**International Journal of Advances in Applied Sciences (IJAAS)**
Vol. 14, No. 1, March 2025, pp. 282~290
ISSN: 2252-8814, DOI: 10.11591/ijaas.v14.i1.pp282-290 

# Application of turmeric as heat stress therapy for broiler chickens

**Agung Adi Candra, Dwi Desmiyeni Putri, Sakhira Najla Oktyana**
Department of Livestock Production Technology, Faculty of Animal Husbandry, Politeknik Negeri Lampung, Lampung, Indonesia

**Article Info**

***Article history:***

Received Aug 23, 2024
Revised Dec 31, 2024
Accepted Jan 26, 2025

***Keywords:***

Application
Broiler
Heat stress
Therapy
Turmeric

**ABSTRACT**

This study aims to analyze the productivity of broilers kept in heat-stress conditions by drinking water mixed with turmeric (*Curcuma domestica*). This research was conducted in the Politeknik Negeri Lampung, Indonesia cage in September 2023. This study uses the experimental method by comparing the turmeric treatment group with as much as 500 mg/kg of chicken body weight which will be compared with the group without treatment (control). The results of the research on the provision of drinking water given turmeric (*Curcuma domestica*) to broilers kept under heat stress, based on the results of the study it can be concluded that the provision of drinking water mixed with turmeric (*Curcuma domestica*) as much as 500 mg/kg body weight of chickens on the productivity of broilers reared under heat stress conditions able to increases consumption and weight gain in chickens and can reduce feed conversion in broiler chickens experiencing heat stress.



***Corresponding Author:***

Agung Adi Candra
Department of Livestock Production Technology, Faculty of Animal Husbandry
Politeknik Negeri Lampung
Soekarno Hatta Street No. 10 District Rajabasa, Lampung Province, Indonesia
Email: adicandra@polinela.ac.id

## 1. INTRODUCTION

Broilers are farm animals that provide protein for humans. Broiler growth is very fast because it uses genetically selected chicken seeds with high efficiency in feed use. Broiler growth requires an ideal environmental temperature for maintenance ranging from 18 to 24 °C [1]. If these conditions are not met, chickens will expend more energy to adjust to the environmental temperature. The condition of expending energy and heat to adjust to this temperature is then known as heat stress which will affect productivity in broilers.

Indonesia is a tropical country that has a fairly high ambient temperature with an average daily temperature of 20.1 °C (minimum) and 27 °C (maximum) [2]. The island of Sumatra in Lampung Province, Indonesia has a fairly high ambient temperature with an average daily temperature of 27.7 °C [2]. High ambient temperatures can cause heat stress in broilers which leads to decreased performance. In addition, heat stress also has an impact on reducing performance due to an increase in the production of free radicals in the body [3], [4]. One way to overcome this problem is by providing antioxidants and vitamin C. Vitamin C is known to be responsible for the mobilization of energy required for various vital functions, especially in maintaining temperature. Supplementation of Vitamin C also improved growth performance in heat-stressed broilers under standard animal density conditions [5]. Due to the high price of vitamin C, it is considered less effective. Therefore, an alternative antioxidant is needed at a low price by utilizing turmeric (*Curcuma domestica*).

Indonesia's location on the equator results in high daily temperatures. Broiler growth requires an ideal ambient temperature for maintenance ranging from 18 to 24 °C [1]. Chicken is one of the livestock that is very susceptible to heat stress. Broilers have a limited tolerance level for temperature. When the ambient temperature rises above the chicken's tolerance limit, they will experience heat stress. The high daily ambient temperature will respond to broilers by releasing excess heat from the body and causing stress called heat stress. This heat stress condition causes an increase in the feed use ratio, which contributes to the increase in feed costs due to the use of energy to stabilize the body due to heat stress. Some previous studies on the incidence of heat stress in broilers are feed consumption, weight gain, water intake, feed conversion ratio, and percentage of feed given were significantly higher in the heat-free group compared to the heat-stressed group [6]. Economically, the heat stress losses were significant while the heat-free group was beneficial. It was concluded that heat stress hurts broiler performance (Hubbard). Extreme heat stress in broilers hurts poultry production, Lara and Rostagno [4] stated that heat stress is one of the most important environmental stressors challenging poultry production worldwide. The detrimental effects of heat stress on broilers and laying hens range from reduced growth and egg production to decreased poultry and egg quality and safety. Moreover, the negative impact of heat stress on poultry welfare has recently attracted increasing public awareness and concern. Much information has been published on the effects of heat stress on productivity and immune response in poultry. However, our knowledge of basic mechanisms associated with the reported effects, as well as those related to poultry behavior and welfare under heat stress conditions is scarce. Intervention strategies to deal with heat stress conditions have been the focus of many published studies. Nevertheless, the effectiveness of most of the interventions has been variable or inconsistent. This review focuses on the scientific evidence available on the importance and impact of heat stress in poultry production, with an emphasis on broilers and laying hens.

Mujahid *et al*. [7] conducted a study on the duration of heat stress, stating that exposure of broilers to various durations of acute heat stress resulted in different time-dependent physiological responses. This result may indicate that broilers have no compensatory mechanism for very short durations of heat exposure (minutes), but when the period of heat exposure is extended (hours), broilers can adapt to keep blood pH within the physiological range. Possible reasons may be due to the slow adaptive response, lack of homeostasis during the initial period of heat exposure, or slow replenishment of the plasma buffer system. Alternatively, the capacity of broilers for pH compensation may depend solely on the ambient temperature.

