, such as temperatures below -28°C (Knezacek, 2010), can lead to hypothermia and even localized heat stress in the truck. The latter occurs when curtains restrict airflow, creating pockets of warmer air. In a transportation simulation using a heat chamber, Strawford (2011) found that broilers began exhibiting signs of cold stress (both physiological and behavioral changes) at temperatures below -5°C.

The time of day during transportation significantly influences broilers' exposure to temperature and humidity. Marzuki et al. (2016) conducted a study in Jember, Indonesia, involving transportation of 90 broilers at different times of the day. The results showed weight loss of 3.09% during early morning transportation (02:00 WIB), 8.66% during afternoon transportation (12:00 WIB), and 4.36% during late afternoon transportation (16:00 WIB). The highest weight loss occurred during the afternoon, corresponding to peak ambient temperatures, while the lowest loss occurred in the late afternoon. High daytime temperatures lead to increased shrinkage as heat accumulates in the crates and continues into the night, as reported by Barbosa Filho et al. (2014). Although temperature played an important role in weight loss, transportation duration also contributed to the variation in results. The morning, afternoon, and late afternoon transportation durations were 92, 131, and 117 minutes, respectively, which may have influenced the weight changes observed.

Crating Density

Crating density refers to the live weight of chickens per unit of crate area. Both excessively high and low crating densities can impose stress on broilers. Chauvin et al. (2011) identified high crating density as a significant stressor, as it leads to increased humidity and poor ventilation, impairing thermoregulation. These conditions heighten the risk of hyperthermia and, in severe cases, death. Conversely, Vinco (2016) found that crates with higher ceilings, which allow more space for movement, also pose risks. Increased movement (such as flapping wings or chickens falling on one another) can cause injuries, abrasions, and even mortality. Furthermore, Jacobs (2017) noted that low-density crates create challenges during cold transport. Cold-stressed chickens expend additional energy to maintain body temperature, which leads to weight loss and a heightened risk of hypothermia. Increasing the density by adding more chickens could be done to minimize the cold stress experienced. Both overcrowding and excessive space within crates disrupt the balance needed for safe transportation, underscoring the importance of optimizing crating density to minimize stress, injury, and mortality.

Hussnain et al. (2020) research in Pakistan, as discussed in the "Transportation Distance" section, also examined the effects of varying crating densities on broiler chickens weighing 1900–2050 grams. The study tested three crating densities: 10 birds per crate or D1 (37.96-40.96 kg m-2), 12 birds per crate or D2 (45.55-49.15 kg m-2), and 15 birds per crate or D3 (56.94-61.44 kg m-2). The highest weight loss was observed at the highest density, D3 (6.33 ± 0.23%), followed by D2 (5.04 ± 0.21%) and D1 (4.89 ± 0.22%). Similarly, mortality rates increased with higher crating densities, with D3 showing 10.17 ± 2.33%, D2 reporting 5.00 ± 1.36%, and D1 recording the lowest mortality at 3.33 ± 1.11%.

However, the study also found that lower crating densities resulted in more injuries and bruising. Broilers in D3 experienced minimal physical injuries (0%), breast bruises (2.22 ± 1.54%), and wing bruises (0%). In contrast, D2 resulted in higher injuries: 2.22 ± 1.54% physical injuries, 7.78 ± 3.81% breast bruises, and 2.22 ± 2.22% wing bruises. The lowest-density group, D1, reported the highest incidence of injuries, with 4.44 ± 2.10% physical injuries, 10.00 ± 3.96% breast bruises, and 6.67 ± 3.35% wing bruises.

These results are in line with the findings of Chauvin et al. (2011) and Vinco (2016), showing that both high and low crating densities introduce different risks. While higher densities increase stress, weight loss, and mortality due to poor ventilation and overcrowding, lower densities allow excessive movement, leading to injuries and bruising. This demonstrates the need to carefully balance crating density to minimize both physiological stress and physical injuries during transportation.

To minimize both weight loss and injuries, crating density must be carefully managed during broiler transportation. According to the European Commission (2005), the optimal crating density for broiler ranges from 52.63 kg/m² to 63.00 kg/m², striking a balance between minimizing stress and preventing physical injuries. Barbut (2015), reported that a crate size of 80 x 60 x 30 cm can accommodate 12–15 broilers depending on the size and weight. Meanwhile, Indonesian practices commonly use crates measuring 95 x 50 x 25 cm, which provide a surface area of 0.475 m². These crates are suitable for transporting 12-15 broilers weighing 2 kg each or 14-17 broilers weighing 1.7 kg.

The recommendations aim to align with practical transport needs and infrastructure limitations, ensuring that crates are neither too densely packed nor too sparse. Overcrowding leads to increased humidity, poor ventilation, and thermoregulatory issues, resulting in weight loss and mortality (Chauvin et al., 2011). Conversely, low-density crating can lead to injuries, bruises, and hypothermia from excessive movement (Vinco, 2016; Jacobs, 2017). Therefore, the ideal crating density must be adjusted based on the weight of broilers and crate dimensions to ensure efficient transport with minimal stress and injuries.

