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Effect of Coconut Water on Weight Loss and Physiological Responses of Sheep after Short-Distance Transportation

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ABSTRACT

Transportation can cause stress, which leads to changes in body weight and physiological responses. Coconut water can reduce oxidative stress and improve the physiological response of sheep, as well as maintain hydration and metabolism to prevent weight loss. This study aims to analyze changes in body weight and physiological responses in thin-tailed Sheep given coconut water-based electrolyte solution. A total of 20 male thin-tailed Sheep with an average weight of 21.47 ± 1.47 kg were used in this study. The study used a Completely Randomized Design (CRD) with four treatments and five replications: P0 = control (400 ml of water), P1 = 100 ml of coconut water + 300 ml of water, P2 = 200 ml of coconut water + 200 ml of water, and P3 = 300 ml of coconut water + 100 ml of water. Data were analyzed using ANOVA, followed by Duncan's test. The results showed that the administration of coconut water to thin-tailed Sheep had no significant effect (P > 0.05) on rectal temperature, but had a significant effect (P < 0.05) on body weight loss, heart rate, and respiratory rate. The administration of coconut water to thin-tailed Sheep before transportation can reduce stress and body weight loss after transportation.

Keywords: coconut water, sheep, transportation

ABSTRAK

Transportasi merupakan salah satu faktor yang dapat menyebabkan stres pada ternak yang berpotensi mengubah bobot badan dan respon fisiologis. Penelitian ini bertujuan untuk menganalisis perubahan bobot badan dan respon fisiologis pada domba ekor tipis yang diberi larutan elektrolit berbasis air kelapa. Sebanyak 20 ekor domba ekor tipis jantan dengan rata-rata bobot 21,47 ± 1,47 kg digunakan dalam penelitian ini. Penelitian ini menggunakan Rancangan Acak Lengkap (RAL) dengan empat perlakuan dan lima ulangan, yaitu P0 = kontrol (400 ml air), P1 = 100 ml air kelapa + 300 ml air, P2 = 200 ml air kelapa + 200 ml air, dan P3 = 300 ml air kelapa + 100 ml air. Data dianalisis menggunakan ANOVA, dilanjutkan dengan uji Duncan. Hasil penelitian menunjukkan bahwa pemberian air kelapa pada domba ekor tipis tidak berpengaruh signifikan (P > 0,05) terhadap suhu rektal, namun berpengaruh signifikan (P < 0,05) terhadap penurunan bobot badan, denyut jantung, dan frekuensi pernapasan. Pemberian air kelapa pada domba ekor tipis sebelum transportasi dapat mengurangi stres dan penurunan bobot badan setelah transportasi.

Kata kunci: air kelapa, domba, transportasi

INTRODUCTION

Livestock transportation, an unavoidable aspect of animal husbandry, has been widely recognized as a major source of stress in animals. A combination of physical, psychological, and environmental factors contributes to the stress experienced during road transport. Common stressors include restricted space, limited mobility, inadequate access to feed and water, and social conflict due to mixing with unfamiliar individuals (Kumar *et al.* 2023).

The findings indicate that these stressors not only alter animal behavior but also lead to significant physiological disturbances. Transportation-induced stress, which is exacerbated by environmental conditions, vibration, and the duration of travel, has been associated with elevated adrenal activity, immunosuppression, and body weight loss (Naldurtiker *et al*. 2023). Consequently, stress related to transportation has emerged as a critical issue, with implications for both economic productivity and animal welfare, thereby drawing increasing scientific and regulatory attention.

Sheep, as a key provider of animal protein in Indonesia, are particularly susceptible to such stress. According to Lendrawati *et al.* (2019), the rising demand for sheep products contrasts with the current lack of specific transportation regulations, which often results in suboptimal handling practices that disregard animal welfare considerations (Gopar *et al.* 2020). Prolonged periods of transport and feed deprivation have been shown to significantly increase weight loss, hematocrit values, and neutrophil percentages, while decreasing lymphocyte counts in sheep (Lendrawati *et al.* 2020).