Several studies have reported the use of turmeric (*genus Curcuma*) as a supplement for heat stress conditions with its antioxidant activity. Turmeric (*Curcuma*) belongs to the ginger-ginger family and has long been known to be rich in curcumin, which is effective in ameliorating oxidative stress in both humans and animals [8]. The most abundant turmeric in Indonesia is *Curcuma longa* and *Curcuma xanthrorriza*. In vivo studies conducted by Sugiharto [9] showed that treatment with *Curcuma longa* can restore impaired growth performance, physiological changes, weakened immune system, and impaired antioxidant system in broilers subjected to heat stress [10], and therefore may reduce or replace the role of synthetic antioxidants that have recently been legislatively restricted [10]. Meanwhile, the utilization of turmeric (*Curcuma xanthorriza*) to overcome heat stress still needs further research. Turmeric (*Curcuma xanthorriza*) is an herbal plant that has benefits as a traditional medicine. *Curcuma xanthorriza* is also useful as an anti-microbial, anti-inflammatory, and antioxidant. Water and fat-soluble extract of turmeric and its curcumin component exhibit strong antioxidant activity comparable to Vitamin C and E [11]. Until now, the use of turmeric in drinking water for broilers as an antioxidant to deal with the negative effects of heat stress has not been widely reported, therefore this study explores turmeric as a natural antioxidant that can optimize the productivity of broilers reared under heat stress conditions and the impact of turmeric on broilers under heat stress conditions on the value of income over feed chick cost (IOFCC). This study aims to analyze the productivity of broilers kept under heat-stress conditions by drinking water mixed with turmeric (*Curcuma domestica*).

## 2. RESEARCH METHOD

This research was conducted during the year carried out in the Politeknik Negeri Lampung, Indonesia cage and carried out in September 2023, which was the peak dry period in 2023. In this study, birds were equally divided into two groups: the heat-free group and the heat-stress group. Both were fed on a basal diet. We divided 40 broiler chickens into 2 groups of 20 chickens each. One group will be given turmeric treatment compared to one group without treatment (control). All groups conducted heat stress condition group reared at (35-38 °C) on a litter housing system. In the treatment group, turmeric powder was given at a dose of 500 mg/kg body weight of chickens. The basis for determining the provision of turmeric at a dose of 500 mg/kg of chicken body weight was adopted by [12] who reported that in their research giving a dose of 500 mg/kg of chicken body weight got good results on the productivity of broilers. Therefore, the researchers used a dose of 500 mg/kg body weight to prove that with this dose, it can be obtained that

turmeric as an antioxidant can overcome heat stress and optimize productivity and IOFCC. The treatment of turmeric powder is by maceration or soaking for 2 hours in drinking water while the control group is given ordinary drinking water. At the time of maceration, the chicken was not given a drink, and the rectal temperature was checked. Data collection was carried out by weighing the chickens one by one every week with food coloring marks on the chickens' bodies as a reminder record.

Broiler chickens are maintained for 4 weeks by feeding according to standards and giving unlimited drinking (*ad libitum*). The parameters of observation in this study include: i) Body weight gain, body weight gain was obtained utilizing final body weight reduced by initial body weight in grams; ii) Feed conversion, the conversion value is an estimate of the amount of ration needed to get 1 kg of meat. The value obtained by ration consumption is divided by body weight gain during the study in grams; iii) Feed efficiency, the ration efficiency is the percentage of ration used by the chicken's body to be converted into meat. The efficiency value of the ration is obtained by increasing body weight divided by the consumption of rations then multiplied by 100%; iv) Carcass quality, a measured percentage of carcass compared to weight, percentage of chest weight, thigh to a carcass, and weak abdominal content; v) IOFCC, the IOFCC is income in rupiah obtained from the sale of one chicken at the end of the study with the average expenditure of the purchase of one day old chick (DOC) tail at the beginning of maintenance and the average of the food spent on one chicken during maintenance, and vi) Gross income [7], gross income per 100 chickens is calculated by (1).

$$(the\ price\ of\ live\ chicken\ per\ kg \times average\ weight\ of \times 100 \times percent\ of\ live\ chicken) - (cost\ of\ chicken\ ration) \quad (1)$$

## 3. RESULTS AND DISCUSSION

### 3.1. Heat stress status of research chickens

The rearing period in this study was carried out in the Politeknik Negeri Lampung, Indonesia cage in September 2023. According to the Indonesian Agency for Meteorological, Climatological and Geophysics (*BMKG*) [2], data in 2023, Lampung province at the beginning of September 2023 experienced daily average air temperature conditions of 27.7 °C, with daily average maximum air temperature reaching a value of 29.3 °C, while the daily average minimum air temperature reached a value of 26.1 °C. During mid-September, Lampung experienced daily maximum temperature conditions of 34.6 °C, with the highest daily maximum air temperature reaching 36.0 °C, while the lowest daily maximum air temperature reached a value of 32.2 °C. At the end of September, Lampung experienced daily minimum temperature conditions of 22.2 °C, with the highest daily minimum air temperature reaching a value of 24.4 °C, while the lowest daily minimum air temperature reaches a value of 20.8 °C humidity. According to *BMKG* [2], in 2023 Lampung province in September 2023 had a daily average air humidity of 69%, with a daily average maximum air humidity reaching a value of 78% which occurred on September 7, 2023, while the minimum average daily humidity reached 59% which occurred on September 14, 2023. The average cage temperature during rearing in September 2023 was 33.4 °C or 92.1 °F.