Stress Mitigation

Mitigating stress during transportation can be achieved through both improved transport practices and nutritional interventions. One of the primary strategies is to reduce distance since longer distances increase stress, leading to greater weight loss and higher mortality rates (Afnan et al., 2016; Widyasari et al., 2021). Shorter transportation distances limit broilers' exposure to the external environment and reduce the negative effects of prolonged feed withdrawal typically carried out before transportation. Transportation also should be scheduled during cooler periods, such as such as during the early hours of the night or during rainy seasons (Dos Santos, 2017). Extreme temperatures during the day can amplify stress levels, increasing risks of weight loss and mortality,

Proper lairage under controlled climate conditions plays a vital role in reducing heat stress and mortality following transportation. The duration and microclimatic conditions within the lairage area determine how effectively broilers recover from stress. Longer lairage times allow broilers to regain their thermal comfort, mitigating the effects of heat stress since they remain responsive to favourable environmental conditions. However, transportation duration and distance affect how beneficial lairage can be determined. Broilers transported over short distances recover more efficiently with longer lairage, while those transported over long distances arrive weakened from energy depletion. For these weakened broilers, prolonged lairage can increase mortality risks due to delayed slaughter, making shorter lairage times more effective.

According to Vieira et al. (2010), lairage time in a proper slaughterhouse with a controlled climate exceeding 2 hours is recommended for broilers transported over short distances, while less than 60 minutes is more suitable for journeys over 50 km. Additionally, the time of day influences lairage duration recommendations. Vieira (2015) suggested 2–3 hours in the morning, above 3 hours in the afternoon, and 1–2 hours at night, corresponding to mortality rates of 0.29%, 0.32%, and 0.32%, respectively.

Water spraying is widely used by transporters to mitigate heat stress during and before transportation of broilers. This method effectively reduces thermal resistance in broilers by wetting their feathers (Webb and King, 1984), thereby facilitating heat dissipation through evaporation (Wolfenson et al., 2001). Jiang (2016) found that combining water spraying with forced ventilation helps alleviate heat stress, as shown by slowed postmortem glycolysis, improved meat water holding capacity, and a reduction in the occurrence of PSE (Pale, Soft, Exudative) meat after slaughter. Tamzil et al. (2018) observed that broilers subjected to water spraying exhibited lower rectal temperatures (RT) and heterophil lymphocyte (HL) ratios compared to those that were not sprayed, recording temperatures of 40.94 °C and 0.48 versus 41.06 °C and 0.5. Similarly, Abidin (2022) reported that broilers receiving a 10-minute water spray prior to 3-hour transportation had significantly lower RT (40.83 ± 0.09°C), corticosterone (CORT) levels (2.83 ± 0.22 ng/ml), and heat shock protein (HSP70) concentrations (603.9 ± 95 pg/ml) compared to the untreated group (41.17 ± 0.08°C RT, 4.16 ± 0.53 ng/ml CORT, and 824 ± 135 pg/ml HSP70).

In addition to water spraying, allowing broilers to drink during transport significantly contributes to mitigating heat stress. Research by Afnan et al. (2022) investigated the impact of water consumption on broilers during transportation. The research involved four treatments: morning transportation with drinking water (T1), morning transportation without drinking water (T2), afternoon transportation with drinking water (T3), and afternoon transportation without drinking water (T4). Broilers in treatments T1 and T3 had access to water through a modified drinking system featuring a pipeline with nipples, allowing them to drink during transportation. The results showed that broilers with access to drinking water (T1 and T3) experienced lower weight loss compared to those without access (T2 and T4). These findings indicate that enabling broilers to drink during transportation provides the necessary hydration for thermoregulation, thereby reducing the risk of heat stress. This practice not only enhances the welfare of the birds but may also improve overall transport outcomes by maintaining better physiological conditions.

The supplementation of nutrients during the rearing period or a short time before transport is another method that can be used to mitigate the negative impact of heat stress during transport. The supplementation of nutrients or other supplements has been common practice on farms to reduce the effects of heat stress during the rearing period. This approach can also be applied to reduce transportation stress. For instance, supplementing ascorbic acid two hours before transportation has been shown to lower rectal temperature and decrease the expression of the HSP70 gene, indicating reduced heat stress levels (Tamzil et al., 2016). Additionally, research demonstrates that incorporating symbiotic supplements in feed from hatching until slaughter age can reduce the HL (heterophile-lymphocyte) ratio, a key indicator of heat stress following transportation (Ghareeb and Böhm, 2009). The supplementation of either pre-biotic chicory rich in inulin or probiotic *Lactobacillus sp.* also yielded the same result (Ghareeb et al., 2008).

CONCLUSION

In conclusion, transportation causes heat stress, which causes weight loss and mortality. Heat stress is primarily caused by climatic conditions (season and time of day) and crating density, while handling, transport distance, and transport duration affect the intensity of the heat stress experienced. The negative effects of transportation can be mitigated under non-extreme temperatures, non-crowded crating densities, shorter transportation distances, and durations. Manipulating lairage time, water spraying before transportation, and supplementation of nutrients before movement could also be carried out. For broilers' transportation in Indonesian climate and traffic conditions, it is recommended to transport them during the early hours of the morning when the environmental temperature is lower while using the shortest route possible. This helps minimize the effects of heat stress experienced during transport.

AUTHOR CONTRIBUTIONS

Insan Mujahid Afnan: Conceptualization, visualization, and writing the original draft.
Rudi Afnan and Niken Ulupi: Designing, guiding, critical review, and editing of the paper

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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