The findings further suggest that effective strategies are urgently needed to mitigate the physiological consequences of transportation stress. One potential intervention involves the administration of coconut water, which is rich in electrolytes and antioxidant compounds. According to Setiawan *et al*. (2019), coconut water has been shown to reduce oxidative stress, improve physiological resilience, maintain hydration, and support metabolic function, thereby minimizing weight loss and stress-related physiological disruptions during transport.

This approach becomes particularly relevant given the inherent susceptibility of sheep to transportation-induced stress. Sheep are sensitive to environmental fluctuations, especially changes in climate and temperature during transit. Such environmental stressors activate homeostatic mechanisms aimed at maintaining a stable internal body temperature (Cockram *et al.* 2021). In this process, sheep dissipate excess heat through evaporation, defecation, and diuresis, which concurrently results in the loss of essential electrolytes such as sodium (Na^+), potassium (K^+), and chloride (Cl^-). This electrolyte and fluid loss may lead to dehydration, decreased body weight, and elevated oxidative stress in transported livestock (Wulansari *et al.* 2024).

The physiological response to increased ambient temperature includes elevated respiratory rate and vasodilation, which enhance heat dissipation but also increase cardiovascular activity. As homeothermic animals, sheep strive to maintain a constant internal temperature (Rafael *et al.* 2021). Parameters such as body temperature, respiratory rate, and heart rate serve as reliable indicators of transport-induced stress. The findings further suggest that the administration of natural electrolyte solutions, those mimicking the ionic composition of body fluids can effectively mitigate fluid and electrolyte loss (Darussalam *et al.* 2015). Compared to synthetic alternatives, natural sources are generally regarded as safer and more physiologically compatible (Kariyawasam *et al.* 2024).

One such natural electrolyte source is coconut water, which contains an ionic composition similar to that of body fluids. Despite its potential, the utilization of coconut water, particularly from mature coconuts, remains limited in Indonesia. In traditional markets, coconut vendors typically prioritize the flesh of the fruit, discarding the water without consideration. This practice poses environmental concerns, as the acidity of coconut water can damage soil structure, hinder plant growth, and, if discharged into water bodies, lead to aquatic life mortality (Nurdyansyah & Widyastuti 2017). Recognizing both its physiological benefits and current underutilization, this study aims to analyze changes in body weight and physiological responses in thin-tailed sheep administered a coconut water-based electrolyte solution. Given its high nutritional content and isotonic nature, coconut water is expected to rapidly alleviate dehydration during transportation (Wulansari *et al.* 2015).

MATERIALS AND METHODS

Twenty male thin-tailed sheep, approximately 1 year old and weighing 21.47 ± 1.47 kg, were used in this study. Coconut water used came from old green coconut fruit (*Cocos nucifera veridis*). Giving coconut water treatment was done 3 hours before transportation. The following is the specific composition of coconut water.

Table 1. Composition of coconut water

Component	Concentration	Unit	Source
Water	95,5	%	Kumar *et al.* 2023
Carbohydrates	4	%	Kumar *et al.* 2023
Fat	0,1	%	Kumar *et al.* 2023
Potassium (K)	1.112 – 2.185,3	Ppm	Mantra & Widnyana 2022
Calcium (Ca)	45 – 128.92	Ppm	Mantra & Widnyana 2022
Magnesium (Mg)	29.3 – 86.525	Ppm	Mantra & Widnyana 2022
Sodium (Na)	27 - 50	ppm	Tahir *et al.* 2018
Vitamin C	2-Apr	mg/100 mL	Kumar *et al.* 2023

Transportation of sheep was carried out for 6 hours with a distance of about 244 km. Sheep were transported without being given feed and water. Livestock were not rested during the trip. Transportation was carried out from 10:00 am to 4:00 pm. This was done to see the effect of coconut water as an anti-stress and anti-dehydration agent when sheep were transported while the sun was still present. The average speed during the trip was 40 km/h. The density of sheep in the pick-up car was 0.174 m^2/head. Sheep were transported standing up.