Broiler growth requires an ideal ambient temperature for maintenance ranging from 18 to 24 °C [1]. Chicken is one of the livestock that is very susceptible to heat stress. Broilers have a limited tolerance level for temperature. When the ambient temperature rises above the chicken's tolerance limit, they will experience heat stress. Heat stress also has an impact on reduced productivity, decreased egg or meat quality, decreased chicken health, and death. This is the opinion of Li *et al.* [13], which states that heat stress conditions can affect chicken body weight, feed consumption, disruption of metabolic processes in the body, chicken health, and reduce the growth rate of chickens. The heat stress index is a parameter used to measure the level of danger or not in chicken livestock by considering the air temperature, humidity, and rectal temperature of chickens. The heat stress index can guide the level of heat stress experienced by chickens and can manage the risk of heat in chickens. The heat stress index can be obtained using (2).

$$Heat\ Stress\ Index = Temperature + Moisture \quad (2)$$

Based on temperature and humidity data during maintenance and adjusted to Table 1. Basic heat stress standards that the maintenance of chickens in September 2023 with an average temperature of 33.4 °C or 92.1 °F and a humidity of 69% which results in a heat stress index value of 161.1 is stated that broilers reared experience a dangerous zone or the occurrence of heat stress. So, the justification for heat stress conditions in this study is not conditioned or artificial heat stress, but heat stress conditions based on natural conditions. In addition to temperature, behavioral changes are the first response of broilers to thermal stress due to lower energy costs compared to other physiological adjustments [14]. Under heat stress conditions, broilers spend more time resting, drinking, and panting and less time feeding, walking, dan standing [15].

In this study, many chickens experienced heat stress by having characteristics such as panting, spreading wings, and stretching. In the treatment group, it was found that chickens experienced heat stress characteristics such as panting almost all chickens at noon or at 2 pm where the average temperature in the cage was 34.3 °C and had an average rectal temperature of 42.9 °C higher than in the group without treatment, while in the group without treatment, it was found that chickens experienced heat stress also with the characteristics of panting, spreading wings and stretching with an average rectal temperature of 41.6 °C. Giving turmeric extract to drinking water is given to the treatment group that experiences heat stress to have an impact, namely to reduce the characteristics of heat stress because turmeric contains antioxidants and vitamin C. This is in accordance with the opinion of Gupta *et al.* [16], the substances that have an important effect on turmeric are vitamin C, vitamin E, curcumin, and flavonoids which act as natural antioxidants that can ward off free radicals in the body. Vitamin C can function in the antioxidant defense system under heat stress because it can reduce free radicals [17]. The results of the study from the comparison of groups treated with turmeric (*Curcuma xanthorriza*) as an antioxidant in drinking water with the untreated group on the productivity of broilers raised for 5 weeks with variables including heat stress index, ration consumption, body weight gain, ration conversion, mortality, ration efficiency, and carcass percentage.

Table 1. Feed consumption, body weight gain, feed conversion ratio, and efficiency of the addition of turmeric (*Curcuma xanthorriza*)

| Variable | Treatment | |
|---|---|---|
| | Without turmeric treatment | Turmeric treatment |
| Feed consumption (g/head) | 2,581.7 | 2,560.1* |
| Body weight growth (g/head) | 1,428.5 | 1,462.4 |
| Mortality (%) | 0% | 0% |
| Feed conversion ratio (FCR) | 2.03 | 1.99 |
| Ration efficiency (%) | 74% | 75% |
| Carcass percentage (%) | 86% | 88% |

**Correlations is significant T-test at 5%*

### 3.1.1. Feed consumption

Based on research using broilers that were kept for 4 weeks, the data showed that feed consumption with the turmeric group was lower with a result of 2,560.1 g/head compared to the group without turmeric which had a result of 2,581.7 g/head. Statistical analysis showed that the provision of turmeric treatment was significantly different in broiler feed consumption ($P<0.05$). The T-test showed that the provision of turmeric treatment was significantly different from the control. This shows that giving turmeric treatment of 500 mg/kg body weight of chickens can affect feed consumption. Feeding is lower in the turmeric treatment group compared to the control group, indicating more efficiency in feed utilization. Abdollahi *et al.* [18] state that numerous factors affect feed intake, and hence nutrient intake, of the broilers including dietary (feed form, nutrient density, and anti-nutritional factors), management (stocking density, temperature, lighting, stress, and water supply), and bird (genotype, sex, age, and capacity of digestive tract) factors. The high temperature of the cage is also one of the factors causing stress and the feed consumed decreases. This is also the opinion of Tamzil [19], who states that high temperatures can reduce feed consumption and increase the use of drinking water in broilers.

Previous research reported by Jahejo *et al.* [6] which used Hubbard strain broilers resulted in a decrease in feed consumption, weight gain, water intake, feed conversion ratio, and percentage of feed given were significantly higher in the heat-free group compared to the heat-stressed group. Economically, the heat stress losses were significant while the heat-free group was beneficial. It was concluded that heat stress hurts broiler performance.

### 3.1.2. Body weight growth

Body weight gain can be obtained using the difference between the body weight of the final chicken maintenance with the body weight of the chicken at the beginning. Based on the results of the study, it was found that the turmeric treatment group did not have an effect on body weight gain with a value of 1,428.5 g/head compared to the control group which had a greater value of 1,462.4 g/head. Statistical analysis showed that the provision of turmeric treatment did not significantly affect the body weight gain of broilers ($P>0.05$). The T-test showed that the provision of turmeric treatment was not significantly different from the control. It is suspected that body weight gain can be influenced by the amount of feed consumed. According to the opinion of Attia *et al.* [20], heat stress negatively affects feed intake and affects body weight gain and feed efficiency. Other factors that can affect the decrease in body weight gain are the same strain, the age of the chicken, the protein content of the feed given, and good environmental conditions.

Donkoh [21] states that broiler growth performance was assessed by measuring body weight gain, food intake, food conversion ratio (food again), water consumption, and mortality rate. High environmental temperature depresses food intake and body weight and causes deterioration in food conversion [21]. In addition, Fallah and Mirzaei [22] stated essential oil in turmeric can improve broiler protein metabolism. This is in accordance with the opinion of Lokesh *et al.* [23], which blood biochemistry parameters and antioxidant activity are important biomarkers of health status and nutrient metabolism in the body of an organism in the broiler's body.

Heat stress is a condition wherein animals are not capable of getting rid of excess heat in their bodies causing an increase in body temperature. Heat stress can occur when the heat load is greater than the animal's capacity to release the excess heat from the body. Thermal stress has been reported to cause several detrimental effects on broilers, including retarded growth rate, reduced feed intake, physiologic changes, gut microbial upset, compromised immune responses, and oxidative damage [10]. Thermal stress caused mucosal and villus damage to the small intestine, which can be attributed to the compromised digestive and absorptive functions of chickens. The latter authors also revealed that heat stress modulated oxidative stress and inflammation as well as impaired intestinal integrity and nutrient transport of broilers. In the digestive system of broilers, the function of the small intestine plays an important role in the absorption of nutrients. This, damage to the villi of the small intestine will cause a decrease in the absorption of nutrients. This has an impact on the ability of livestock to convert feed into body weight. This condition also will later affect the broiler feed conversion capability/feed conversion ratio.

### 3.1.3. Feed conversion ratio

Ration conversion or FCR is the ratio between the amount of feed consumption and the body weight gain of livestock. The ration conversion rate shows the level of efficiency of ration use, meaning that if the ration conversion value is low, the higher the ration efficiency value is and more economical. The provision of turmeric flour in this study did not affect ration conversion so it can be seen in Table 1, that the ration conversion value of the turmeric treatment group had a greater value of 1.99 compared to the control group which was 2.03 which was lower. Statistical analysis showed that the provision of turmeric treatment did not significantly affect the ration conversion of broilers ($P>0.05$). The T-test showed that the provision of turmeric treatment was not significantly different from the control.

This is in line with the opinion of Candra and Putri [12], who said that turmeric given to broilers did not have a significant effect on the ration conversion value of broilers raised for 35 days. This is in accordance with the opinion of Baracho *et al.* [24], that high feed conversion is multifactorial, such as feed quality, including quality of ingredients, failures in the production process, the health of birds including vaccination programs, sanitary challenges, and lastly, the management which involves issues with equipment, installations, ambient, and workers. The greater the feed conversion rate, the less economical the use of feed, on the contrary, if the conversion rate is smaller, it means that it is more economical. It is necessary to intensify the management techniques in the environment so that the feed conversion does not increase beyond what is expected for the genetic strain [25]. Baracho *et al.* [24] stated that small changes in the conversion rate whatever the price of the ratio will have a substantial impact on the financial margin. A good ratio conversion value is less than one on the best-used feed and a conversion value of more than one indicates a non-optimal conversion. This may indicate that the provision of turmeric in drinking water has not been able to increase the effectiveness of ration conversion. This is different from the opinion of Irwani *et al.* [26], which states giving turmeric in rations can increase body weight, optimize feed conversation, and reduce fat. Environmental conditions that are above the broiler tolerance limit cause the broiler to respond physiologically. Considering that heat stress may enhance the energy expenditure for maintenance rather than for production, the improved stress response with feeding turmeric may therefore partially save the energy for growth in heat-stressed broilers. Thermal stress has been attributed to the attenuated activity of thyroid hormones, triiodothyronine (T3) and thyroxine (T4), and thereby lower metabolic rate and energy production [10]. Given that curcumin may elevate plasma concentrations of thyroid hormones [27], feeding turmeric may, therefore, compensate for the reduced activity of thyroid hormones due to heat stress. Moreover, the potential of turmeric to improve the immune and oxidative systems [28], [29] and thus health is most also likely to save energy for broiler growth during heat stress.

### 3.1.4. Mortality

Based on research conducted during 4 weeks of maintenance, a mortality rate of 0% can be obtained. In the study by giving the addition of turmeric flour to drinking water has a low impact on mortality rates due to the addition of turmeric to drinking water can reduce the mortality rate of chickens due to turmeric containing curcumin compounds that contain anti-bacterial can increase immunity in the chicken body. This is the opinion of Rajput *et al.* [30], which states that turmeric (*Curcuma domestica*) also contains

curcumin compounds that have various biological benefits such as anti-inflammatory, antioxidant, antimicrobial, anticoagulant, antidiabetic, and antiulcer [29]. The benefits of turmeric are cancer treatment using herbs, lowered blood cholesterol levels, an effect on the stomach, can be very helpful in maintaining one's the ideal weight, diabetes treatment, elimination of free radicals that are responsible for damaging cells in the body, has antibacterial effects, and increases antioxidants in the body [31]. Turmeric also has anti-stress, antioxidant, anti-inflammatory, and antimicrobial properties [32].