The ambient temperature and humidity during the transportation process were 29 ^oC and 74%. Road conditions are relatively smooth and congestion is rare. In addition, the Pantura (North Coast Road of Java) is quite wide, straight and paved. However, there are still some potholes because the Pantura (North Coast Road of Java) is heavily traveled by large vehicles. The design used is a completely randomized design (CRD) consisting of 4 treatments, namely P0 = Control (400 mL water), P1 = 100 mL coconut water + 300 mL water, P2 = 200 mL coconut water + 200 mL water, P3 = 300 mL coconut water + 100 mL water. Each treatment used five replicates.

$$\mathbf{Yij = \mu + Pi + \varepsilon ij}$$

Description:
Yij : Observation value
µ : Common mean value
Pi : Effect of treatment at the i-th level
εij : Effect of experimental error from the i-th treatment in the j-th replication
I : Treatment (i = 4)
j : Repeat (j = 5)

The data obtained were analyzed using ANOVA analysis of variance. If the data obtained are significantly or very significantly different, it will be continued with Duncan's comparative test.

RESULTS AND DISCUSSION

Body Weight Loss

Transportation is an unavoidable activity in the livestock industry, but transportation causes uncomfortable conditions for livestock, thus triggering stress (Wulansari *et al.* 2024). Shrinkage of sheep body weight that occurs after transportation is thought to be due to sheep performing homeostatis such as heat expenditure through respiration, sweating, and urination. This has the potential to reduce sheep body water, so that the sheep's body weight shrinks, and the release of feces during transportation can also affect the shrinkage of sheep body weight (Susanti 2018).

Coconut water is known as a natural source of electrolytes such as potassium, sodium, magnesium, and calcium, which play an important role in maintaining body fluid balance and preventing dehydration. This condition helps to avoid weight loss during stress or heavy physical activity (Kautsar and Yulianti 2025). The electrolytes contained in the drink enter the body and are distributed throughout the tissues, making them crucial in preventing dehydration and stress in livestock. Electrolyte supplementation has been shown to reduce heat stress responses and decrease mortality rates in livestock (Gamba *et al.* 2015).

Electrolytes also play a vital role in maintaining performance and stable blood profiles in livestock raised in tropical environments (Gamba *et al.* 2015). Electrolytes consist of various minerals, with coconut water being one of the local sources rich in electrolytes. Coconut water contains several electrolytes, including potassium, sodium, magnesium, and phosphorus (Sarker *et al.* 2022). The composition of coconut water has a pH ranging from 4.63 to 5.4, with potassium levels between 50.88 and 67.56 mEq/L, sodium 1.98 to 8.03 mEq/L, magnesium 4.14 to 14.06 mEq/L, calcium 4.87 to 8.78 mEq/L, and chloride 31.83 to 47.69 mEq/L (Sarker *et al.* 2022). Data on sheep body weight after transportation in treated thin-tailed sheep can be seen in Table 2.

The results of the analysis showed that the administration of coconut water-based electrolyte solution to transported thin-tailed sheep had a significant effect ($P < 0.05$) on changes in sheep body weight. Stress due to transportation can be detrimental to farmers, namely shrinkage of livestock body weight (Wardiman 2016). The results showed that the body weight shrinkage of thin-tailed sheep was in the range of 0.46 - 0.76 kg. Sheep treated with P0 water showed the highest weight loss. Meanwhile, sheep treated with coconut water P1, P2 and P3 showed lower weight loss. After transportation, all treatments experienced changes in average body weight. This is due to the transportation of sheep that have a space allowance that is less in accordance with the recommendations of the Farm Animal Welfare Advisory Council (FAWAC 2007) which is 0.20 - 0.30 m^2 / head for sheep with body weight < 55 kg. Meanwhile, this study used a space allowance of 0.17 m^2/head with a body weight range of 18-24 kg, so the animals experienced stress. This study uses this density because it adapts to the livestock density commonly used by farmers

Table 2. Weight loss and percentage of weight loss of thin-tailed sheep

Treatment	Initial Weight	Final Weight	Weight Loss (kg)	Weight Loss Percentage (%)
P0	21.66 ± 1.26	20.90 ± 1.23	0.76 ± 0.11a	3.64 ± 0.57a
P1	21.58 ± 1.81	21.08 ± 1.79	0.50 ± 0.12b	2.38 ± 0.58b
P2	22.18 ± 0.99	21.62 ± 0.99	0.56 ± 0.11b	2.59 ± 0.53b
P3	20.48 ± 1.60	20.02 ± 1.48	0.46 ± 0.15b	2.27 ± 0.61b
Average	21.48 ± 0.71	20.91 ± 0.66	0.57 ± 0.13	2.72 ± 0.63