High ambient temperature has been recognized as one major environmental factor influencing poultry production. The optimal temperature for performance is 19 to 22 °C for laying hens and 18 to 22 °C for growing broilers [33]. When the ambient temperature is higher than the thermoneutral temperature, heat stress may occur. This can lead to higher body temperature and thus heat burden. The adverse effects of heat stress include high mortality, decreased feed consumption, and lower body weight gain in broiler chickens [34].

### 3.1.5. Ration efficiency

Based on Table 1 above, it can be interpreted that the ration efficiency of the group giving turmeric gets greater results with a value of 75% compared to the group without giving turmeric with a value of 74%. Statistical analysis showed that the provision of turmeric treatment had no significant effect on ration efficiency in broilers ($P>0.05$). The T-test showed that the provision of turmeric treatment was not significantly different from the control. This is because turmeric contains vitamin C, vitamin E, curcumin, and flavonoids which act as natural antioxidants that can ward off free radicals in the body [16]. Candra and Putri [12] said that turmeric given to broilers did not have a significant effect on the efficiency value of broiler rations maintained for 35 days. The content in turmeric is curcumin and essential oils that can help the enzymatic metabolic process in the chicken body [23]. Giving turmeric mixed in drinking water to broilers can increase ration efficiency in broilers. This is the opinion of Archer *et al.* [35], which states selection to improve efficiency might be achieved by measuring the feed intake of growing animals and utilizing genetic correlations that are likely to exist between the efficiency of growing animals and mature animals.

### 3.1.6. Carcass percentage

Carcass percentage is obtained by dividing carcass weight by live weight multiplied by 100%. Carcasses are chickens after slaughter, feathers, heads, necks, legs, and internal organs are removed to obtain carcass weight [36]. The percentage of carcass weight of broilers in maintenance for 4 weeks obtained results with the turmeric treatment group of 88% while the control group obtained results of 86%. Tamzil *et al.* [36] state high carcass weight can be caused by genetic factors (broilers strains) and also factors that affect carcass percentage, namely with increasing age, carcass weight will increase. Turmeric is also a supporting factor in increasing carcass weight because turmeric has antioxidant activity and contains beneficial phytochemicals such as curcumin, ar-turmerones, and curlone [37]. As explained again by Yesuf *et al.* [37], turmeric can increase the amount of lean meat ratio. The decrease in fat may be caused by curcumin which has the potential to suppress or inhibit preadipocyte differentiation through the downregulation of lipogenesis in the liver [38]. The results of statistical analysis showed that the comparison between the group given turmeric treatment in drinking water with the group that was not given the treatment did not have a significant effect on the percentage of broiler carcasses. Irshad *et al.* [39] stated that meal animal carcasses vary in composition through genetic, age, and sex of animals, nutrional, and environmental effects.

The detrimental effects of heat stress in broilers seem to be very consistent, it is important to consider that stocking density has a major role as a potential compounding factor, both from the standpoint of productivity as well and welfare [40]. It has been reported that chronic heat exposure negatively affects fat deposition and meat quality in broilers, in a breed-dependent manner. Recent studies demonstrated that heat stress is associated with the depression of meat chemical composition and quality in broilers. Another recent study [41] demonstrated that chronic heat stress decreased the proportion of breast muscle while increasing the proportion of thigh muscle in broilers. Moreover, the study also showed that protein content was lower and fat deposition higher in birds subjected to heat stress.

### 3.1.7. Income over feed chick cost

IOFCC was calculated as the difference between total revenue, which resulted from selling live chickens at the price of DOC, and the total cost of feed used during the rearing of the birds until harvest [42]. From this study, the IOFCC value with the turmeric group was IDR 15,184 due to low feed consumption compared to the control group with a value of IDR 15,544. This is because the final weight of chickens in the turmeric group is not much different from the final weight of chickens in the group without turmeric. Therefore, the income obtained is also not much different from the group giving turmeric as IDR 32,893 compared to the control group as much as IDR 32,794.5. This is to the opinion of Fisher and Boorman [43],

that ration costs occupy a large proportion of production costs. Similarly, Agbisit *et al.* [44] state that higher IOFCC values are due to lower feed costs and better feed efficiency.

Many studies have been published about the effects of heat stress on the efficiency of broiler production. As previously seen, the exposure of birds to high environmental temperatures generates behavioral, physiological, and immunological responses, which impose detrimental consequences on their productivity. Heat stress results in an estimated total annual economic loss to the U.S. livestock production industry of USD 1.69 to USD 2.36 billion; from this total, USD 1.28 to USD 1.65 million occurs in the poultry industry [45]. According to studies [46], [47] stated that broilers subjected to chronic heat stress had significantly reduced feed intake (16.4%), lower body weight (32.6%), and higher feed conversion ratio (+25.6%) at 42 days of age.

## 4. CONCLUSION

Based on the results of the study it can be concluded that the provision of drinking water mixed with turmeric (*Curcuma domestica*) as much as 500 mg/kg body weight of chickens on the productivity of broilers reared under heat stress conditions has not been able to increase consumption and weight gain in chickens and can reduce feed conversion in broiler chickens experiencing heat stress.

## ACKNOWLEDGEMENTS

The author would like to thank Politeknik Negeri Lampung for research funding DIPA and permission to the author to conduct this research. This acknowledgment is also given to the sponsors and financial support provided. This research was funded by the Politeknik Negeri Lampung, with Basic Research Grant No. 208.5/PL.15.8/PP/2023.

## REFERENCES

[1] R. Hirakawa *et al.*, "Heat stress causes immune abnormalities via massive damage to effect proliferation and differentiation of lymphocytes in broiler chickens," *Front. Vet. Sci.*, vol. 7, Feb. 2020, doi: 10.3389/fvets.2020.00046.

[2] BMKG Klimatologi Station Lampung, *Analysis and rain forecast province lampung (in Indonesian: analisis dan prakiraan hujan bulanan provinsi lampung)*, Vol. 27. Buletin, 2023. [Online]. Available: https://lampung.bmkg.go.id/doc/bulletin/bulKlimatologi_202310.pdf

[3] H. Hu, S. Dai, J. Li, A. Wen, and X. Bai, "Glutamine improves heat stress–induced oxidative damage in the broiler thigh muscle by activating the nuclear factor erythroid 2–related 2/Kelch-like ECH-associated protein 1 signaling pathway," *Poult. Sci.*, vol. 99, no. 3, pp. 1454–1461, Mar. 2020, doi: 10.1016/j.psj.2019.11.001.

[4] L. Lara and M. Rostagno, "Impact of heat stress on poultry production," *Animals*, vol. 3, no. 2, pp. 356–369, Apr. 2013, doi: 10.3390/ani3020356.

[5] P. C. Situmorang, S. Ilyas, S. Hutahaean, and R. Rosidah, "Histological changes in placental rat apoptosis via FasL and cytochrome c by the nano-herbal Zanthoxylum acanthopodium," *Saudi J. Biol. Sci.*, vol. 28, no. 5, pp. 3060–3068, May 2021, doi: 10.1016/j.sjbs.2021.02.047.

[6] A. R. Jahejo *et al.*, "Effects of heat stress on the performance of Hubbard broiler chicken," *Cells, Anim. Ther.*, vol. 2, no. 1, pp. 1–5, 2016, [Online]. Available: https://shorturl.at/i9y1m

[7] A. Mujahid, Y. Akiba, and M. Toyomizu, "Progressive changes in the physiological responses of heat-stressed broiler chickens," *J. Poult. Sci.*, vol. 46, no. 2, pp. 163–167, 2009, doi: 10.2141/jpsa.46.163.

[8] S. Hewlings and D. Kalman, "Curcumin: a review of its effects on human health," *Foods*, vol. 6, no. 10, p. 92, Oct. 2017, doi: 10.3390/foods6100092.

[9] S. Sugiharto, "Alleviation of heat stress in broiler chicken using turmeric (curcuma longa) - a short review," *J. Anim. Behav. Biometeorol.*, vol. 8, no. 3, pp. 215–222, 2020, doi: 10.31893/jabb.20028.

[10] H. Akhavan-Salamat and H. A. Ghasemi, "Alleviation of chronic heat stress in broilers by dietary supplementation of betaine and turmeric rhizome powder: dynamics of performance, leukocyte profile, humoral immunity, and antioxidant status," *Trop. Anim. Health Prod.*, vol. 48, no. 1, pp. 181–188, Jan. 2016, doi: 10.1007/s11250-015-0941-1.

[11] L. Labban, "Medicinal and pharmacological properties of turmeric (curcuma longa): a review," *Int. J. Pharm. Biomed. Sci.*, vol. 5, no. 1, pp. 17–23, 2014.

[12] A. A. Candra and D. Putri, "Application turmeric as antioxidant for broiler chickens," *J. Phys. Conf. Ser.*, vol. 1450, no. 1, p. 012058, Feb. 2020, doi: 10.1088/1742-6596/1450/1/012058.

[13] M. Li, J. Wu, and Z. Chen, "Effects of heat stress on the daily behavior of wenchang chickens," *Rev. Bras. Ciência Avícola*, vol. 17, no. 4, pp. 559–566, Dec. 2015, doi: 10.1590/1516-635X1704559-566.

[14] T. Branco, D. J. Moura, I. A. Nääs, and S. R. M. Oliveira, "Detection of broiler heat stress by using the generalised sequential pattern algorithm," *Biosyst. Eng.*, vol. 199, pp. 121–126, Nov. 2020, doi: 10.1016/j.biosystemseng.2019.10.012.

[15] L. A. Mack, J. N. Felver-Gant, R. L. Dennis, and H. W. Cheng, "Genetic variations alter production and behavioral responses following heat stress in 2 strains of laying hens," *Poult. Sci.*, vol. 92, no. 2, pp. 285–294, Feb. 2013, doi: 10.3382/ps.2012-02589.

[16] N. Gupta, K. Verma, S. Nalla, A. Kulshreshtha, R. Lall, and S. Prasad, "Free radicals as a double-edged sword: the cancer preventive and therapeutic roles of curcumin," *Molecules*, vol. 25, no. 22, p. 5390, Nov. 2020, doi: 10.3390/molecules25225390.

[17] S.-H. Yun, Y.-S. Moon, S.-H. Sohn, and I.-S. Jang, "Effects of cyclic heat stress or vitamin C supplementation during cyclic heat stress on HSP70, inflammatory cytokines, and the antioxidant defense system in Sprague Dawley rats," *Exp. Anim.*, vol. 61, no. 5, pp. 543–553, 2012, doi: 10.1538/expanim.61.543.