Note: Means in the same column/row with different superscript differ significantly ($P < 0.05$)

in Indonesia, which is 0.07-0.10 m^2/head (Putra 2015). Generally, sheep transportation in Indonesia still does not have a standard density of livestock in the vehicle, but rather for the sake of efficiency, thus allowing stress to occur.

The analysis also showed that the provision of coconut water-based electrolyte solution had a significant effect ($P < 0.05$) on the percentage of sheep weight loss. Transportation of sheep for 6 hours caused body weight loss of 2.27% - 3.64%, as shown in Table 2. Body weight shrinkage in this study was lower than Lendrawati *et al.* (2020) who reported that the decrease in body weight in thin-tailed sheep during 8 hours of transportation was 5.94%. Transportation for 16 hours also causes shrinkage of body weight of fat-tailed sheep by 4.73% (Gopar *et al.* 2020). The body weight shrinkage in this study was lower because the transportation distance in this study was shorter than the previous study. The temperature and humidity of the environment during transportation are still in the comfort zone, namely 28-31 ºC with 74% humidity. Based on SNI (2017), the normal ambient temperature for sheep is 22-31 ºC with air humidity less than 75%.

Sheep treated with P0 water showed the highest percentage of body weight shrinkage of 3.64%. Meanwhile, sheep treated with coconut water P1, P2 and P3 showed lower weight loss of 2.38%, 2.59% and 2.27%. This is because the provision of coconut water for transportation can suppress body weight shrinkage than the provision of water treatment. Coconut water has a high nutritional content and contains the main components consisting of water, potassium, carbohydrates, protein and some mineral salts. The nutritional content of coconut water is not only macro elements, but also micro elements. The macro elements found in coconut water are carbon and nitrogen. The carbon element in coconut water is simple carbohydrates such as glucose, sucrose, fructose, sorbitol, inositol, and others. The nitrogen element is protein composed of amino acids, such as aline, arginine, alanine, cystine and serine. As an illustration, the amino acid content of coconut water is higher than the amino acids in cow's milk. In addition to carbohydrates and protein, coconut water also contains microelements in the form of minerals that the body needs. These minerals include potassium (K), calcium (Ca), magnesium (Mg), ferum (Fe), cuprum (Cu), phosphorus (P), and sulfur (S). This natural water is sterile and contains high levels of potassium, chlorine, and chlorine (Wahyuni 2018).

Sweat output and evaporation due to sunny weather during the transportation process, resulting in disruption of ions contained in the body, resulting in dehydration of livestock. Dehydration results in shrinkage of livestock body weight in accordance with the opinion of Kassab and Mohammed (2014) which states that shrinkage of body weight is also caused because during transportation sheep lose water or commonly called dehydration. The provision of coconut water-based electrolyte solutions can minimize dehydration, as evidenced in each coconut water treatment there was a smaller decrease in body weight than the control treatment that was not given coconut water. In this study, livestock were transported in a standing position. The standing position of livestock showed a higher body weight loss of 1 kg compared to the lying position of 0.72 kg (Lendrawati *et al.* 2019). This is because in the standing position livestock experience greater stress, related to efforts to withstand body weight against shocks and vibrations influenced by road conditions during travel. In contrast, in the lying position, the sheep is in a stable state, so it is more resistant to shocks and vibrations during the trip. Vibration, shock and road conditions are among the stressors in livestock transportation (Miranda de Lama *et al.* 2011).