[18] M. R. Abdollahi, F. Zaefarian, and V. Ravindran, "Feed intake response of broilers: impact of feed processing," *Anim. Feed Sci. Technol.*, vol. 237, pp. 154–165, Mar. 2018, doi: 10.1016/j.anifeedsci.2018.01.013.
[19] M. H. Tamzil, "Heat stress on poultry: metabolism, effects and efforts to overcome," *Indones. Bull. Anim. Vet. Sci.*, vol. 24, no. 2, Oct. 2014, doi: 10.14334/wartazoa.v24i2.1049.
[20] Y. A. Attia, M. A. Al-Harthi, and A. Sh. Elnaggar, "Productive, physiological and immunological responses of two broiler strains fed different dietary regimens and exposed to heat stress," *Ital. J. Anim. Sci.*, vol. 17, no. 3, pp. 686–697, Jul. 2018, doi: 10.1080/1828051X.2017.1416961.
[21] A. Donkoh, "Ambient temperature: a factor affecting performance and physiological response of broiler chickens," *Int. J. Biometeorol.*, vol. 33, no. 4, pp. 259–265, 1989, doi: 10.1007/BF01051087.
[22] R. Fallah and E. Mirzaei, "Effect of dietary inclusion of turmeric and thyme powders on performance, blood parameters and immune system of broiler chickens," *J. Livest. Sci.*, vol. 7, pp. 180–186, 2016, [Online]. Available: https://livestockscience.in/wp-content/uploads/turmeric-thym-brolier-iran.pdf
[23] G. Lokesh, S. R. Ananthanar, and V. N. Y. Murthy, "Changes in the activity of digestive enzymes in response to chemical mutagen diethyl sulfate in the Silkworm Bombyx Mori L. (Lepidoptera: Bombycidae)," *Asian J. Appl. Sci.*, vol. 5, no. 6, pp. 431–437, Aug. 2012, doi: 10.3923/ajaps.2012.431.437.
[24] M. Baracho, I. Nääs, N. Lima, A. Cordeiro, and D. Moura, "Factors affecting broiler production: a meta-analysis," *Brazilian J. Poult. Sci.*, vol. 21, no. 3, 2019, doi: 10.1590/1806-9061-2019-1052.
[25] F. Lupatini, "Avaliação do efeito de variáveis produtivas na conversão alimentar de frangos de corte," Universidade Federal de Goiás, 2015. [Online]. Available: http://repositorio.bc.ufg.br/tede/handle/tede/4610
[26] N. Irwani, Zairiful, and I. K. Habsari, "Feed intake and feed conversion ratio of broiler supplemented with herb extract," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 1012, no. 1, p. 012069, Apr. 2022, doi: 10.1088/1755-1315/1012/1/012069.
[27] X. Dong *et al.*, "Protective effects of curcumin against thyroid hormone imbalance after gas explosion-induced traumatic brain injury via activation of the hypothalamic-pituitary-thyroid axis in male rats," *Environ. Sci. Pollut. Res.*, vol. 29, no. 49, pp. 74619–74631, Oct. 2022, doi: 10.1007/s11356-022-20943-2.
[28] N. John Sushma *et al.*, "Facile approach to synthesize magnesium oxide nanoparticles by using clitoria ternatea—characterization and in vitro antioxidant studies," *Appl. Nanosci.*, vol. 6, no. 3, pp. 437–444, Mar. 2016, doi: 10.1007/s13204-015-0455-1.
[29] F. Sadeghian *et al.*, "The trend of burn mortality in Iran - a study of fire, heat and hot substance-related fatal injuries from 1990 to 2015," *Burns*, vol. 45, no. 1, pp. 228–240, Feb. 2019, doi: 10.1016/j.burns.2018.09.006.
[30] N. Rajput, N. Muhammad, R. Yan, X. Zhong, and T. Wang, "Effect of dietary supplementation of curcumin on growth performance, intestinal morphology and nutrients utilization of broiler chicks," *J. Poult. Sci.*, vol. 50, no. 1, pp. 44–52, 2013, doi: 10.2141/jpsa.0120065.
[31] R. K. Verma, P. Kumari, R. K. Maurya, V. Kumar, R. B. Verma, and R. K. Singh, "Medicinal properties of turmeric (curcuma longa l.): a review," *Int. J. Chem. Stud.*, vol. 6, no. 4, pp. 1354–1357, 2018, [Online]. Available: https://www.chemijournal.com/archives/2018/vol6issue4/PartV/6-4-314-742.pdf
[32] Y. Panahi, M. S. Hosseini, N. Khalili, E. Naimi, M. Majeed, and A. Sahebkar, "Antioxidant and anti-inflammatory effects of curcuminoid-piperine combination in subjects with metabolic syndrome: a randomized controlled trial and an updated meta-analysis," *Clin. Nutr.*, vol. 34, no. 6, pp. 1101–1108, Dec. 2015, doi: 10.1016/j.clnu.2014.12.019.
[33] H. Lin, H. C. Jiao, J. Buyse, and E. Decuypere, "Strategies for preventing heat stress in poultry," *Worlds. Poult. Sci. J.*, vol. 62, no. 1, pp. 71–86, Mar. 2006, doi: 10.1079/WPS200585.
[34] W. M. Quinteiro-Filho *et al.*, "Heat stress impairs performance parameters, induces intestinal injury, and decreases macrophage activity in broiler chickens," *Poult. Sci.*, vol. 89, no. 9, pp. 1905–1914, Sep. 2010, doi: 10.3382/ps.2010-00812.