Physiological Responses

Transportation is one of the factors that can cause stress in livestock which results in changes in physiological responses such as rectal temperature, heart rate and respiratory frequency. Factors such as travel duration, environmental conditions, livestock density, and the quality of ventilation in the vehicle can trigger increased stress and disrupt the balance of sheep body homeostasis (Knowles *et al.* 2020). Increases in rectal temperature, heart rate and respiratory frequency are often observed as compensatory mechanisms to stressful conditions during transportation (Mitchell *et al*. 2018). The physiological responses of sheep are important indicators in assessing livestock welfare and adaptation to various environmental conditions, including changes in temperature, humidity and other stress factors. An increase in ambient temperature can trigger an increase in respiratory frequency as a compensatory mechanism to release body heat. Stressors that occur during transportation have a major impact on the neuroendocrine system. Stress stimuli result in the activation of the adrenal glands which then secrete catecholamine and glucocorticoid hormones, both of which play a role in increasing heart rate and respiratory frequency (Fuentes *et al.* 2020).

Table 3. Mean difference of physiological responses of thin-tailed sheep

Treatment	Rectal Temperature (ºC)	Heart Rate (times/minute)	Respiration Frequency (times/minute)
P0	0.72 ± 0.23	13.60 ± 2.30a	9.60 ± 1.14a
P1	0.66 ± 0.30	11.00 ± 2.55ab	8.20 ± 2.68ab
P2	0.48 ± 0.16	11.60 ± 1.95ab	6.40 ± 1.14b
P3	0.58 ± 0.26	9.20 ± 1.30b	6.80 ± 1.48b
Average	0.61 ± 0.10	11.35 ± 1.81	7.75 ± 1.45

Note: Means in the same column/row with different superscript differ significantly ($P < 0.05$)

The causes of physiological stress that arise when livestock are transported to their destination are fatigue, fear and inappropriate livestock density. The increase in air temperature and the process of handling livestock during transportation will result in an increase in pulse frequency and respiration rate every minute (Putra 2015). Transportation that does not pay attention to animal welfare can cause a mortality rate of 0.35%, a fatigue rate of 2.5%, and an injury rate of 0.35% (Lendrawati 2020). Data on the mean difference in rectal temperature, heart rate and respiration rate during the trip can be seen in Table 3.

Rectal temperature is one of the main indicators in assessing the physiological response of sheep due to stress during transportation. According to research by Hall *et al*. (2018), sheep that experienced long transportation showed an increase in rectal temperature due to increased metabolism and sympathetic nerve activity in an effort to maintain body balance. Another study by Stockman *et al*. (2019) showed that the rectal temperature of sheep can increase especially when transportation is carried out under high ambient temperature conditions. Rectal temperature is a good indicator to measure body heat, in addition, rectal temperature is also one of the variables that can show the effects of environmental heat stress. Rectal temperature is a good indicator to describe the internal body temperature of livestock (Nurmi 2016).

The analysis showed that the administration of coconut water-based electrolyte solution to transported thin-tailed sheep had no significant effect ($P > 0.05$) on the rectal temperature of the sheep. Changes in rectal temperature of thin-tailed sheep are still within the normal range. Sheep rectal temperature in the normal range between 38.2 - 40 ºC (Nurmi 2016). Based on the table above, the average rectal temperature of sheep before and after transportation is in the range of 38.78 - 38.92 ºC. In all treatments, after transportation there was a slight change in the average rectal temperature. This is because the rectal temperature of the sheep has begun to recover and adapt during transportation. In addition, this can be due to the environmental temperature at the time of transportation in the normal range of 28-31 ºC with 74% humidity. According to Frans *et al.* (2020), environmental temperatures that are higher or lower than body temperature can affect the ability of livestock to maintain a constant body temperature. The results showed that environmental temperature and humidity are important factors affecting body temperature and livestock welfare.

Sheep as homeotherm livestock will try to maintain a relatively constant body temperature (homeostasis), because when the body temperature is allowed to rise too high or fall too low it will cause death. To maintain their body temperature balance, livestock constantly produce heat and give off heat to their environment. Heat is always transferred from inside the body to the outside through the skin surface (evaporation), and passed on to the environmental air (Abbas 2009). The mechanism of heat release through the skin surface (evaporation) will result in dehydration of the sheep due to lack of water and ions in the body. Loss of water in the body will result in an increase in body temperature (Schwartzkopf-Genswein *et al.* 2021).

The provision of certain supplements, such as coconut water, has been reviewed in several studies as an alternative to reduce the negative effects of transportation stress in sheep. Coconut water contains natural electrolytes that can help maintain fluid and electrolyte balance in the body, potentially stabilizing the physiological response after transportation (Siregar *et al.* 2020). In several studies, the provision of coconut water has been shown to increase the body's resistance to thermal stress and help faster recovery after transportation (Hadi *et al*. 2021). Studies conducted by Kumar *et al.* (2023) showed that coconut water can reduce plasma cortisol levels and improve electrolyte balance in sheep, thus reducing the risk of dehydration during transportation. In addition, research by Ali *et al.* (2023) found that coconut water supplementation can increase appetite and accelerate body weight recovery after a long journey.

The results of the analysis showed that the administration of coconut water-based electrolyte solution on the heart rate of transported thin-tailed sheep had a significant effect ($P < 0.05$). Based on the table above, the average difference in sheep heart rate before and after transportation was 11.35 ± 1.81 times/minute. The average heart rate of sheep is in the range of 72.60 - 83.95 beats/minute. The normal range of heart rate in sheep is between 60 -120 beats per minute (Isnaini 2006). In all treatments, after transportation there was an increase in heart rate. In the P3 treatment, the increase in heart rate was not too significant at 9.20 ± 1.30 compared to the P0 treatment which was 13.60 ± 2.30. This is because during the evaporation process, the reserve ions contained in coconut water can suppress the increase in sheep heart rate. Meanwhile, the P1 and P2 treatments showed results that were not significantly different from the other treatments.

Heart rate increases as the hypothalamus responds by releasing corticotropin-releasing hormone (CRH), which then stimulates the pituitary gland to release adrenocorticotropic hormone (ACTH). ACTH further triggers the adrenal glands to release the major stress hormones, namely cortisol and catecholamines (epinephrine and norepinephrine). These hormones cause an increase in cardiac activity by speeding up heart rate and increasing blood pressure to prepare the body for stressful situations (Broom *et al.* 2013). Other factors that affect sheep heart rate during transportation include the duration of the journey, noise level, and treatment during transfer. According to research by Miranda-de la Lama *et al.* (2018), sheep transported for more than five hours experienced a significant increase in heart rate, especially if not accompanied by adequate rest and access to drinking water.

The results of the analysis showed that the administration of coconut water-based electrolyte solution to transported thin-tailed sheep had a significant effect ($P < 0.05$) on the frequency of sheep breathing. Based on the table above, the average difference in respiratory frequency of sheep before and after transportation is in the range of 7.75 ± 1.45 times/minute. According to Smith (1998), the range of normal respiratory frequency in sheep is 26 - 54 times/minute. In all treatments after transportation there was an average increase in respiratory frequency. In the P2 and P3 treatments, the increase in respiratory frequency was not too significant at 6.40 ± 1.14 and 6.80 ± 1.48 when compared to the P0 treatment which was 9.60 ± 1.14. Meanwhile, the P1 treatment showed results that were not significantly different from the other treatments. According to Gopar *et al.* (2020), the average measurement of respiratory frequency in sheep before transportation was 66.39 times/minute and after transportation was 73.23 times/minute. The more stressed the livestock, the greater the heat generated from metabolism, in addition to the heat obtained from metabolism, the livestock's body can also obtain heat from the environment that can be released through the repiration process (Sutedjo 2016). Respiratory frequency is closely related to heart rate, when heart rate increases, respiratory frequency will also increase. Respiratory frequency increases because sheep perform a homeostasis process, so that their body temperature remains within the normal range (Lopez *et al*. 2017).

CONCLUSION

Giving a coconut water-based electrolyte solution to thin-tailed sheep before transportation in amounts of 200 ml and 300 ml was able to reduce body weight loss by 1.37 - 1.05% and suppress the increase in heart rate by 4.4 - 2 times/minute and respiratory frequency by 3.2-2.8 times/minute of the sheep. However, giving coconut water was not able to reduce the increase in sheep's rectal temperature. The use of coconut water as an electrolyte solution can be an effective strategy in reducing the negative impact of transportation on thin-tailed sheep.

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