[35] J. A. Archer, E. C. Richardson, R. M. Herd, and P. F. Arthur, "Potential for selection to improve efficiency of feed use in beef cattle: a review," *Aust. J. Agric. Res.*, vol. 50, no. 2, p. 147, 1999, doi: 10.1071/A98075.
[36] M. H. Tamzil, M. Ichsan, N. S. Jaya, and M. Taqiuddin, "Growth rate, carcass weight and percentage weight of carcass parts of laying type cockerels, kampong chicken and Arabic chicken in different ages," *Pakistan J. Nutr.*, vol. 14, no. 7, pp. 377–382, Jun. 2015, doi: 10.3923/pjn.2015.377.382.
[37] K. Y. Yesuf, B. T. Mersso, and T. E. Bekele, "Effects of different levels of turmeric, fenugreek and black cumin on carcass characteristics of broiler chicken," *J. Livest. Sci.*, vol. 8, pp. 11–17, 2017, [Online]. Available: https://livestockscience.in/wp-content/uploads/turmcarcasbroiler-ethiopia.pdf
[38] B. S. Ferguson, H. Nam, and R. F. Morrison, "Curcumin inhibits 3T3-L1 preadipocyte proliferation by mechanisms involving post-transcriptional p27 regulation," *Biochem. Biophys. Reports*, vol. 5, pp. 16–21, Mar. 2016, doi: 10.1016/j.bbrep.2015.11.014.
[39] A. Irshad *et al.*, "Factors influencing carcass composition of livestock: a review," *J. Anim. Prod. Adv.*, vol. 3, no. 5, p. 177, 2013, doi: 10.5455/japa.20130531093231.
[40] I. Estevez, "Density allowances for broilers: where to set the limits?," *Poult. Sci.*, vol. 86, no. 6, pp. 1265–1272, Jun. 2007, doi: 10.1093/ps/86.6.1265.
[41] Z. Y. Zhang *et al.*, "Effects of constant and cyclic heat stress on muscle metabolism and meat quality of broiler breast fillet and thigh meat," *Poult. Sci.*, vol. 91, no. 11, pp. 2931–2937, Nov. 2012, doi: 10.3382/ps.2012-02255.
[42] I. G. Permana, D. M. Suci, A. S. Yuwono, Y. Firdaus, S. R. Mawarni, and A. Rosmalia, "Supplementing broiler diets with black soldier fly (hermetia illucens) as a protein source: performance, carcass traits, viscera organ, and economic perspectives," *J. Adv. Vet. Res.*, vol. 14, no. 6, pp. 959–963, 2024, [Online]. Available: https://www.advetresearch.com/index.php/AVR/article/view/1872
[43] C. Fisher and K. N. Boorman, *Energy requirements of avian species. in nutrient requirements of poultry and nutritional research*. Butterworth, 1986.
[44] J. Elpidio M. Agbisit, R. K. S. Cu, V. A. Magpantay, B. A. Oliveros, M. R. T. Manaig, and C. P. Lavega, "Production performance and carcass characteristics of broilers fed diets with or without phytase supplementation," *Philipp. J. Vet. Anim. Sci.*, vol. 39, no. 1, pp. 81–90, 2013, [Online]. Available: https://www.pjvas.org/index.php/pjvas/article/view/30/25
[45] N. R. St-Pierre, B. Cobanov, and G. Schnitkey, "Economic losses from heat stress by us livestock industries," *J. Dairy Sci.*, vol. 86, pp. E52–E77, Jun. 2003, doi: 10.3168/jds.S0022-0302(03)74040-5.
[46] M. U. Sohail *et al.*, "Effect of supplementation of prebiotic mannan-oligosaccharides and probiotic mixture on growth performance of broilers subjected to chronic heat stress," *Poult. Sci.*, vol. 91, no. 9, pp. 2235–2240, Sep. 2012, doi: 10.3382/ps.2012-02182.
[47] O. O. Apalowo, D. A. Ekunseitan, and Y. O. Fasina, "Impact of heat stress on broiler chicken production," *Poultry*, vol. 3, no. 2, pp. 107–128, Apr. 2024, doi: 10.3390/poultry3020010.

## BIOGRAPHIES OF AUTHORS

**Agung Adi Candra** is an experienced lecturer with a proven work history of more than 20 years in the Department of Livestock Production Technology, Faculty of Animal Husbandry, Politeknik Negeri Lampung, Indonesia. Skilled in the field of veterinary medicine and livestock diseases. He is a graduate of the undergraduate and master's programs at IPB University. He can be contacted at email: adicandra@polinela.ac.id.

**Dwi Desmiyeni Puteri** is an experienced lecturer with a proven work history of more than 30 years in the Department of Livestock Production Technology, Faculty of Animal Husbandry, Politeknik Negeri Lampung, Indonesia earned a Doctorate in Animal Biomedical Engineering at IPB University, her research interests include veterinary medicine, immunology, and animal health science. She can be contacted at email: desmiyenidwi@gmail.com.

**Sakhira Najla Oktyana** is a graduate student in Animal Husbandry at the Department of Livestock Production Technology, Faculty of Animal Husbandry, Politeknik Negeri Lampung, Indonesia. She received her S.Tr.Pt. Degree in 2024. Her research interest is the provision of turmeric in broilers to overcome heat stress. She can be contacted at email: sakhiranajlaoktyana384@gmail.com.